CHAPTER 6: METHODOLOGY

6.1 Introduction

This chapter provides details of the methods used for two studies. The main study was concerned with an examination of the self-regulatory practices of older drivers (Chapters 8-10). This study required a group of older drivers to complete a questionnaire concerned with their driving behaviour and attitudes, together with a series of functional tests, and an on-road driving test. The other study (Chapter 7) was concerned with validating the visual attention measure (Computerised Visual Attention Test - CVAT), which was developed for use in the self-regulation study. The validation study examined the CVAT's test-retest reliability by assessing a sub-sample of drivers from the self-regulation study on the CVAT on a second occasion, and examined the CVAT's construct and predictive validity by additionally assessing the same sub-sample of drivers on a series of commonly used standard tests of attention. The methodology for the main study on self-regulation is described in section 6.2, followed by the methodology for the validation study in section 6.3.

6.2 Study One: Self Regulation

6.2.1 Participants

A group of 104 older drivers (aged 60 years or more) was recruited from two sources: the general community (n = 93) and the client pool of the Driver Assessment Rehabilitation Service (DARS) at the University of South Australia (n = 11). Those from the general community were recruited through Senior Citizens clubs and Australian Retired Persons Association clubs in metropolitan Adelaide. The drivers from the DARS client pool were referred, mostly by general practitioners, for an assessment of their ability to drive and, hence, their right to continue to hold a driver's licence. Participants were recruited from both the general community and DARS in order to sample a wide range of driving abilities.

The total sample consisted of 65 females and 39 males, and their ages ranged from 60 to 92, with a mean of 74.2 (*SD* = 6.3). The number of years of formal education of the sample ranged from six to 21, with a mean of 10.9 (*SD* = 3.0). Their IQ scores, as estimated from the Wechsler Test of Adult Reading (Wechsler, 2001) using the American standardisation sample, ranged from 85 to 126, with a mean of 108.6 (*SD* = 9.4).[2]

All participants were required to be fluent in English, to be in possession of a full driver's licence (i.e. at least Class C, able to drive non-commercial motor vehicles not exceeding 4,500kg), and to have been driving for over ten years. The latter requirement was imposed to ensure that the driving behaviour of participants was not influenced by inexperience. Another requirement was that no participant had suffered a cerebrovascular accident (stroke), traumatic brain injury, or other event causing a sudden loss of functioning, in the past year. The reason for this is that such events lead to a compulsory suspension of the person's licence and such alterations to driving behaviour are externally imposed rather than reflecting voluntary changes.

6.2.2 Materials

The materials for the study included a questionnaire measuring self-reported health and driving attitudes and behaviour; a number of visual, physical, psychological and neuropsychological tests (hereafter referred to as "functional tests"); and an on-road driving test.

[2] The participants from the referral group were not found to differ significantly from the general community participants in terms of years of education or IQ, but were found to have a higher mean age (M=79.1, SD=5.6 versus M = 73.7, SD = 6.2, $t(102) = -2.8$, $p = .006$).

6.2.2.1 Questionnaire

The questionnaire used in the study was the Driver Mobility Questionnaire, which consisted of 72 questions and was divided into three sections (refer to Appendix 6A for the complete questionnaire). The first section of the questionnaire asked for the participants' age, gender, and whether they had held a drivers' licence for more than ten years.

The next section contained 16 questions relating to medical conditions and medications. Participants were provided with a list of 14 medical conditions in this section and asked to indicate whether they suffered from each condition or not. The 14 conditions were chosen because they were likely to compromise driving ability. Additionally, participants were asked to name any other conditions they had that were not on the list. For each condition that they nominated, participants were asked to indicate on a three point scale how much they thought it affected their everyday functioning. A health scale of this nature has previously been used by Steinberg et al. (1994) and in a road safety context by Stalvey and Owsley (2000). The self-ratings of the extent to which medical conditions affected everyday functioning were summed for each participant to give an index of general health. Participants were also asked to list the medications they took more often than once a month. In order to classify medications according to whether they were potentially hazardous to driving, details of the medications were obtained from the Monthly Index of Medical Specialities (MIMS) annual published in 2000 (MIMS Australia, 2000). The MIMS annual is a publication providing details about currently available prescription and non-prescription medications, including likely and possible side-effects. All medications described as commonly causing drowsiness, dizziness, or disturbance of central nervous system functioning were classified as being "potentially hazardous to driving".

The third section of the Driver Mobility Questionnaire was a combination of selected questions from the Driving Habits Questionnaire (DHQ) used by Owsley et al. (1999) and the Driver Perceptions and Practices Questionnaire used by Stalvey and Owsley (2000). The questions taken from the DHQ included those concerned with current driving, driving exposure (amount of driving done per week), driving confidence (plus supplementary questions about avoidance of driving used by Stalvey and Owsley), crashes and citations, and driving space (the geographical area over which driving is done). Questions taken from the Driver Perceptions and Practices Questionnaire included those concerned with perceived barriers to self-regulation and regulatory self-efficacy. However, a number of questions were altered to provide additional information or to adjust them for a South Australian, rather than American, context. The details of the adjustments that were made to the original source questionnaires are provided in Appendix 6B.

The self-ratings variables (driving ability, vision, dual task ability) were all scored on five point scales from 1 = poor to 5 = excellent. The driving exposure variables derived from the Driver Mobility Questionnaire included the number of days driven per week, the number of trips taken per week, and the number of kilometres driven per week. For driving confidence, participants had to rate their confidence in nine difficult driving situations (e.g. driving in the rain) on five point scales, with 1 = not at all confident and 5 = completely confident. These ratings were summed to create an overall confidence score ranging from 9 (not confident at all in any difficult driving situation) to 45 (completely confident in all driving situations). “Driving space” (the geographical area in which driving is done) was based on whether participants drove in five particular areas (e.g. local neighbourhood, interstate), with one point awarded for each area they drove in, giving a maximum score of five (indicative of driving in all areas). Avoidance of difficult driving situations was based on the same nine driving situations as the driving confidence measure. Participants had to report their level of avoidance for each situation on a five point scale from 1 = never avoid to 5 = always avoid. These ratings were summed to create an overall avoidance score ranging from 9 (never avoid any driving situations) to 45 (always avoid all difficult driving situations). For perceived barriers of self-regulation, participants had to indicate whether they strongly agreed, agreed, disagreed or strongly disagreed that each of six factors (e.g. unavailability of public transport) stopped them from changing when and where they drove. Scores on a four point scale for each factor (strongly agree = 4, strongly disagree = 1) were summed to produce an overall score ranging from 6 (no barriers to self-regulation) to 24 (many barriers to self-regulation). Finally, regulatory self-efficacy was assessed by asking participants how hard they would find it to avoid each of eight difficult driving situations (e.g. rain). Responses of 'very hard' were given one point, 'somewhat hard' given two points and 'not hard at all' given three points. The sums of these scores gave an overall self-efficacy score ranging from 8 (low self-efficacy) to 24 (high self-efficacy).

Four of the questions asked participants about their crash and traffic violation records in the previous five years (i.e. number of crashes, number of police-reported crashes, number of traffic violations, number of times pulled over by the police). In order to check their responses concerning crashes on official databases, participants were asked to provide their driver's licence numbers. These licence numbers were then used to search the Traffic Accident Reporting System (TARS) database for crashes in the previous five years.

Participants were also asked questions about their preferred mode of travel, whether they wear glasses when driving, how their usual driving speed compares with other traffic, whether anyone had ever suggested to them that they cease or limit their driving (and if so, whom), who they thought was the best person to make decisions regarding driving cessation, and whether they had reduced their driving in the previous ten years (and if so, why). The DMQ measures concerned with driver beliefs and behaviour that were used in the study are summarised in Table 6.1.

Table 6.1
Driver attitude and driving behaviour measures in the Driver Mobility Questionnaire

Measure	Question numbers	Range of scores
Preferred mode of travel	1	NA
Wear glasses	2	NA
Relative speed of driving	3	1 - 5
Suggestions to limit driving	4	NA
Self-ratings		
Of driving ability	5	1 - 5
Of vision	6	1 - 5
Of dual task ability	7	1 - 5
Best person to decide on cessation	8	1 - 4
Driving exposure		
Days driven per week	9	0 - 7
Trips taken per week	10	min of zero
Kilometres driven per week	11	min of zero
Reductions in driving	12	NA
Driving confidence		
In specific driving situations	13 - 21	1 - 5
Overall		9 - 45
Crashes and citations	22 - 25	min of zero
Driving space	26 - 30	0 - 5
Driving avoidance		
In specific driving situations	31 - 39	1 - 5
Overall		9 - 45
Perceived barriers to self-regulation		
For specific barriers	40 - 45	1 - 4
Overall		6 - 24
Regulatory self-efficacy		
In specific situations	46 - 53	1 - 3
Overall		8 - 24

Note: NA = not applicable, a categorical variable; min of zero = minimum of zero

6.2.2.2 Functional Measures

Participants completed a number of functional measures. The measures were as follows:

Geriatric Depression Scale (Brink et al., 1982). This is a 30-item questionnaire that assesses the presence of depressive symptoms and was designed specifically for use with elderly populations. Each item requires a yes/no response (sample question: "Do you frequently feel like crying?"). Scores range from 0 to 30, with higher scores indicating a higher level of depressive symptoms. The scale is suitable for older adults because it has few somatic items that could artificially inflate the scores of persons in older age groups.

State-Trait Anxiety Inventory (Speilberger, 1983). This is a two part questionnaire assessing state anxiety (current level of anxiety) and trait anxiety (usual level of anxiety). Both parts consist of 20 items, each of which is a statement related to anxiety (e.g. "I feel relaxed") requiring a response on a four point scale. In the state anxiety section, the participant must indicate how much their feelings are the same as those expressed in the item ("not at all" to "very much so"). In the trait anxiety section, the participant must indicate how often they experience what is expressed in the item ("almost never" to "almost always"). Scores for each scale range from 20 to 80, with a higher score indicating higher levels of anxiety.

Snellen Static Visual Acuity. Static visual acuity was measured for each eye separately, and also binocularly, using a Snellen wall chart (black letters on a white background) adjusted for a viewing distance of 3m. The rows of letters on the chart correspond to visual acuity levels of 6/60 (i.e. person able to read at 6m what an average person is able to read at 60m), 6/36, 6/24, 6/18, 6/12, 6/9, 6/6 and 6/5. The smallest line for which the participant was able to read over half of the letters was recorded as their visual acuity level, with higher scores reflecting poorer visual acuity. As monocular vision measures have been found to be of importance for driving studies (Ivers et al., 1999), both binocular and monocular scores were used in the analyses.

Pelli-Robson Contrast Sensitivity (Pelli et al., 1988). This test involves a wall chart displaying letters of a constant size but varying levels of contrast with the background. The letters are arranged in sets of three and each set of letters is of a lower contrast level than the preceding set. The chart is read at a distance of 1m, first with each eye separately and then binocularly. For each condition, the participant's contrast sensitivity level is the log of the lowest contrast level for which the participant is able to correctly identify two of the three letters in a set. The chart provides scores ranging from zero to 2.25, with higher scores corresponding to better contrast sensitivity. As for visual acuity, both binocular and monocular scores were used in the analyses.

Each participant's *visual field* was measured using a simple procedure, which involved holding up a small object at a distance of one metre in the participant's peripheral visual field and asking if he or she could see it. A black rectangular object (13 x 3 cm) was chosen as the visual target, for its strong contrast with the white walls of the testing room. The participant was asked to stare at a small marker on the wall directly in front of him or her and the object was moved closer to the participant's central field of view at 10 degree intervals until he or she could see it. This was repeated for both the left and right sides of the participant's visual field. The greatest angle, with a maximum of 90 degrees, at which the participant could see the object was recorded for both the left and right side visual fields. This procedure was similar to one used in a previous study (Marottoli et al., 1998) that found a significant relationship between visual field and adverse driving events.

Neck mobility was assessed with a goniometer (supplied by Mentone Educational Centre, Victoria, Australia). This device was attached to the participant's seat in the testing room and was lowered to a position slightly above the participant's head. The participant was then asked to look straight ahead and the goniometer was set at zero degrees. The participant was then requested to turn his or her head horizontally to the left and then the right as far as possible, while keeping his or her shoulders straight. The angles of left and right neck rotation, to the nearest ten degrees, were measured and recorded. Higher scores reflect better neck mobility.

The *Modified Mini-Mental State Examination (3MS)* (Teng & Chui, 1987). This test is an updated version of the Mini Mental State Examination (Folstein et al., 1975) and measures basic cognitive functioning. It assesses basic abilities in a number of cognitive domains, including mental reversal, recall, temporal and spatial orientation, verbal fluency and speech production. Possible scores for the 3MS range from zero to 100. It is also possible to calculate a score out of 30, corresponding to the score the participant would have achieved for the original Mini Mental State Examination, for which a cut-off of 24 is standard for suspected dementia (Lezak, 1995). For comparison purposes, both scores out of 30 and 100 were used in the analyses.

Wechsler Test of Adult Reading (Wechsler, 2001). This test was used to provide an estimate of intellectual ability (IQ). It assesses word pronunciation and involves participants reading aloud a list of 50 words with irregular spellings that are presented on a card. A point is awarded for each word correctly pronounced, producing a score out of 50, which was then converted to a standard IQ score using age stratified norms, based on an American sample.

Symbol Digit Modalities Test (Smith, 1982). This test measures speed of information processing. It features a code that matches digits 1 to 9 with meaningless symbols. Participants are provided with rows of boxes containing the symbols in random order and a blank space below them. Participants must produce the appropriate digit for each symbol. The test involves two trials, each lasting 90 seconds, in which they must produce as many correctly matched digits as possible. In the first trial, the participants write the correct number for each symbol in the blank spaces provided and in the second they verbally produce the digits. The second trial provides a measure of speed of information processing without a hand motor component. The two different administrations of the test, using the two different response modalities, can follow each other directly because neither order of administration nor recency of first administration affects performance (Lezak, 1995). Scores can range from zero to 110. For the purposes of the study, only the scores for the written version were used. This was because no participants presented with a significant hand motor deficiency that would retard scores on the written test (the written and oral tests had a Pearson's Correlation of .92).

The *Spatial Span* subtest from the third edition of the Wechsler Memory Scale (Wechsler, 1997) was used to measure spatial memory. It involves the test administrator touching the tops of a group of ten small cubes (blue cubes on a white base) in set patterns that the participant must then replicate. The test has forward and backward subtests. In the forward subtest, the participant must exactly replicate the spatial pattern presented by the administrator, while in the backward subtest, the participant must produce the pattern in reverse order. For each subtest, the number of cubes that are touched starts at two and progresses to a maximum level of nine, with two trials given at each level. The test ends when the participant fails to produce the correct pattern on both trials at any level. The score for both subtests is the number of trials for which the participant correctly reproduces the appropriate pattern, giving minimum and maximum scores of zero and 16, respectively. For the purposes of this study, only the Total Spatial Span (the sum of the two subtests) was used as the Spatial Span measure.

The *Computerised Visual Attention Test (CVAT)* was developed specifically for this study and is described in Chapter 5. The CVAT requires participants to detect and react to targets in both central and peripheral vision, and was designed to measure selective and divided attention. The measure and the method of administration are described in detail in the method section of the second pilot study (section 5.2.2). The only change to the measure was that the subtests that used a slow rate of presentation of the letters in the primary task (X-detection) were omitted. Thus, there were five subtests, which were as follows:

- primary task (X-detection) only: measure of simple attention in central vision
- secondary task (car detection) only without visual distracters (houses): measure of simple attention in peripheral vision
- secondary task only with visual distracters: measure of selective attention in peripheral vision
- dual task (primary and secondary tasks) without visual distracters on the secondary task: measure of divided attention, central and peripheral vision
- dual task with visual distracters on the secondary task: measure of divided and selective attention, central and peripheral vision

For each of these subtests, the CVAT produced measures of target detection failures, false alarms (responses in the absence of a target), and reaction time. However, as explained previously (refer to section 5.2.4), only detection failures and reaction time measures were used for this study, thus providing one measure each of accuracy and speed on the attention tasks. Detection failures are hereafter referred to as "detection errors".

The order of the CVAT subtests was varied across participants so that the relationship between the attention variables and other measures could not be confounded with learning or fatigue effects. This variation in the order of the five CVAT subtests was done according to Orthogonal Latin Squares tables printed in Fisher and Yates (1957) so that, across the entire sample, each subtest was performed first, second, third, fourth and fifth by an equal number of participants.

The functional measures used in the self-regulation study are summarised in Table 6.2. For each measure, the functional ability it assesses and the range of possible scores are provided.

Table 6.2
Health and functional measures used in the self-regulation study

Measure	Functional ability	Range of scores
Health		
General health (in DMQ)		min of zero
Medication use (in DMQ)		min of zero
Use of medications potentially hazardous for driving (in DMQ)		min of zero
Psychological functioning		
Geriatric Depression Scale	Depressed mood	0 - 30
State-Trait Anxiety Inventory	Anxiety	
State Anxiety		20-80
Trait Anxiety		20-80
Vision		
Snellen visual acuity	Visual acuity	
Left eye		6/60 - 6/5
Right eye		6/60 - 6/5
Binocular		6/60 - 6/5
Pelli-Robson contrast sensitivity	Contrast sensitivity	
Left eye		0.00 - 2.25
Right eye		0.00 - 2.25
Binocular		0.00 - 2.25
Visual field	Horizontal visual field	
Left side		0 - 90°
Right side		0 - 90°
Total		0 - 180°
Physical functioning		
Neck mobility	Neck mobility	
Left side		0 - 90°
Right side		0 - 90°
Total		0 - 180°
Mental status		
Mini Mental State Exam (MMSE)	Mental status	0 - 30
Modified Mini-Mental (3MS)	Mental status	0 - 100
Speed of information processing		
Symbol Digit Modalities Test	Speed of information processing	0 - 110
Spatial memory		
Total Spatial Span	Spatial memory	0 - 32

Table 6.2 cont.
Health and functional measures used in the self-regulation study

Visual attention		
CVAT reaction time		
Primary task	simple attention, central vision	max 1999 ms
Secondary task, no distract	simple attention, peripheral vision	max 1999 ms
Secondary task, distract	selective attention, peripheral vision	max 1999 ms
Dual task, no distract[1]	divided attention	max 1999 ms
Dual task, distract[1]	divided and selective attention	max 1999 ms
CVAT target detection		
Primary task	simple attention, central vision	0 - 100%
Secondary task, no distract	simple attention, peripheral vision	0 - 100%
Secondary task, distract	selective attention, peripheral vision	0 - 100%
Dual task, no distract[1]	divided attention	0 - 100%
Dual task, distract[1]	divided and selective attention	0 - 100%

Note. DMQ = Driver Mobility Questionnaire; CVAT = Computerised Visual Attention Test, distract = visual distracters, min of zero = minimum score of zero; max 1999 ms = maximum score of 1999 milliseconds
[1] Scores for both primary and secondary tasks were calculated for dual task subtests

6.2.2.3 On-Road Driving Assessment

Participants' driving ability was determined using an on-road driving assessment conducted by the Driver Assessment Rehabilitation Service (DARS), located in the School of Occupational Therapy at the University of South Australia. DARS is an organisation that undertakes fitness-to-drive assessments on a referral basis. Their clients are referred mostly by general practitioners, and are predominantly older drivers affected by various medical conditions, such as dementia and stroke. DARS also assesses drivers recovering from traumatic injuries, including traumatic brain injury, and older drivers who refer themselves to check on their driving ability. DARS assessments include a standardised on-road driving test conducted by an occupational therapist with postgraduate training in driver assessment and rehabilitation, and a professional driving instructor. The driving instructor directs the driver through the test route and uses dual controls to maintain safety, while the occupational therapist sits in the back seat and scores the driver on his or her performance using a standard scoring protocol.

DARS devised a set test route specifically for the study that closely matched the task requirements of a route utilised in a previous study on driving and dementia (Clark et al., 2000), which in turn had been based on testing procedures used in other studies (Dobbs, 1997; Hunt et al., 1997; Parasuraman & Nestor, 1991). The test was broken into four different sections: familiarisation, low demand, moderate demand, and high demand. The *familiarisation* section involved familiarising the driver with the controls of the vehicle, and assessing whether the driver could follow simple instructions and perform basic vehicle control tasks (e.g. starting a car and moving off). The *low demand* section was conducted on low traffic roads and mainly involved negotiating roundabouts. The *moderate demand* section involved driving on main roads but did not require complex manoeuvres. In this section, all intersections were negotiated by driving straight through or turning with a dedicated turning arrow. In the *high demand* section, drivers had to perform unprotected right turns at intersections on main roads, as well as merging manoeuvres on multi-lane roads and driving in areas featuring high pedestrian activity. The driving test, therefore, progressed through a series of increasingly challenging stages, with progressively more difficult manoeuvres required in the presence of increasingly complex traffic conditions. The on-road assessments took between 40 minutes and an hour to complete. The complete driving assessment protocol is provided in Appendix 6C.

All driving assessments were conducted in dual-controlled, medium-sized sedans (1997 Toyota Corollas) fitted with power steering and manual or automatic transmission, depending on the participant's preference. Attempts were made to maintain consistency in the personnel conducting the driving assessments but there was some variation. Two different occupational therapists were employed for the study, one conducting 57% of the assessments, with the remaining 43% conducted by the other therapist. The same driving instructor was available for 95% of the assessments.

Assessments were conducted at three different times during the day: 9:30am, 11:00am, and 1:00pm. The choice of these times meant that drivers did not have to perform any part of their driving test during peak hour traffic.

The scoring system for the on-road driving assessment was the same as that developed for a study by Clark et al. (2000). In this system, points were awarded for various component skills and behaviours for each driving manoeuvre required in the test. For some behaviours (observation, coming to a stop, mirror checks), the occupational therapist recorded whether the behaviour was exhibited or not. If recorded as “yes”, the driver was awarded one point, if recorded as “no”, no point was awarded. For some skills (speed, positioning, speed of approach, gap selection), the performance was recorded as “safe” or “unsafe”. For safe performance, one point was awarded; for unsafe performance no point was awarded. Performance of some skills (response to lights, speed at a school zone, choice of lane, selection of a location to park, selection of a location to perform a U-turn) was recorded as being either “correct” or “incorrect”. Correct performance received one point, while incorrect performance did not. In total, the low demand section was scored out of 151 points, the moderate demand section out of 106 points, and the high demand section out of 161 points, giving a total maximum score of 418 points. The familiarisation section was not scored. A complete description of the scoring criteria is provided in Appendix 6D.

Although the scoring protocol was detailed, there was no cut-off score indicating that a driver had passed or failed the test. As is standard practice for DARS, test failure was based on agreement between the occupational therapist and driving instructor about the safety risk posed by the driver, given the types of errors that they made and the level of active intervention required on the part of the driving instructor to ensure safety during the test (applying brakes, taking hold of the steering wheel, explicit verbal guidance to aid execution of manoeuvres). Errors that posed a greater safety risk, such as speeding, disregarding traffic signals and Stop or Give Way signs, drifting into other lanes, and stopping unexpectedly without reason, were most likely to be associated with failure of the test.

In order to take into account the differential emphasis placed on different error types in determining the overall outcomes of the driving assessments, raw scores for the driving test (out of 418) were not used as an outcome measure for the study. In keeping with the studies by Dobbs et al. (1998), Janke and Eberhard (1998) and Staplin et al. (1998b), in which different weightings were given for different road test errors, a weighted scoring system was developed that assigned different weightings to different errors in order to produce an overall score that more closely matched the outcomes of the assessments (i.e. pass or fail). Errors were classified as either “habitual” (mistakes probably made habitually that are unlikely to place the driver in danger of a crash) or “hazardous” (mistakes with a greater potential for leading to crash involvement). Habitual mistakes included failure to check mirrors or blind spots, failure to indicate, inappropriate lane selection and poor parking ability. Hazardous errors included exceeding the speed limit, inappropriate high speed, unsafe gap selection, unsafe positioning, and disobeying traffic lights. Disobeying a Stop sign was classed as hazardous if the participant drove through the junction in a manner indicative of not noticing the sign, while merely creeping over the Stop line without having come to a complete stop was classed as an habitual error. If the driving instructor felt it necessary for safety reasons to actively intervene (applying brakes, taking hold of the steering wheel, explicit guidance to aid the execution of manoeuvres), then this was recorded as a “driving instructor intervention”. It was decided that the overall score for the driving test would combine these different error types but with weightings determined on the basis of best matching the scores to the pass/fail judgements made by the assessors.

The sensitivity (correctly identified failures), specificity (correctly identifying passes) and diagnostic power (overall percentage correct) were calculated for a number of different combinations of weightings for driving instructor interventions, hazardous errors and habitual errors. For each combination of weighted errors, a cut-off score was chosen to maximise diagnostic power but, in keeping with the suggestion of Janke and Eberhard (1998), it was also decided to try and maximise sensitivity while maintaining very high levels of specificity. Table 6.3 provides a number of equations using weightings of the different error types, and the levels of sensitivity, specificity and diagnostic power associated with the cut-off scores (a score equal to the cut-off was classified as a likely pass). It shows that the best diagnostic power (94%) was achieved with a score using 10 times the driving instructor interventions, plus five times the hazardous errors, plus the habitual errors, and a cut-off score of 199. The sensitivity for this equation and cut-off score was 79% and the specificity was 97%.

Table 6.3
Combinations of error types, cut-off scores, sensitivity, specificity, and diagnostic power for the on-road assessment (N=90)

Equation	Weightings for different error types			Cut-off	Sensitivity	Specificity	Diagnostic Power
	DII	Hazardous	Habitual				
1	1	0	0	2	71	95	91
2	1	0	0	1	93	86	87
3	0	1	0	19	79	95	92
4	2	1	0	20	86	88	88
5	6	3	1	139	79	95	92
6	8	4	1	170	79	95	92
7	10	5	1	199	79	97	94
8	5	5	1	180	79	93	91
9	5	10	1	281	79	92	90

Note. DII = Driving Instructor Interventions

In the studies by Staplin et al. (1998b) and Janke and Eberhard (1998), the weighted error score used was based on three times the number of "critical" errors plus five times the number of "hazardous" errors plus other errors. In these studies, critical errors were errors that would normally lead automatically to test failure, while hazardous errors were a subset of critical errors that were dangerous enough to require intervention from the examiner. These "critical" and "hazardous" errors seem to correspond with the present study's hazardous errors and driving instructor interventions, respectively. This suggests that the present study is consistent with those of Staplin et al. (1998b) and Janke and Eberhard (1998) in terms of the relative weightings of different errors used to determine driving performance scores.

A recent study by DiStefano and MacDonald (2003) looked at the types of errors most predictive of driving test failure among older drivers referred for a licence assessment. They found that driving instructor interventions were most closely associated with the outcome, and that these interventions were most often made during intersection negotiation, to maintain position and speed and to ensure an adequate safety margin during gap selection. The scoring model they developed provided diagnostic power of 94%. Again, these findings fit well with the model developed for the present study, which also emphasised driving instructor interventions and produced a level of diagnostic power of 94%.

6.2.3 Procedure

The recruitment of participants from the general community occurred at information sessions at Senior Citizens and Australian Retired Persons Association clubs, at which the names and telephone numbers of interested people were collected. These people were later contacted by telephone and given more detailed information about the study, allowing an informed choice concerning participation. DARS clients, on the other hand, were told about the study by the DARS administrative officer and the names and telephone numbers of those interested in the study were passed on to the Investigator, who then contacted the clients to provide them with more detailed information about the study and asked them if they wanted to participate.

Participants recruited from the general community completed the various components of the study in a set order. First, they completed the Driver Mobility Questionnaire, which was mailed out to them. Next, they attended an individual session at the University of Adelaide in which they completed the functional tests (i.e. the visual, physical, psychological and neuropsychological tests). Within two weeks following the testing session, they had their driving assessment with DARS. The participants recruited from the pool of DARS referrals also completed the questionnaire prior to the functional test session but the test session could occur within two weeks prior to, or following, their on-road assessment.

Prior to the functional test session, participants were sent a copy of the Driver Mobility Questionnaire, an appointment sheet for their testing session, an information sheet about the study (the general community participants' information sheet is provided in Appendix 6E and the referral participants' information sheet is provided in Appendix 6F), a map showing the location of the testing session at the University of Adelaide, and a taxi voucher to enable travel to and from the University. When the participants arrived for the functional testing session, they gave written informed consent for each component of the study. Both groups (general community and referral) filled in consent forms for the questionnaires and functional tests (same form as for the pilot study - provided in Appendix 5B), and for provision of their driver's licence numbers to allow the checking of official crash records (form provided in Appendix 6G). Participants from the general community also filled in a consent form for undertaking a driving assessment (provided in Appendix 6H) and the referral group filled in a consent form to allow the Investigator to obtain a copy of the results of their driving assessments from DARS (provided in Appendix 6I). Separate consent forms were used so that participants could decide not to participate in certain parts of the study (on-road test, provision of licence number) if they wished. A driver's licence number was not provided by 4.8% of the sample, while 11.8% of the general community group decided not to perform the on-road test. After completing the consent forms, participants were asked if they had had any problems with the questionnaire and, if so, the investigator discussed these problems, and ensured that the participants understood the questions and had answered all items.

The functional tests were also administered in a set order. After recording the participant's age, sex, years of education, and driver's licence number (for those who consented), the testing session began with the participant completing pen and paper versions of the Geriatric Depression Scale and State Trait Anxiety Inventory. Next, the Modified Mini Mental State Examination was administered. Vision was tested next, using the Snellen Static Visual Acuity chart, the Pelli-Robson Contrast Sensitivity Test, and the simple test of visual field.

Next, the Computerised Visual Attention Test (CVAT) was explained and demonstrated to the participant, who was given practice on each component of the test. After completing all of the practice trials, the participant completed the first subtest. The remaining non-computer administered functional tests were interpolated between the CVAT subtests to ensure that participants did not have to spend more than five consecutive minutes looking at the computer screen.

After the first CVAT subtest[3], participants completed the Wechsler Test of Adult Reading. This was followed by the second CVAT subtest, which was, in turn, followed by the Digit Symbol Modalities Test, with the written version first and the oral version second. The third CVAT subtest was next, followed by measurement of neck mobility with a goniometer. After the measurement of neck mobility, participants performed the fourth CVAT subtest. Finally, the participant undertook the Spatial Span Test and finished with the fifth CVAT subtest.

---

[3] *NB*: The order of presentation of the CVAT subtests varied between participants (refer to section 6.2.2.2).

All functional test sessions were conducted by the same researcher and in the same office at the Centre for Automotive Safety Research, the University of Adelaide. The sessions were conducted on week days and began at either 10am or 2pm. The sessions usually took approximately two hours. Participants were informed before they began that, at the end of any test, they were permitted to take a break before starting the next test.

At the conclusion of the functional testing session, all materials required for the driving assessment by participants recruited from the general community were provided (i.e. another appointment sheet, another map showing the location of DARS in the University of South Australia, and taxi vouchers for travel to and from the driving assessment). For the referral group, all arrangements regarding the driving assessment were left solely to DARS.

All participants were paid $25 for completing the questionnaires and the functional testing session. Participants recruited from the general community were paid an additional $25 for undertaking a driving assessment. Participants referred to DARS for an assessment were not paid for their driving test as they were obliged to have a test, regardless of the study. The cost of the driving assessment for participants from the general community ($165) was paid using study funds, but those referred for an assessment had to meet the cost themselves.

For the general community participants, feedback on the driving assessment was given by the occupational therapist immediately following the test. Drivers recruited from the general community who failed the on-road test did not have their licence cancelled. Instead, a letter was sent to their general practitioner who would decide what, if any, action was required. For both groups of participants, general feedback regarding performance on the functional tests was given over the telephone by the investigator.

6.3 Study Two: Validation of the Computerised Visual Attention Test

6.3.1 Participants

A subset of 20 participants (6 males, 14 females) from the larger study on older driver self-regulation was recruited for the validation study. These 20 participants were all from the general community and recruited through Senior Citizens Clubs and Australian Retired Persons Association clubs in metropolitan Adelaide. They ranged in age from 60 to 85, with a mean of 73.8 (SD = 6.5). The number of years of formal education for the sample ranged from seven to 21, with a mean of 11.0 (SD = 3.3). Their IQs, estimated from scores on the Wechsler Test of Adult Reading (Wechsler, 2001), ranged from 87 to 125, with a mean of 109.2 (SD = 11.7).[4]

6.3.2 Materials

In addition to the CVAT developed for the self-regulation study, the participants also completed the state anxiety section of the State-Trait Anxiety Inventory (refer to section 6.2.2.2) for a second time. This was done to ensure that test-retest reliability was not affected by differences in state anxiety between the two testing sessions. Participants also completed four other tests that are purported to measure attention. These were as follows:

Paced Auditory Serial-Addition Task (Gronwall, 1977). This test assesses rate of information processing, and sustained and divided attention. A pre-recorded tape delivers a series of 61 single digit numbers (1 to 9). The participant must add each number to the one preceding it on the tape, so that the second number is added to the first, the third is added to the second, and so on. Responses are verbal. There are four different lists presented at four different rates of presentation: a number every 2.4s, 2.0s, 1.6s and 1.2s. The order of the lists is always the same, progressing from the slowest to

[4] Independent samples t tests were used to assess whether the sub-sample of participants involved in the validation study were different from the participants who were not. There were no differences between the two groups in terms of age, years of education or estimated IQ.

the fastest rate of presentation. The scores for each list are the number of correct additions out of a total of 60. For the purposes of minimising the number of scores to be analysed in the study, the four PASAT scores were averaged to produce an overall score for the test. The PASAT takes approximately 15 minutes to administer.

Ruff 2 and 7 Selective Attention Test (Ruff, Evans, & Light, 1986; Ruff, Niemann, & Allen, 1992). This is a paper and pencil measure of selective attention in which participants must cross out "2"s and "7"s (targets) embedded randomly in rows of either letters of the alphabet or other digits (distracters). The stimuli are arranged in 20 blocks of three rows, with 50 stimuli (targets and distracters) in each row. Participants are allowed 15s for each block, giving a total time of five minutes to complete the test. Scores for each block are the number of hits (correctly crossed out targets), and the number of omissions (missed targets) and commissions (incorrectly crossed out distracters). Scores are summed separately for the 10 blocks featuring letters as distracters and the 10 blocks featuring digits as distracters. For the purposes of the study, overall scores for the two conditions (letters or numbers as distracters) were calculated by subtracting the number of omissions and commissions from the number of hits. A similar test to this has been found previously to be related to the crash involvement (Marottoli et al., 1998) and driving performance (Richardson & Marottoli, 2003) of older drivers.

Delis-Kaplan Executive Functioning System Colour-Word Interference Test (Delis, Kaplan, & Kramer, 2001). This is a measure of selective attention and cognitive flexibility based on a test that was first developed by Stroop (1935). For the present study, only conditions 3 and 4 were administered. In condition 3 (inhibition) participants must name the colour of the ink that a series of words are printed in, with the words being the names of colours that conflict with the ink colour. For example, the word "blue" written in green ink requires the answer, "green". This condition, therefore, requires the participant to inhibit the tendency to read the word. In condition 4 (switching), half of the words have boxes drawn around them and, for these words, participants must read the word itself, ignoring the ink colour. For the words without boxes, participants must respond with the ink colour, as in condition 3. This condition, therefore, requires the participant to switch between response categories. Both conditions have a time limit of 180s. Raw scores are the time taken to give all 50 answers, the number of uncorrected errors, and the number of self-corrected errors for each condition. For this study, only the time taken in each condition was used in the analyses. The test takes approximately ten minutes to administer. Variations of this test have previously been found to be related to crash involvement (Daigneault et al., 2002a) and driving performance (Clark et al., 2000) among older drivers.

Delis-Kaplan Executive Functioning System Trail Making Test (Delis et al., 2001). This test, based on a test first developed by Partington (1949), combines selective attention, sequencing, mental flexibility, visual search, and motor function. The Delis-Kaplan version includes five conditions, three of which (conditions 2, 3 and 4) were used in this study. All conditions involve encircled numbers and/or letters randomly arranged on a large piece of paper. In condition 2, participants must draw pencil lines connecting 16 numbers in ascending order. In condition 3, they must connect 16 letters in alphabetical order, while in condition 4, they must alternate between ascending numbers and alphabetically ordered letters. That is, they must connect 1 to A to 2 to B, and so on, until finishing with connection of 16 to P. When an error is made in any subtest, the examiner points out the error and asks the participant to correct it before proceeding. For conditions 2 and 3, a maximum time of 150s is given to complete the test, while for condition 4, the time limit is 240s. Scores for each subtest of the Trail Making Test are the number of errors made, and time taken for completion. In this study, only the raw scores for test completion time were used in all analyses. The test takes approximately ten minutes to administer. Performance on variations of this test have previously been found to be related to crash involvement (Lundberg et al., 1998; Stutts et al., 1998) and driving performance (Clark et al., 2000; Cushman, 1996; Janke, 2001) among older drivers.

6.3.3 Procedure

After participants completed the laboratory testing session for the self-regulation study, they were provided with an information sheet concerning the CVAT validation study (provided in Appendix 6J). After participants had completed the driving test, they were contacted by telephone and asked if they were willing to be involved in the validation study. Those who were willing received an appointment sheet, map of the University, and taxi vouchers in the mail. The second testing session was organised so that it was one month after the first test session for each participant. Recruitment continued until a sample of 20 participants had agreed to take part in the validation study.

Upon arrival for the validation study testing session, participants were required to fill in a form giving their informed consent for participation (provided in Appendix 6K). Next, they were asked to complete the state anxiety section of the State-Trait Anxiety Inventory. This was followed by the first of the five CVAT subsets. The test was explained and practice given in exactly the same manner as when the participants undertook the test in the testing session for the self-regulation study. Also, the order of the different subtests for each participant was the same as in the previous session.

Following the first subtest of the CVAT, participants performed the remaining tests in the following order: Paced Auditory Serial Addition Task, second subtest of the CVAT, Ruff 2 and 7 Selective Attention Test, third subtest of the CVAT, D-KEFS Colour-Word Interference Test, fourth subtest of the CVAT, Trail Making Test, fifth subtest of the CVAT.

Consistent with the self-regulation study, all test sessions were conducted by the same researcher and in the same office at the Centre for Automotive Safety Research, at the University of Adelaide. The sessions were conducted on week days and began at either 10am or 2pm. The sessions took approximately ninety minutes. Participants were informed before testing began that, at the end of any test, they were permitted to take a break before starting the next test. At the end of the session, participants were given a taxi voucher for travel home and $25 for completion of the testing. They were contacted later by telephone and given general feedback concerning their performance.

CHAPTER 7: VALIDATION STUDY FOR THE COMPUTERISED VISUAL ATTENTION TEST

7.1 Introduction

In order to examine the relationship between functional abilities and the self-regulatory practices of older drivers, a test was developed to measure visual attention: the Computerised Visual Attention Test (CVAT). As part of the process of developing and using a new test, it is necessary to assess the test's reliability and validity. To this end, a study was conducted in which participants completed the CVAT for a second time, enabling an assessment of test-retest reliability. Participants also completed a number of standard tests of attention and, by examining the relationships between the newly developed CVAT and the established measures of attention, it was possible to assess the construct validity of the CVAT. Finally, the predictive validity of the CVAT was assessed by examining its relationship with on-road driving ability. Details of the methods used for this study were provided in section 6.3.

7.2 Statistical Analyses

Test-retest reliability was assessed by calculating Pearson's Product Moment Correlation coefficients between test scores in the first and second test sessions. Construct validity was evaluated by calculating Pearson's correlations between scores on the CVAT and the established tests purported to measure attention. Finally, predictive validity was assessed by examining correlations between the weighted error score on the driving test (see section 6.2.2.3) and both the CVAT and the established attention tests. For all tests, statistical significance was accorded any test result with $p<.05$. With a sample of 20 participants, only correlations of .45 or greater reach statistical significance. This meant that only high-moderate to strong correlations (Cohen, 1992) were identified as significant. All statistical analyses were conducted using SPSS 10 for Macintosh software.

7.3 Results

7.3.1 Descriptive Statistics

State anxiety was measured in the validation testing session using the State-Trait Anxiety Inventory (Speilberger, 1983), described in section 6.2.2.2. The means were 29.8 (*SD* = 8.6) for the first session (self-regulation study test session) and 30.9 (*SD* = 10.5) for the second (validation study test session). These means were not found to differ significantly ($t_{(19)} = -.72$, $p = .483$), indicating that there were no differences in state anxiety that could affect results on the two separate administrations of the CVAT. Table 7.1 shows the descriptive statistics for the standard attention tests, which were only administered once. The mean score for the PASAT was slightly below those of the oldest age group (50 to 69) in the published norms of Stuss, Stethem and Pelchat (Stuss, Stethem, & Pelchat), which is likely to be due to an older participant age range in this study. Similarly, mean scores for the Ruff 2s and 7s Selective Attention Test were slightly below average compared to the norms for those aged 55 to 70 (Ruff et al., 1986). All scores for the Colour Word Interference Test and the Trail Making Test were slightly above average for adults aged between 60 and 79, except for Trails Switching, which was in the average range (Delis et al., 2001).

Table 7.2 shows statistics for reaction time scores on the visual attention test for the two separate testing sessions. The pattern of means and standard deviations for CVAT reaction time scores were similar across the two sessions, although reaction times tended to be slightly shorter in the second session.

Table 7.1
Means and standard deviations for standard attention tests

Test measure	Mean	Standard deviation
PASAT	30.0	9.1
Ruff 2 and 7s Selective Attention Test		
Digit-Digit	103.9	20.8
Digit-Letter	100.0	25.6
Colour-Word Interference Test		
Inhibition, time	67.3	14.5
Switching time	69.5	16.1
Trail Making Test		
Numbers, time	43.7	14.9
Letters, time	48.5	19.3
Switching, time	118.8	48.1

Note. PASAT = Paced Auditory Serial Addition Test

Table 7.2
Descriptive statistics for median reaction times on the CVAT in the two testing sessions

CVAT tasks	First session		Second session	
	Mean (ms)	*SD*	Mean (ms)	*SD*
Single task				
Primary	433.8	38.5	434.8	36.4
Secondary, no visual distracters	430.5	52.9	424.8	50.1
Secondary, visual distracters	558.3	76.8	544.3	93.4
Dual Task				
Primary, no visual distracters on secondary	476.5	41.4	462.8	39.2
Secondary, no visual distracters	484.0	67.0	473.0	64.5
Primary, visual distracters on secondary	490.5	31.7	477.5	39.3
Secondary, visual distracters	627.8	112.0	591.5	100.7

Note. CVAT = Computerised Visual Attention Test

Table 7.3 shows statistics for target detection performance for the two separate sessions. The detection error percentages demonstrate a noticeable reduction in the second testing session compared to the first.

As indicated in section 6.2.2.3, performance on the driving test was measures using a weighted error score based on the following equation:

10 (driving instructor interventions) + 5 (hazardous errors) + habitutal errors

For the 20 participants in the CVAT validation study, the mean score on the driving test was 129.5 (*SD* = 57.8). Performance on the driving test was used as an outcome measure for assessment of the CVAT's predictive validity.

Table 7.3
Descriptive statistics for detection errors on the CVAT in the two testing sessions

CVAT tasks	First session		Second session	
	Mean	*SD*	Mean	*SD*
Single task				
Primary	0.5	1.2	0.0	0.0
Secondary, no visual distracters	0.2	0.8	0.2	0.8
Secondary, visual distracters	2.1	4.2	0.6	1.4
Dual Task				
Primary, no visual distracters on secondary	3.1	4.8	0.8	1.3
Secondary, no visual distracters	0.9	2.7	0.6	1.8
Primary, visual distracters on secondary	6.4	7.3	3.7	5.6
Secondary, visual distracters	7.4	11.8	2.9	4.6

Note. CVAT = Computerised Visual Attention Test

7.3.2 Test-Retest Reliability

In order to assess the test-retest reliability of the CVAT, Pearson's product-moment correlations were calculated between scores on the CVAT in the first and second testing sessions. The test-retest correlations for the median reaction time scores and detection errors are shown in Table 7.4. It can be seen that five of the seven test-retest correlations for the reaction time measures of the CVAT were .80 or more, indicating good reliability. The only measure with a reliability of less than 0.7 was reaction time on the secondary task in the single task condition, without visual distracters, which had a test-retest correlation of .63.

Table 7.4

Test-retest correlations for median reaction times and detection errors on the CVAT

CVAT tasks	Median reaction time	Target detection error
Single task		
Primary	.82**	-
Secondary, no visual distracters	.63**	-.05
Secondary, visual distracters	.81**	-.09
Dual Task		
Primary, no visual distracters on secondary	.74**	.58**
Secondary, no visual distracters	.80**	.79**
Primary, visual distracters on secondary	.80**	.80**
Secondary, visual distracters	.82**	.60**

Note. CVAT = Computerised Visual Attention Test
* $p < .05$, ** $p < .01$

Few of the detection error percentages had test-retest correlations as strong as those for the median reaction time scores. Detection errors on the primary task in the dual task condition featuring visual distracters and on the secondary task in the dual task condition without visual distracters were the only measures with test-retest correlations of approximately .80. Correlations for the secondary task in the single task conditions were very low and no participants failed to detect an X (primary task) in the single task condition in the second test session, making the calculation of a correlation impossible.

7.3.3 Construct Validity

Pearson's product-moment correlations between the CVAT and the standard tests of attention were calculated in order to assess the construct validity of the CVAT. This was done for all of the CVAT median reaction time scores and the target detection error scores from the dual task CVAT subtests, using scores from the first test session. The detection error scores from the single task subtests were not used due to low reliability.

An inter-correlation matrix for the reaction time scores and standard attention tests is provided in Table 7.5. There were only two significant correlations with the established tests of attention. Secondary task reaction times in the dual task condition with visual distracters was correlated with the Ruff 2 and 7s Selective Attention scores for both detection of targets among the letters and among the digits. The negative correlation means that poorer performance on the CVAT (longer reaction time) was associated with poorer performance on the Ruff test (fewer targets detected).

There were more significant correlations between established tests of attention and the detection errors on the CVAT (see Table 7.6 for a complete inter-correlation matrix). There were four significant correlations with detection errors on the primary task in the dual task condition without visual distracters on the secondary task. These were with the Ruff test for detection of targets, both among the letters and among the digits; time on the Trails switching task; and time on the Colour Word inhibition task. There were two significant correlations with detection errors for the primary task in the dual task condition with visual distracters on the secondary task. These were with the Ruff test for detection of targets among the letters, and among the digits.

Table 7.5
Inter-correlation matrix for the CVAT reaction time scores and standard tests of attention

	CVAT reaction times						
Attention Tests	Prim only	Sec only, no distract	Sec only, distract	Prim, dual, no distract	Sec, dual, no distract	Prim, dual, distract	Sec, dual, distract
PASAT	-.02	.25	-.04	.21	.10	.03	-.10
Ruff D-D	-.08	-.20	-.43	-.36	-.22	-.40	-.55*
Ruff D-L	-.03	-.03	-.30	-.10	-.25	-.32	-.65*
CW Inhib	.20	.21	.33	.27	.17	.28	.34
CW Swit	.02	.11	.19	.27	.10	.11	.25
Trails Num	-.24	-.09	-.06	-.12	-.04	-.08	.11
Trails Let	.13	.25	.02	.11	-.06	-.03	.01
Trails Swit	-.22	-.15	-.12	.10	-.23	-.01	.05

Note. CVAT = Computerised Visual Attention Test; Prim = primary task; Sec = Secondary task; distract = visual distracters; dual = dual task; PASAT = Paced Auditory Serial Addition Test; Ruff D-D = Ruff 2s and 7s Selective Attention Test, digits condition; Ruff D-L = Ruff 2s and 7s Selective Attention Test, letters condition; CW Inhib = Colour Word Interference Test, inhibition condition; CW Swit = Colour Word Interference Test, switching condition; Trials Num = Trail Making Test, Number Sequencing; Trails Let = Trail Making Test, Letter Sequencing; Trails Swit = Trail Making Test, Switching condition
* $p < .05$

Table 7.6

Inter-correlation matrix for the CVAT detection error scores and standard tests of attention

	CVAT detection errors			
Attention Tests	Prim, dual, no distract	Sec, dual, no distract	Prim, dual, distract	Sec, dual, distract
PASAT	-.42	.38	-.30	-.04
Ruff D-D	-.50*	-.16	-.46*	-.34
Ruff D-L	-.52*	-.09	-.48*	-.36
CW Inhib	.46*	.19	.25	.36
CW Swit	.35	.15	.25	.19
Trails Num	.12	-.03	.05	.04
Trails Let	-.02	-.12	-.22	.09
Trails Swit	.56*	-.19	.39	.00

Note. CVAT = Computerised Visual Attention Test; Prim = primary task; Sec = Secondary task; distract = visual distracters; dual = dual task; PASAT = Paced Auditory Serial Addition Test; Ruff D-D = Ruff 2s and 7s Selective Attention Test, digits condition; Ruff D-L = Ruff 2s and 7s Selective Attention Test, letters condition; CW Inhib = Colour Word Interference Test, inhibition condition; CW Swit = Colour Word Interference Test, switching condition; Trials Num = Trail Making Test, Number Sequencing; Trails Let = Trail Making Test, Letter Sequencing; Trails Swit = Trail Making Test, Switching condition

* $p < .05$

7.3.4 Predictive Validity

If the CVAT is to be useful in studies of older drivers, then it needs to be a better predictor of driving ability than other existing measures of attention (to have better "predictive validity" for measures of driving performance). To assess this, Pearson's product-moment correlations were calculated between all of the attention measures, including the CVAT, and the weighted error score on the driving test. These correlations are shown in Tables 7.7 (for CVAT measures) and 7.8 (for the standard attention tests). Correlations were not calculated for target detection in the single task CVAT subtests because of low reliability.

Among the reaction time scores, significant correlations with driving performance were found for the secondary task in the single task condition with visual distracters, the secondary task in the dual task condition without visual distracters, and the secondary task in the dual task conditions with visual distracters. Among the detection error scores, a significant correlation with driving performance was found for the secondary task in the dual task condition with visual distracters. For the established tests of attention, there was only one significant correlation with driving performance, that for Trail Making, Number Sequencing. These results suggest better predictive validity, with regard to driving performance, for the CVAT than for the established tests of attention.

Table 7.7

Correlations between driving performance and median reaction times and detection errors on the CVAT

CVAT tasks	Correlation with driving performance	
	Median reaction time	Target detection error
Single task		
Primary	.32	
Secondary, no visual distracters	.39	
Secondary, visual distracters	.52*	
Dual Task		
Primary, no visual distracters on secondary	.14	.41
Secondary, no visual distracters	.64**	.32
Primary, visual distracters on secondary	.24	.09
Secondary, visual distracters	.51*	.50*

Note. CVAT = Computerised Visual Attention Test

* $p < .05$, ** $p < .01$

Table 7.8

Correlations between driving performance and standard attention tests

Test measure	Correlation with driving performance
PASAT	-.18
Ruff 2 and 7s Selective Attention Test	
Digit-Digit	-.23
Digit-Letter	-.24
Colour-Word Interference Test	
Inhibition, time	.30
Switching time	.34
Trail Making Test	
Numbers, time	.46*
Letters, time	.13
Switching, time	.15

Note. PASAT = Paced Auditory Serial Addition Test

* $p < .05$

7.4 Discussion

In order to assess the test-retest reliability of the Computerised Visual Attention Test (CVAT), a small sample of older adults were asked to complete the test a second time, one month after they first completed it. The test-retest correlations for the CVAT were generally better for the reaction time scores (around .80) than for the detection error scores. Two of the latter measures had test-retest correlations of approximately .80, two had correlations of approximately .60 and the remaining three (all single task conditions) were not significantly different from zero.

These lower test-retest correlations for the detection scores could be due to a high number of participants detecting 100% of the targets. For secondary task target detection in the single task condition without visual distracters, all of the cars were detected by 19 out of 20 participants in both sessions. For secondary task target detection in the single task condition featuring visual distracters, 14 out of 20 participants detected all the targets in the first session and 17 out of 20 detected them all in the second session. The detection of all targets by the majority of participants led to restricted ranges of scores for these variables, which, in turn, may have affected the correlational analyses. The target detection score with the highest test-retest correlation was for the primary task in the dual task condition featuring distracters on the secondary task, a task for which all of the targets were detected by only four participants in the first session and two participants in the second session.

Improved target detection in the second session is likely to be due, in part, to practice effects. Practice effects were also apparent for the reaction time tasks but were not as large as those for the detection error scores. Importantly, the pattern of means for the reaction time scores stayed the same over the two sessions. That is, in both test sessions, reaction times increased in the dual task conditions (divided attention effect) and in the presence of visual distracters (selective attention effect).

Another reason for the excellent target detection by most participants was the use of a sample of healthy, community-dwelling adults. It could be that a better indication of the test-retest reliability of the detection error scores could be obtained by repeating the study using a larger sample of older adults affected by various impairments (e.g. visual, cognitive) who would be more likely to miss a greater percentage of the targets.

In order to assess the construct validity of the CVAT, correlations between this and other accepted measures of attention were examined. It was found that detection error scores showed better correlations with the other attention measures than did reaction time scores. This may indicate that the detection of targets is more closely related to pure attentional ability than reaction time, for which speed of information processing may be a major component.

The only established test of attention with which the CVAT was well correlated was the Ruff 2 and 7s Selective Attention Test, especially for reaction times to cars embedded within visual distracters. This suggests a common requirement for selective attention. In contrast, the established test of divided attention, the PASAT, did not correlate with any of the CVAT measures.

The low number of significant relationships between the CVAT and the Trail Making Test, Colour Word Interference Test and PASAT could be due to "attention" being a multi-faceted ability. The CVAT could be measuring other aspects of attention not measured by these other attention tests. It is also likely that the CVAT and the established tests of attention are not pure measures of attention but also measures of non-attentional abilities. If there are considerable differences between the tests in terms of the non-attentional abilities they measure, then there is a limit to the extent that they are likely to share common variance. As noted, the reaction time component of the CVAT requires good speed of information processing. The PASAT would also assess mathematical ability, an ability not required by the CVAT. The two tests taken from the Dellis-Kaplan Executive Functioning System (Colour Word Interference and Trail Making) are both purported to measure selective attention but would also be expected to make large demands on executive functioning capabilities.

It also needs to be borne in mind that the reliability of a test places a limit on any correlations calculated between that test and any other measure. Thus, correlations between the CVAT and the established tests of attention have, as an upper limit, not 1.0 but the square root of their reliability (Carmines & Zeller, 1979). This means that, for the seven reaction time scores on the CVAT, the maximum correlations possible with the established tests of attention ranged between .80 and .90. For the four detection error scores in the dual task conditions (ignoring the detection error scores in the single task conditions for which the reliability coefficients were not significantly different from zero), the maximum correlations possible with other measures ranged from .76 to .89.

Upper limits on correlations caused by less than perfect reliability would also apply to the established tests of attention. For the Ruff 2s and 7s Test, with which the CVAT shared the most significant correlations, test-retest reliability coefficients have been found to range from .84 to .97 (Spreen & Strauss, 1997), giving high upper limits for correlations with other measures ranging from .92 to .98. Similarly, the PASAT has high test-retest reliability coefficients of over .9 (Spreen & Strauss, 1997). However, for the Trail Making Test, the test-retest reliability coefficients among those aged between 50 and 89 were .37 (number sequencing), .70 (letter sequencing) and .55 (switching) (Delis et al., 2001), giving low upper limits for correlations of .61, .84 and .74, respectively. Similarly, the test-retest reliability coefficients among those aged 50 to 89 for the Colour Word Interference Test were .50 for the inhibition condition and .57 for the switching condition (Delis et al., 2001), giving upper limits for correlations of only .71 and .75, respectively. These restrictions on the upper limits of correlations with other variables could also have contributed to the low number of significant correlations between the CVAT and the established tests of attention, especially for the Trail Making and Colour Word Interference tests.

Although the construct validity of the CVAT was unable to be firmly established, it was still important to assess the degree to which the test could predict driving test performance compared to the established tests of attention. It was found that three reaction time scores and one detection error score were significantly correlated with the weighted error score on the driving test. Of the eight scores from the established tests of attention, only one (Trail Making Number Sequencing) was significantly correlated with driving test performance. This suggests that the CVAT is more useful than established tests of attention for predicting driving ability.

It is important to note that this study included only a small sample of 20 participants, which meant that Pearson's correlation coefficients had to reach .45 before being statistically significant. This study was therefore only able to detect large effect sizes. However, a stringent criterion is appropriate for the assessment of reliability and validity and reliability, for which it is important to have this magnitude or greater.

The overall conclusion from the validation study is that the reaction time scores of the Computerised Visual Attention Test (CVAT) show good reliability but that a number of detection error scores (those for the single task conditions) were not shown to be reliable for healthy older adults. The construct validity has not been established, except that the task of detecting targets (cars) in the presence of visual distracters is related to selective attention, as intended. Further validation of the test in the future may require comparison to more complex, computer-administered tasks of divided attention and speed of information processing, such as the Useful Field of View test (Owsley et al., 1998), and use of samples of older adults with a broader range of abilities (e.g. visual, cognitive). The CVAT has, however, been shown to be a better predictor of driving ability than established tests of attention previously linked to driving test performance measures. The overall conclusions, therefore, are that the CVAT is a reliable measure of abilities including, but not restricted to, attention, and that the CVAT is correlated with driving ability. On the basis of these findings, the CVAT appears to be an appropriate functional measure for use in a study of older driver self-regulation.

CHAPTER 8: THE RELATIONSHIP BETWEEN HEALTH, FUNCTIONAL AND DRIVING MEASURES

8.1 Introduction

This chapter examines the relationships between health and functional measures and on-road driving performance. First, there is an examination of the relationships between these variables and age, in order to determine if increasing age was associated with poorer health, poorer functional abilities and deficits in driving ability. If poorer driving performance was found to be related to increasing age, then the relationships between driving performance and the health and functional measures would need to be shown to be independent of age. The relationships between the health and functional measures and driving performance are then examined and the measures most predictive of driving performance are identified. These findings are then compared to those of other studies that have examined these relationships.

The findings in this chapter are used in analyses presented in a later chapter (Chapter 11) comparing the health and functional measures related to driving performance with the health and functional measures related to the avoidance of difficult driving situations (self-regulation). If the two sets of measures are similar, then that would suggest that older drivers are limiting their driving in response to declines in the health factors and functional abilities that are related to driving difficulties. This, in turn, would suggest that older drivers are able to practise self-regulation in a manner that limits safety risks without unduly restricting mobility.

As discussed in section 3.2, there is a relationship between crash involvement or poorer driving ability and a number of medical conditions, including cataract (e.g. Owsley et al., 1999), glaucoma (e.g. Wood, 2002b), dementia (e.g. Cooper et al., 1993b), cerebrovascular accidents (e.g. Sims et al., 2000), diabetes mellitus (e.g.

Vernon et al., 2002), epilepsy (e.g. Hansotia & Broste, 1991) and various medications (anti-depressants, benzodiazepines, analgesics, hypnotics, antipsychotics, antihypertensives, non-steroidal anti-inflammatory drugs, anticoagulants and hypoglycaemics) (e.g. Ray, Gurwitz et al., 1992). Concerns have also been expressed about the effects of multiple medical conditions on the driving capabilities of older drivers (e.g. Marottoli, 2002).

Various functional measures have also been related to on-road driving ability or crash involvement. These have included visual acuity (e.g. Vernon et al., 2002), contrast sensitivity (e.g. Wood, 2002a), visual field (e.g. Johnson & Keltner, 1983), head and neck flexibility (e.g. Marottoli et al., 1998), mental status (e.g. Clark et al., 2000), speed of information processing (e.g. Janke, 2001), spatial memory (e.g. Lundberg et al., 1998), and visual attention (e.g. De Raedt & Ponjaert-Kristoffersen, 2001). The present study included measures of all of these abilities, enabling identification of the strongest predictors of driving ability.

Given the previous findings of significant relationships for health and functional measures with either crash involvement or on-road driving ability, it was hypothesised that the health and functional measures examined in the present study would be significantly correlated with performance on the on-road driving test. Specifically, it was predicted that a greater level of medical complaints (worse "general health") and greater medication use, especially use of medications potentially hazardous for driving, would both be associated with poorer driving test performance. It was also hypothesised that poorer functioning (in terms of mood, physical functioning, vision, mental status, speed of information processing, spatial memory and visual attention) would be associated with poorer driving test performance. Additionally, it was predicted that worse health and poorer functioning would be associated with poorer driving test performance independently of age. An analysis identifying the best predictors of driving test performance was also conducted, using a linear regression procedure.

The health and functional measures used in this study were: self-reported general health (based on self-reported medical conditions and the extent to which these conditions affect daily functioning), self-reported prescription medication use, use of medications potentially hazardous to driving, depressed mood, state anxiety, trait anxiety, neck mobility, visual acuity (left eye, right eye, binocular), contrast sensitivity (left eye, right eye, binocular), visual field (left, right, total), mental status, speed of information processing, spatial memory, and visual attention (reaction time and detection errors on the CVAT). Driving ability was measured using the weighted error score on the driving test. Full details for all of these measures are provided in Chapter 6.

8.2 Analyses

The relationships between variables were assessed using Pearson's Product Moment Correlations. Hierarchical regression analyses were used to test the strength of the significant relationships between driving performance and health and functional measures after controlling for age. All correlational analyses used an alpha level of .01 rather than the conventional .05, in order to guard against the increased likelihood of Type I errors resulting from multiple comparisons. This conservative alpha level was chosen ahead of using the Bonferroni method of correcting for multiple comparisons because the former allows for a consistent alpha level across the entire thesis rather than a different one for each set of analyses, and also because it has been argued that the Bonferroni method is too conservative when the number of comparisons gets too large (Jaccard & Wan, 1996). The size of correlations was also evaluated according to Cohen's (1992) effect size classifications. According to this system of classification, correlations of between .1 and .3 are “small” (accounting for between 1 and 9% of the variance), those between .3 and .5 are “medium-sized”(between 9 and 25% of the variance) and those over .5 are “large”(over 25% of the variance). The exploratory analysis to identify the best predictors of driving ability was conducted using a linear regression procedure, with a stepwise method of entry and the conventional entry criterion of alpha = .05. Only those variables found to be significantly correlated with driving test performance at the level of $p < .01$ were used in the regression analysis.

8.3 Results

8.3.1 Descriptive Statistics For Health/Functional Measures

8.3.1.1 Health Measures

The first part of the Driver Mobility Questionnaire asked participants to answer questions about specific medical conditions they might have had and to list any conditions they had that were not included in the questionnaire. It can be seen in Table 8.1 that over 83% of participants had at least one medical condition but few (less than 13%) had more than three. Participants were also asked to indicate, on a three point scale, the degree to which their medical conditions affected their daily functioning, in order to create a variable that took into account the severity of the conditions. When a variable was calculated that took these severity ratings into account, it ranged from zero to 12, with a mean of 2.57 and a standard deviation of 2.03. This suggests that the drivers in the sample were not strongly affected by the medical conditions they reported having. This variable (“general health”) was used as an index of the degree to which the participants were affected by medical complaints.

Table 8.1
Number of medical conditions reported by participants (N = 104)

Number of conditions	Number of participants	Percentage
0	17	16.3
1	23	22.1
2	25	24.0
3	26	25.0
4	9	8.7
5	3	2.9
6	1	1.0
Total	104	100.0

The prevalence of specific medical conditions is provided in Table 8.2. For each medical condition, the table includes details about the number of participants who reported having it and the extent to which it affected their daily functioning. Despite not being included in the questionnaire, hypertension is included in the table because it was frequently mentioned by participants under "other medical conditions". The medical conditions most reported by participants were arthritis, hypertension and heart disease, with arthritis the condition most likely to have been affecting participants' daily functioning. Only one participant reported that any medical condition affected their daily functioning "a lot".

Table 8.2
Self-reported medical conditions and impact on daily functioning (N = 104)

Medical condition	Have the condition (%)	Functioning unaffected (%)	Functioning affected a bit (%)	Functioning affected a lot (%)
Glaucoma	7.7	5.8	1.9	-
Cataract	11.5	8.7	2.9	-
Macular degeneration	0.0	-	-	-
Diabetic retinopathy	0.0	-	-	-
TIA/Stroke[a]	10.6	8.7	1.9	-
Heart disease	15.4	13.5	1.9	-
Arrhythmia	9.6	8.7	1.0	-
Cancer	4.8	4.8	-	-
Arthritis	45.2	21.2	23.1	1.0
Alzheimer's Disease	1.0	1.0	-	-
Parkinson's Disease	1.0	-	1.0	-
Epilepsy	0.0	-	-	-
Diabetes	9.6	8.7	1.0	-
Sleep apnoea	2.9	1.9	1.0	-
Hypertension	30.8	30.8	-	-

[a] TIAs and strokes not suffered in the last year, as a recent stroke was an exclusion criterion

Participants were also asked to provide details of any prescription medications they took at least once a month. The number of medications used by participants is summarised in Table 8.3, where it can be seen that over 60% of participants reported using at least one prescription medication each month.

Table 8.3
Number of medications used at least once a month by participants (N = 104)

Number of medications	Number of participants	Percentage of participants
0	41	39.4
1	19	18.3
2	13	12.5
3	7	6.7
4	14	13.5
5	8	7.7
6	1	1.0
7	1	1.0
Total	104	100.0

The types of medications and the number of users are summarised in Table 8.4. Most of the medications are described in terms of the conditions they are designed to treat (e.g. "Hypertension"). The types of medication most commonly used by the participants were treatments for hypertension, followed by those used to treat heart problems and high cholesterol.

Table 8.4
Types of medications and number of users (N = 104)

Medication Type	Number of Participants	Percentage of Participants
Hypertension	28	26.9
Heart problems	15	14.4
Cholesterol	15	14.4
Arthritis	14	13.5
Calcium deficiency	13	12.5
Acid reflux/ulcer	12	11.5
Thyroid	9	8.7
Depression	6	5.8
Blood thinner	6	5.8
Diabetes	6	5.8
Hormone replacement	4	3.8
Asthma	3	2.9
Gout	3	2.9
Other	10	9.6

Given that many medications would have no effect on driving at all, the medications listed by participants were categorised according to whether they could potentially have a negative effect on driving (refer to section 6.2.2.1 for how this was done). Table 8.5 shows that the majority of participants did not regularly use a medication that could negatively affect driving. Furthermore, the majority (30 of 44) who did use a medication that could affect driving used only one.

Table 8.5
Number of medications potentially affecting driving that were used regularly by participants (N = 104)

Number of medications	Number of participants	Percentage of participants
0	60	57.7
1	30	28.8
2	6	5.8
3	7	6.7
4	1	1.0
Total	104	100.0

The types of medications categorised as potentially affecting driving and the number of cases of their use are shown in Table 8.6. Note that where one participant uses more than one medication to treat the same problem, each of these medications is included in the table as a separate case of its use, meaning that the number of cases of use of a medication in Table 8.6 may exceed the number of participants taking a medication for that condition reported in Table 8.4. Among the medications potentially affecting driving, the most common were those used to treat hypertension, heart problems, acid reflux or ulcers, and depression.

8.3.1.2 Functional Measures

Descriptive statistics for the functional measures are provided in Table 8.7, with the exception of visual acuity scores (ordinal data more suited to presentation in terms of frequencies, see Table 8.8) and the Computerised Visual Attention Test scores (see Table 8.9).

Table 8.6
Types of medications potentially affecting driving used by participants (N = 104)

Medication Type	Number of Cases of Use	Percentage of Cases
Hypertension	20	29.9
Heart problems	18	26.9
Acid reflux/ulcer	8	11.9
Depression	6	9.0
Arthritis	3	4.5
Gout	2	3.0
Calcium deficiency	1	1.5
Asthma	1	1.5
Other	8	11.9
Total	67	100.0

There were low levels of depressed mood among the sample, with only eight participants scoring above nine (suggestive of mild depression) and none scoring above 19 (suggestive of severe depression) (Spreen & Strauss, 1997). There were also low levels of anxiety with the means for state and trait anxiety both being below norms for those aged 50 to 69 (approximately 35 for both types of anxiety) (Speilberger, 1983). The contrast sensitivity levels were slightly lower than norms presented in Mantyjarvi and Laitinen (2001) but this is probably due to an older average age of the sample in the present study (M = 74.2, SD = 6.3 versus M = 67.8, SD = 4.9). There were very few deficits in horizontal visual field among the sample, with the majority of participants recording the maximum visual field (90˚) for both eyes. Some degree of limited neck mobility was recorded for almost all of the drivers in the sample, with only 13 of the 104 drivers recording a maximum neck mobility score of 180 degrees. There was little evidence of possible dementia in the sample, with only one participant recording a score of less than 24 on the MMSE, the cut-off for suspected dementia (Lezak, 1995). The mean for the Symbol Digit Modalities test (36.9) approximates the norm for those aged 65 to 74 of 37.4 (Lezak, 1995), as does that for Total Spatial Span (13.3 compared to the norm of 13) (Wechsler, 1997).

Table 8.7
Functional test performance (N = 104)

Test	Mean	*SD*	Range of Possible Scores
Depressed mood			
Geriatric Depression Scale	3.9	3.2	0 - 30
Anxiety			
State Anxiety	31.7	8.1	20 - 80
Trait Anxiety	31.0	7.6	20 - 80
Vision			
Contrast sensitivity, right	1.61	0.15	0 - 2.25
Contrast sensitivity, left	1.61	0.13	0 - 2.25
Contrast sensitivity, binocular	1.77	0.14	0 - 2.25
Visual field, left	86.4	7.5	0 - 90
Visual field, right	86.7	7.7	0 - 90
Total visual field	173.1	12.3	0 - 180
Physical functioning			
Total neck mobility	139.2	25.6	0 - 180
Mental status			
3MS	94.7	5.3	0 - 100
MMSE	28.6	1.7	0 - 30
Speed of info processing			
Symbol Digit	36.9	10.3	0 - 110
Spatial memory			
Total Spatial Span	13.3	3.1	0 - 32

Note. 3MS = Expanded Mini Mental State Examination, MMSE = Mini Mental State Examination

The frequencies for visual acuity scores are provided in Table 8.8. It can be seen that only one person recorded binocular visual acuity worse than 6/12. This is consistent with the large Australian study by Ivers et al. (1999), which reported few drivers aged 50 or more with acuity worse than 6/12.

Table 8.8
Visual acuity frequencies (N = 104)

Visual acuity	Left eye[a]	Right eye	Binocular
6/5	22	27	56
6/6	32	25	24
6/9	31	30	19
6/12	12	14	4
6/18	5	4	1
6/24	1	3	-
6/36	-	-	-
6/60	-	1	-
Total	103	104	104

[a] The total for the left eye is 103 rather than 104 because one participant had a glass left eye. The right eye visual acuity for this participant was taken as his binocular acuity.

In addition to the standardised functional tests, the participants completed the Computerised Visual Attention Test (CVAT). The CVAT produced reaction time and detection error scores for two different targets (Xs in the central visual field for the primary task and cars in the peripheral visual field for the secondary task) in both single and dual task conditions (divided attention manipulation), and with and without visual distracters for the secondary task (selective attention manipulation). Table 8.9 provides the means and standard deviations for median reaction times and detection error scores.

Table 8.9
Median reaction times and detection error percentages on the CVAT (N = 104)

Test condition	Reaction times Mean (ms)	*SD*	Detection errors Mean (%)	*SD*
Single task				
Primary	433.1	44.3	0.3	1.1
Secondary, no visual distracters	414.3	52.9	<0.1	0.4
Secondary, visual distracters	537.1	72.1	1.8	3.7
Dual task				
Primary, no visual distracters on secondary	467.3	53.6	2.5	4.8
Secondary, no visual distracters	481.5	68.5	0.4	1.6
Primary, visual distracters on secondary	494.0	51.7	5.1	5.3
Secondary, visual distracters	635.6	111.6	5.5	8.3

Note. CVAT = Computerised Visual Attention Test

The three reaction time scores for the primary task shown in Table 8.9 were analysed with a repeated measures analysis of variance and found to differ significantly ($F_{(2,206)} = 189.6$, $p = .000$). Similarly, the three detection error scores for the primary task were also found to be significantly different ($F_{(1,193)} = 50.0$, $p = .000$). This suggests that the extra attentional load of the different secondary task conditions (no secondary task, secondary task without visual distracters, secondary task with visual distracters) increased reaction times and detection errors for the primary task.

The four reaction time scores for the secondary task shown in Table 8.9 were analysed with a repeated measures analysis of variance using two within subjects factors: single or dual task condition, and with or without visual distracters. Significant differences were found for the dual task manipulation ($F_{(1,103)} = 221.8$, $p = .000$), the visual distracters manipulation ($F_{(1,103)} = 573.9$, $p = .000$) and the interaction between the two ($F_{(1,103)}$ = 19.3, p = .000). A similar procedure was used for detection error scores and, again, there were significant effects for the dual task manipulation ($F_{(1,103)}$ = 23.8, p = .000), for the visual distracters manipulation ($F_{(1,103)}$ = 52.1, p = .000) and for the interaction between the two manipulations ($F_{(1,103)}$ = 19.6, p = .000). Inspection of the means in Table 8.9 indicates that reaction times and detection errors for the secondary task were greater in the dual task rather than the single task conditions (divided attention effect), were greater in the conditions featuring visual distracters than in the conditions without (selective attention effect), and that the dual task and visual distracter manipulations interacted to increase both reaction time and detection errors.

8.3.2 Descriptive Statistics for Driving Test Performance

Of the 104 participants, 90 completed the driving test. Of these 90 participants, 82 were from the general community and eight were referrals. Ten of the community participants chose not to undergo the driving assessment, while three referral participants and one community participant were not able to complete the driving test and so their results for the driving component had to be discarded. The outcomes of the 90 driving tests, in terms of recommendations by the assessor, were 68 passes (75.6%), eight passes with recommendations for lessons (8.9%) and 14 failures (15.6%).

Scores were calculated for interventions by the driving instructor, hazardous errors and habitual errors. The mean number of driving instructor interventions per test was 1.1 (*SD* = 1.7), the mean number of hazardous errors was 10.5 (*SD* = 10.9) and the mean number of habitual errors was 54.0 (*SD* = 17.5). These results show that interventions by the driving instructor were rare and that hazardous errors were a lot less common than habitual errors. There was also greater variation in driving instructor interventions and hazardous errors than in habitual errors.

To create a continuous variable for use as the outcome measure from the driving test, a total error score for the test was calculated, with different weightings applied to the different types of errors . As indicated in section 6.2.2.3, the equation for the calculation of this weighted error score was:

10 (driving instructor intervention) + 5 (hazardous errors) + habitual errors

The scores on this measure ranged between 18 and 443, with a mean of 117.6 (*SD* = 78.3). It can be seen in a scatterplot of the scores for this variable by age and referral source (Figure 8.1) that there was considerable overlap between the driving scores of DARS referrals and drivers from the general community, with many general community drivers scoring more poorly than half of the referral group. This demonstrates the acceptability of analysing the results for the sample as a whole, rather than for two separate groups.

8.3.3 Relationships with Age

This section provides details of the relationships between the health, functional and driving measures and age. First, Pearson's correlation coefficients were calculated between age, and general health and medication use. The correlation between age and general health was .14 ($p = .163$), between age and medication use was .05 ($p = .626$), and between age and use of medications potentially hazardous for driving was .09 ($p = .353$). Therefore, contrary to expectations, there were no significant correlations between age and general health or medication use among the sample of older drivers.

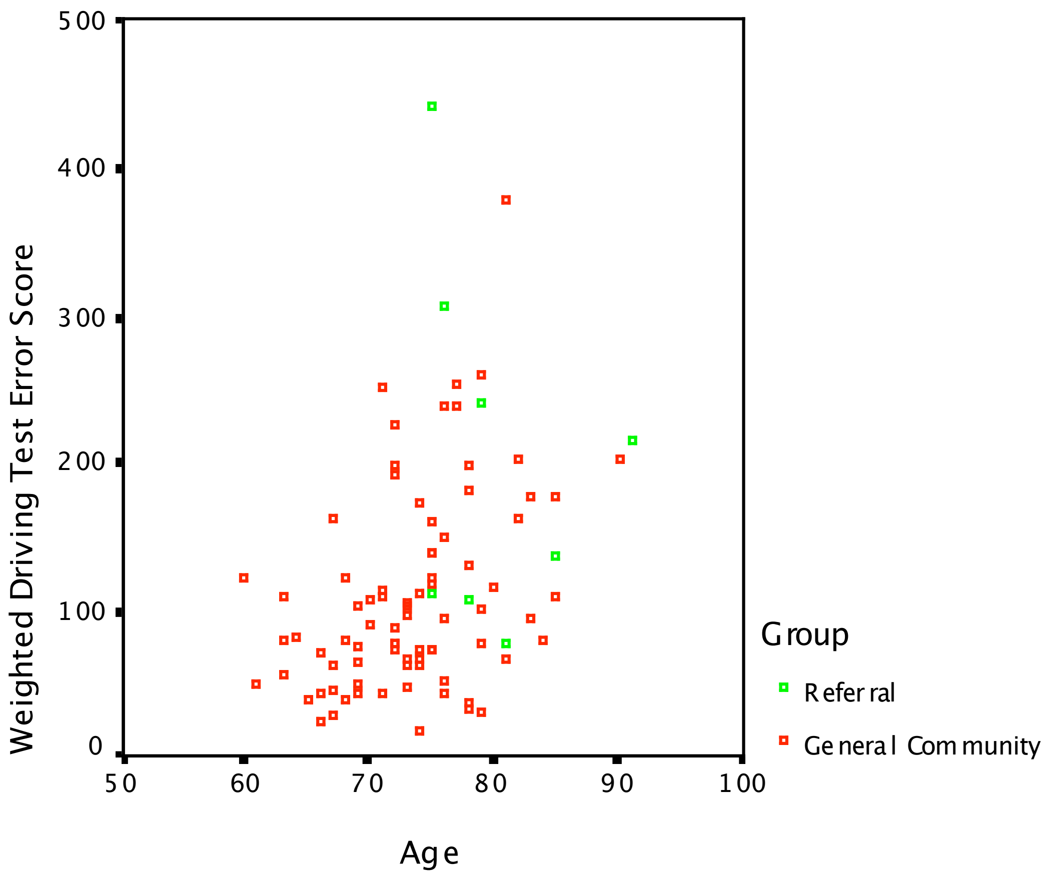

Figure 8.1. Scatterplot showing weighted error scores on the driving test, by age and participant group.

Correlations between age and standard functional measures are shown in Table 8.10, where it can be seen that a number of functional measures were correlated with age. Increased age was significantly associated with decreased right eye and binocular visual acuity, decreased right eye and binocular contrast sensitivity, and poorer performance on the Symbol Digit Modalities test. The two right eye vision scores shared small correlations with age, while the remaining significant correlations were medium-sized. Age was not found to correlate significantly with depressed mood, anxiety, neck mobility, visual field, mental status, or Spatial Span.

Table 8.10

Correlations between standard functional tests and age (N = 104)

Test	Correlation with age
Depressed mood	
Geriatric Depression Scale	.13
Anxiety	
State Anxiety	.01
Trait Anxiety	.02
Physical functioning	
Total neck mobility	-.23
Vision	
Visual acuity, left eye	.24
Visual acuity, right eye	.28*
Visual acuity, binocular	.37**
Contrast sensitivity, left eye	-.24
Contrast sensitivity, right eye	-.28*
Contrast sensitivity, binocular	-.44**
Visual field, left	.03
Visual field, right	-.18
Total visual field	-.09
Mental status	
3MS	.01
MMSE	.09
Speed of info processing	
Symbol Digit	-.38**
Spatial memory	
Total Spatial Span	-.19

Note. 3MS = Expanded Mini Mental State Examination, MMSE = Mini Mental State Examination
* $p < .01$, ** $p < .001$

The relationship between age and visual attention was examined by determining correlations between age and both median reaction time and target detection errors on the CVAT, which are shown in Table 8.11. Three of the seven reaction time measures were positively correlated with age, indicating a decline in performance with increased age. These tasks were the two requiring detection of Xs (primary task) in dual task conditions and the task requiring detection of cars (secondary task) in the presence of visual distracters in the dual task condition. The correlations were in the small to medium range. For detection errors, correlations with age were only calculated for scores in the dual task conditions because detection errors in the single task conditions were not found to be reliable (see Chapter 7). Two of the four remaining measures were significantly correlated with age, with increasing age associated with a higher number of target detection errors. Significant correlations were found for the detection of Xs (primary task) and detection of cars (secondary task) in the dual task condition featuring visual distracters on the secondary task. These correlations were both in the small range.

Table 8.11
Correlations between age and CVAT median reaction times and detection errors (N = 104)

Test condition	Correlations between CVAT scores and age Reaction times	Detection errors
Single task		
Primary	.18	
Secondary, no visual distracters	.09	
Secondary, visual distracters	.25	
Dual Task		
Primary, no visual distracters on secondary	.25*	.11
Secondary, no visual distracters	.18	-.06
Primary, visual distracters on secondary	.26*	.27*
Secondary, visual distracters	.36**	.27*

Note. CVAT = Computerised Visual Attention Test
* $p < .01$, ** $p < .001$

Finally, the weighted error scores on the driving test were found to share a significant, medium-sized correlation with age ($r = .37$, $p = 000$) indicating that increased age was associated with a greater number of errors on the on-road driving test. This significant correlation, in addition to those between age and a number of functional variables, indicates that the confounding effects of age should be controlled for in any analyses of the relationships between functional measures and driving test performance.

8.3.4 The Relationship Between Health and Functional Measures, and Driving Performance

The relationship between medical conditions and driving ability was assessed by calculating Pearson's correlation coefficients between the "general health" variable, based on diagnosed medical problems and associated self-reports of effects on daily functioning, and the weighted error score on the driving test. This correlation was found to be .21, which was only approaching significance ($p = .045$).

The relationship between prescription medication use and driving was also examined, both for overall medication use and use of medications potentially hazardous for driving. The correlation between medication use and driving test performance was not significant ($r = .19$, $p = .075$), while that between use of medications potentially hazardous to driving and driving test performance only approached significance ($r = .22$, $p = .038$).

The relationship between the functional measures and driving test performance was also assessed with correlations (refer to Table 8.12). It can be seen that left eye and binocular contrast sensitivity, the Symbol Digit Modalities test, and the Spatial Span subtest of the WMS-III were all significantly correlated with driving test performance. Each of these significant correlations was in the expected direction, indicating that driving test performance was worse for those with poorer contrast sensitivity, speed of information processing and spatial memory. The correlations were all medium-sized. Correlations between driving test performance and the Geriatric Depression Scale, binocular visual acuity, contrast sensitivity in the right eye and the 3MS were all small but approached significance ($p < .05$).

As age was related to driving test performance, assessments were made of the strength of the relationships between functional measures and driving test performance, independent of age effects. For each functional measure that was significantly correlated with driving test performance, a hierarchical regression analysis was performed, with driving test performance as the dependent variable, and age (entered at step 1), and each functional measure (entered at step 2) as predictor variables. The results of these hierarchical analyses are shown in Table 8.13. It can be seen that binocular contrast sensitivity, Symbol Digit and Total Spatial Span no longer made significant contributions to the prediction of driving test performance once age effects had been controlled, although Total Spatial Span approached significance ($p = .014$).

Only left eye contrast sensitivity made a significant contribution to the prediction of driving test performance independently of age.

Table 8.12
Correlations between functional tests and driving performance (n=90)

Test	Correlation with driving
Depressed mood	
Geriatric Depression Scale	.24
Anxiety	
State Anxiety	.09
Trait Anxiety	.20
Physical functioning	
Total Neck Mobility	-.19
Vision	
Visual acuity, left eye	.19
Visual acuity, right eye	.12
Visual acuity, binocular	.25
Contrast sensitivity, left eye	-.36**
Contrast sensitivity, right eye	-.22
Contrast sensitivity, binocular	-.33*
Visual field, left	.06
Visual field, right	.02
Total visual field	.05
Mental status	
3MS	-.26
MMSE	-.19
Speed of info processing	
Symbol Digit	-.32*
Spatial memory	
Total Spatial Span	-.30*

Note. 3MS = Expanded Mini Mental State Examination, MMSE = Mini Mental State Examination
* $p < .01$, ** $p < .001$

Table 8.13
Results of hierarchical regression procedures examining the contributions of functional measures to the prediction of driving performance, after controlling for age (n = 90)

Variables	*B*	Adj R^2	ΔR^2	ß	*t*
Age	3.69	.121	.121	.290	2.91*
Contrast sensitivity, left eye[1]	-172.44	.187	.066	-.283	-2.85*
Age	3.53	.125	.125	.278	2.59*
Contrast sensitivity, binocular	-114.64	.153	.028	-.212	-1.98
Age	3.60	.125	.125	.284	2.65*
Symbol Digit	-1.63	.150	.025	-.203	-1.90
Age	4.10	.125	.125	.323	3.30*
Total Spatial Span	-6.27	.174	.049	-.245	-2.51

[1] $n = 89$, as one participant had a glass left eye
* $p < .01$, ** $p < .001$

Correlations were also used to determine the relationships between visual attention and driving test performance. Table 8.14 shows the correlations between driving test performance and CVAT reaction times and detection errors. Reaction time scores for the CVAT were all significantly related to driving test performance, with correlations of medium size. The correlations were all in the expected direction, indicating that those with longer reaction times performed less well on the driving test. For detection errors, again only dual task performance was analysed because of the low reliability of single task detection error scores (see Chapter 7). The only significant correlations with driving test performance were for detection of both Xs (primary task) and cars (secondary task) in the dual task condition, with visual distracters on the secondary task (the subtest requiring divided and selective attention). Both of these correlations were medium-sized and positive, indicating worse driving test performance by those who missed more targets on the CVAT.

Table 8.14
Correlations between driving performance, and CVAT median reaction times and detection errors (n = 90)

Test condition	Median reaction times correlations with driving	Detection errors correlations with driving
Single task		
Primary	.38**	
Secondary, no visual distracters	.35*	
Secondary, visual distracters	.43**	
Dual Task		
Primary, no visual distracters on secondary	.33*	.24
Secondary, no visual distracters	.32*	.02
Primary, visual distracters on secondary	.30*	.32*
Secondary, visual distracters	.46**	.36**

Note. CVAT = Computerised Visual Attention Test
$*p < .01$, $**p < .001$

In order to gauge whether these relationships were independent of the effects of age, hierarchical regression analyses were conducted, with the weighted error score on the driving test as the dependent variable, and age (entered at step 1), and CVAT scores (entered at step 2) as predictor variables. Table 8.15 shows the results of these analyses, with all reaction time measures making significant, independent contributions to the prediction of driving test performance beyond the effects of age, except for reaction times to the Xs (primary task) in the dual task conditions. Detection errors significantly predicted driving test performance for the secondary task (in the dual task condition, with visual distracters) but only approached significance for the primary task in the same subtest (dual task, visual distracters on the secondary task). Overall, these results suggest that visual attention, as measured by performance on the CVAT, significantly predicts driving test performance independently of age, particularly when using the reaction time scores.

To summarise the correlational analyses, the functional measures that were significantly related to driving test performance and made a significant contribution to its prediction independent of age were: left eye contrast sensitivity, reaction time scores on the CVAT for all secondary tasks and also for the primary task in the single task condition, and CVAT detection errors on the secondary task in the dual task condition with visual distracters. The variables that were significantly correlated with driving performance but did not significantly predict driving performance after controlling for age were: binocular contrast sensitivity, Symbol Digit Modalities Test, Total Spatial Span, primary task reaction times in the two dual task conditions of the CVAT, and primary task detection errors in the dual task condition with visual distracters on the secondary task of the CVAT. The relationships between a number of the remaining variables and driving test performance only approached significance prior to controlling for age effects. These were: general health, use of medications potentially hazardous to driving, the Geriatric Depression Scale, binocular visual acuity, contrast sensitivity in the right eye, the 3MS and primary task detection errors in the dual task condition without visual distracters on the CVAT secondary task. All of the significant correlations between driving test performance, and health and functional measures were small to medium in size, with no correlations of .50 or more.

Table 8.15

Results of hierarchical regression procedures examining the contributions of median reaction times and detection errors on the CVAT to the prediction of driving performance, after controlling for age (n = 90)

Variables	*B*	Adj R^2	ΔR^2	ß	*t*
Reaction times, single task					
Age	3.81	.125	.125	.300	3.12*
Primary	0.57	.212	.087	.315	3.27*
Age	4.63	.125	.125	.364	3.95**
Secondary, no visual distracters	0.57	.241	.116	.352	3.81**
Age	3.64	.125	.125	.286	3.03*
Secondary, visual distracters	0.40	.244	.119	.365	3.86**
Reaction times dual task					
Age	3.83	.125	.125	.301	3.02*
Primary, no visual distracters on the secondary task	0.38	.173	.048	.247	2.48
Age	4.21	.125	.125	.331	3.45*
Secondary, no visual distracters	0.34	.193	.068	.279	2.91*
Age	3.93	.125	.125	.310	3.07*
Primary, visual distracters on the secondary task	0.33	.158	.033	.213	2.11
Age	3.17	.125	.125	.250	2.58
Secondary, visual distracters	0.28	.247	.122	.378	3.91**
Detection errors, dual task					
Age	3.70	.125	.125	.291	2.79*
Primary, visual distracters on the secondary task	3.08	.154	.029	.210	2.01
Age	3.72	.125	.125	.293	2.98*
Secondary, visual distracters	2.81	.192	.067	.285	2.89*

Note. CVAT = Computerised Visual Attention Test; Primary = Primary task; Secondary = Secondary task
* $p < .01$, ** $p < .001$

In order to determine which variables were the best independent predictors of driving test performance, a linear regression procedure was used, with driving test performance as the dependent variable and all of the measures that were significantly correlated with driving test performance ($p < .01$) as predictor variables. Age was also included as a predictor variable, enabling a test of the hypothesis that age is related to deficits in driving only because it is related to deficits in functioning that are, in turn, related to driving deficits. A stepwise procedure was used for the regression analysis, with the level of significance required for entry into the equation set at $p < .05$. The results of this procedure are summarised in Table 8.16, and a table of inter-correlations between candidate predictor variables is provided in Appendix 8.

As shown in Table 8.16, the variables most predictive of driving test performance were reaction time for the secondary task in two different conditions (dual task with visual distracters and single task without visual distracters), binocular contrast sensitivity, and total spatial span. The model featuring all four variables accounted for 34% of the variance (Adjusted R squared) in the driving measure (the weighted error score on the driving test).

Table 8.16
Results of a linear regression procedure predicting driving test performance, using functional measures as predictor variables (n = 90)

Variables in the model (order of entry)	*B*	Adj R^2	ΔR^2	ß	*t*
Reaction time for car detection, dual task condition, with visual distracters[1]	0.17	.21	.21	.236	2.30*
Binocular contrast sensitivity	-128.40	.25	.04	-.237	-2.63*
Total Spatial Span	-6.41	.29	.04	-.248	-2.74**
Reaction time for car detection, single task condition, without visual distracters[1]	0.42	.34	.05	.255	2.64*

[1] Measure taken from the Computerised Visual Attention Test
* $p < .05$, ** $p < .01$

8.4 Discussion

This chapter examined the relationships between health (general health and medication use) and functional measures (mood-related variables, physical functioning, vision, mental status, speed of information processing, spatial memory, and visual attention), and driving ability (performance on an on-road driving test). This analysis was conducted to allow for a later comparison with the health and functional measures found to be related to older driver self-regulation (Chapter 11). Prior to this, the results of these analyses can be compared with those of previous studies investigating the relationships between health and functional measures, and driving ability among older drivers.

8.4.1 Relationships Between Health and Functional Measures and Driving Ability

General health and driving ability were not strongly related, contradicting the suggestions of some authors (Dobbs et al., 1998; Klavora & Heslegrave, 2002; Marottoli, 2002; Wallace & Retchin, 1992; Waller, 1992) that being affected by a combination of different medical conditions increases the risk of driving problems among older drivers. However, as this variable was based on self-ratings of the effects of medical conditions on daily functioning, it is possible that some participants failed to report all of their medical conditions or understated the extent to which their daily functioning was affected by them. This notwithstanding, the findings suggest that it is more important to evaluate functional abilities than medical conditions when attempting to predict the driving abilities of older drivers. The importance of functional abilities to driver re-licensing and assessment has been advocated previously (Marottoli et al., 1998; OECD, 2001; Sims et al., 1998; Wallace & Retchin, 1992; Waller, 1992; White & O'Neill, 2000) and the findings of the present study provide additional empirical support to this view.

The number of medications used by the drivers was not significantly correlated with driving, consistent with a previous study by Foley et al. (1995) which found no relationship between medication use and crash involvement among older drivers. Use of medications potentially hazardous to driving (those that can cause central nervous system impairment, drowsiness, or dizziness) was also found to be unrelated to driving ability, although the correlation approached significance. These results suggest that medication use is not strongly related to driving ability but caution must be exercised in accepting this conclusion because the information used in this study was self-reported. A more accurate source of information concerning medication use (e.g. medical records) may have produced different results. Despite the weak relationships found here, attention still needs to be given to the medications taken by older drivers and effort should be directed towards minimising the use of medications that could produce side-effects detrimental to driving. It also needs to be remembered that untreated medical conditions may have a greater effect on functional abilities, and hence driving, than the medications used to treat them (Marottoli, 2002).

None of the measures of participant mood (depressed mood, state and trait anxiety) were significantly related to driving ability. Again, some caution must be exercised when interpreting the lack of a relationship between depressed mood and driving ability, as the sample included healthy participants who generally had low levels of depressive symptoms. Only seven of the 90 participants recorded scores above the cut-off for mild depression on the Geriatric Depression Scale. It could be that depressed mood would be found to be related to decrements in driving ability using a sample including more participants with higher levels of depressive symptoms. Previous studies by Sims et al. (2000) and Foley et al. (1995) have found significant relationships between depressive symptoms and crash involvement, whereas a recent study by Garrity and Demick (2001) found no association between depression and on-road driving performance among older drivers.

Consistent with expectations, there were significant correlations between driving ability and contrast sensitivity. Visual acuity was not found to be related to driving ability, although the relationship approached significance. Visual field also was not found to be related to driving ability. A more detailed and technologically advanced measure of participants' visual fields (e.g. Humphrey Field Analyzer; Optifield II) may be necessary, rather than a simple horizontal visual field measure, to adequately measure this variable. Binocular contrast sensitivity was also among four variables that were found in a regression procedure to make significant, independent contributions to the prediction of driving ability. The finding that contrast sensitivity is more strongly related to the on-road driving ability of older drivers than other simple vision measures replicates the results of previous studies (Janke & Eberhard, 1998; Wood, 2002a) and suggests that vision assessments for re-licensing of older drivers should include contrast sensitivity, rather than visual acuity, as a simple vision measure. The Australian guidelines for assessment of fitness to drive (Austroads, 2001) set limits for visual acuity and visual field but not for contrast sensitivity.

No relationship was found between neck mobility and driving ability in the present study, contradicting the findings of McPherson et al. (1988). It was consistent, however, with a number of studies that have failed to find a significant relationship between neck mobility and measures of on-road driving performance (Odenheimer et al., 1994; Staplin et al., 1998b; Tarawneh et al., 1993). It may be that only profound decrements in physical functioning lead to poorer driving ability.

Mental status, as measured by the original Mini Mental State Examination (MMSE), was not related to driving ability, and the relationship between driving and the more recent, expanded version of the test (3MS) only approached significance. The 3MS was chosen as a measure of mental status for this study because it generates a wider range of scores than the MMSE, with less attenuation by ceiling effects (Teng & Chui, 1987). Also, the 3MS includes additional questions (date and place of birth, word fluency, similarities, and delayed recall of words) that are intended to assess functions important for differentiating between those who are healthy and those affected by cognitive impairment. However, the relationship between the 3MS and driving ability was weak, suggesting that mental status may be more important for drivers with dementia, than for healthy, community-dwelling older drivers. Mental status has often been linked with crash involvement or poorer on-road driving performance in previous studies, especially in those including drivers with dementia (Clark et al., 2000; Cushman, 1996; Fitten et al., 1995; Johansson et al., 1996; Odenheimer, 1993; Rizzo et al., 2001) while those studies not finding any relationship have generally been based on only a small sample (Lesikar et al., 2002) or have had an attenuated range of scores (Janke, 2001).

As predicted, speed of information processing, as assessed by the Symbol Digit Modalities Test, was significantly related to driving ability. However, this was not the case after controlling for age. Information processing is known to slow with age (Salthouse, 1985) and it may be that, in a sample of drivers with little cognitive impairment, this measure largely assessed age-related slowing in processing. Thus, it may be that Symbol Digit performance does not provide a greater indication of likely driving ability beyond that given by age.

Spatial memory, as predicted, was related to driving ability, with Total Spatial Span sharing a moderate relationship with performance on the on-road driving test. This relationship remained significant after controlling for the effects of age. This is consistent with studies by de Raedt and Ponjaert-Kristoffersen (2000) and Lundberg et al. (1998), which found that indices of visuospatial memory were related to on-road driving test performance and crash involvement, respectively. Total Spatial Span was also one of the four variables that predicted driving ability in a regression procedure.

As predicted, the CVAT measures were related to driving, with all seven reaction time measures and two detection error scores correlating with driving ability. After controlling for the effects of age, five reaction time measures and one of the detection error scores remained significant predictors of driving ability. Furthermore, when a linear regression was conducted to identify the best predictors of driving ability, two of the four variables identified were reaction time measures from the CVAT: the measure assessing selective and divided attention for stimuli in the peripheral visual field (the secondary task in the dual task condition with visual distracters), and the measure assessing simple visual attention for stimuli in the peripheral visual field (the secondary task in the single task condition without visual distracters). The fact that these two measures predicted driving ability highlights the importance for driving of being able to quickly detect stimuli in the visual periphery. The importance of visual attention for safe driving by older drivers is consistent with the findings of a large number of previous studies (Clark et al., 2000; Cushman, 1996; De Raedt & Ponjaert-Kristoffersen, 2000; Duchek et al., 1998; Haegerstrom-Portnoy et al., 1999; Hunt et al., 1993; Janke, 2001; Lundqvist et al., 2000; Odenheimer et al., 1994; Owsley et al., 1998; Richardson & Marottoli, 2003).

Previous claims that functional performance is more important than age in determining driving ability (Cushman, 1996; Hakamies-Blomqvist, 1996; Staplin et al., 1998b) were supported by the findings of the present study, as age was not among the variables that best predicted performance in the on-road driving test. The two reaction time measures, contrast sensitivity and Spatial Span entered the regression equation prior to age, and once the effects of these variables had been taken into account, age no longer made an independent contribution to the prediction of driving ability. This is an important finding because it reinforces the view that age-based mandatory testing of older drivers is an unsupportable re-licensing policy. Age is mainly associated with declines in driving ability because of its relationship with functional declines that, in turn, are related to driving ability. Retesting of the driving capabilities of older drivers should be undertaken only when there is evidence for declines in functioning, not because a driver has reached a particular age.

It is also important to note that the four variables that entered the regression equation explained only 34% of variance in driving ability. This demonstrates the difficulty of developing measures for identifying at-risk older drivers in the general community (Hakamies-Blomqvist, 2003), and also the complex nature of the driving task.

Previous studies utilising regression procedures to predict performance in on-road driving tests have often been based on samples with a greater proportion of drivers with cognitive impairments or who were referred for an assessment of their driving (e.g. Cushman, 1996; De Raedt & Ponjaert-Kristoffersen, 2000; Duchek et al., 1998; Janke, 2001; Lundqvist et al., 2000). The proportion of variance in driving test scores explained by test measures in these studies has ranged between 15 and 67%. Tarawneh (1993) assessed drivers recruited from the general community and found that five tests accounted for 45% of variance in driving performance scores. Janke (2001) reported the results of two studies predicting driving ability. In one of these, the performance in on-road driving tests of a sample of referrals was examined and a model including age, sex and the results of two functional tests accounted for 50% of variance in driving test scores. In the other study, examining the performance of healthy volunteers only, the amount of variance in driving scores accounted for by regression equations was 20% or less. Therefore, it appears that attempts to predict driving ability tend to be more successful when assessing drivers with a greater likelihood of impairment. Less variance is accounted for in studies of healthy community-dwelling volunteers.

8.4.2 Limitations

Turning to the limitations of the study, it must be recognised that the on-road driving test has not, itself, been validated. Although on-road driving test performance is a good outcome measure for a study of this type, it has not been established that the test methods utilised in this study are predictive of driving ability when not in a test situation, or of future crash involvement. This limitation applies commonly to studies using on-road tests of driving ability. However, the assessments of on-road driving performance used in this study were very detailed and used the expertise of both occupational therapists and professional driving instructors. Also, there are problems with using crash involvement as an indicator of difficulties with driving. One problem is that crashes are rare events, and so drivers with an increased risk of crashing may not be involved in a crash during the study period. To illustrate this, Stutts et al. (1998) stated that less than six percent of licensed drivers crash in any given year. If a factor could be found that identified drivers who had double or triple the normal risk of crashing, only 10 to 20% of the drivers affected by this factor would be expected to crash in the forthcoming year, while 80 to 90% would be crash-free (Stutts et al., 1998). A second problem is that crashes are multi-determined events. That is, the occurrence of a crash is rarely caused by only one factor but, rather, by the simultaneous effects of a number of factors that increase crash risk, many of which are independent of driver error.

One common criticism of the use of on-road driving tests, in either re-licensing assessments or research, is that they do not assess driver ability in emergency situations. There may be drivers who have deficits in functioning and ability that are not serious enough to affect their driving ability in normal driving conditions but which may markedly affect their ability to respond in the emergency situations that can lead to crashes (Hunt et al., 1993; Maycock, 1997; Rizzo et al., 2001; Schlag, 1993; Waller, 1992). This objection to road tests ignores the fact that good driving is likely to lead to the avoidance of emergency situations. Good drivers are less likely to need to use emergency braking or steering because they drive cautiously and also use experience to recognise potentially hazardous situations in advance. Also, in regard to the use of on-road tests for re-licensing procedures, it could be considered unfair to expect older drivers to demonstrate the ability to respond to emergency situations, given that new drivers, to obtain a licence, are not required to demonstrate this ability.

A second limitation of the present study is that it uses a cross-sectional design. It may be that a longitudinal study of within-participant declines in abilities would produce different results. Another limitation is the that the results may have been affected by volunteer bias, such that participants were more likely to be healthy and high-functioning. The inclusion of more participants who were referred for a driving assessment would have broadened the range of abilities that were sampled but it is still likely that, among the general community group, volunteers would have been more likely to be those who were confident about their ability to pass an on-road driving assessment. Lee et al. (2003, p802) described this problem for driving studies as "unavoidable" and said that random sampling is "neither possible nor practical". A final limitation was that the measures of health and medication use were self-reported and so their accuracy cannot be guaranteed.

CHAPTER 9: DRIVING ATTITUDES AND BEHAVIOUR

9.1 Introduction

Self-regulation of driving behaviour involves responding to self-assessed declines in driving ability with avoidance of difficult driving situations (Charlton et al., 2001). The literature on self-regulation of driving behaviour by older drivers was described in section 4.3. It was noted that older drivers most frequently report that they avoid driving at night (e.g. Charlton et al., 2001), and also avoid inclement weather, busy traffic, high speed roads, unfamiliar roads, and performing turns across oncoming traffic (Eberhard, 1996; Holland & Rabbitt, 1994; Stutts, 1998). Older drivers have additionally reported driving more slowly and taking shorter trips (e.g. Forrest et al., 1997). Moreover, this self-regulation is often associated with the perceived difficulty of these driving situations (e.g. Rabbitt et al., 2002), and also with increased age, female gender, and retirement (e.g. Burns, 1999). It is unclear whether previous crash involvement leads to self-regulation, as earlier studies have produced inconsistent findings (Ball et al., 1998; Daigneault et al., 2002a). A number of barriers to self-regulation have also been identified by Stalvey and Owsley (2000), with drivers reporting a need to maintain high levels of driving because of inadequate public transport, the lack of friends or relatives to drive them when needed, and the desire to maintain their active lifestyles.

One of the aims of the present study was to determine the extent to which a sample of drivers in South Australia practised self-regulation of driving. No study in Australia has investigated the driving practices of older drivers in as much depth as was provided by the Driver Mobility Questionnaire described in section 6.2.2.1 (for a full copy refer to Appendix 6A). The questionnaire included questions about:

- preferred mode of travel;

- preferred driving speed compared to other traffic;
- whether the participant had ever been advised to restrict or cease his or her driving and, if so, by whom;
- perceived driving ability, vision, and ability to carry out more than one task simultaneously;
- how much driving the participant did, in terms of the number of days driven per week, trips taken per week, and kilometres driven per week;
- whether the participant had reduced his or her driving in the last ten years and, if so, for what reason;
- level of confidence when driving in various difficult situations (e.g. in the rain at night);
- how many crashes and police-reported crashes the participant had been involved in during the previous five years;
- how many times the participant had been pulled over by the police and the number of traffic violations he or she had been charged with in the previous five years;
- the geographical area over which the participant drove (e.g. local neighbourhood, interstate);
- the extent to which the participant avoids difficult driving situations;
- perceived barriers to reductions in driving;
- and the participant's perceived ability to organise his or her life so that a reduction in driving in difficult situations would be possible (regulatory self-efficacy).

Responses to this questionnaire allowed an examination of the extent of self-regulation among older drivers, its associations with perceived abilities and confidence, and whether there were factors that were reducing the likelihood of self-regulation. Based on previous research, it was hypothesised that increased age and female gender would be associated with lower self-ratings of abilities (driving, vision, dual task), lower driving space (geographical area in which driving is done), reduced driving exposure (amount of driving done), lower confidence in difficult driving situations, and greater avoidance of difficult driving situations (greater self-regulation). With regard to the relationships between the questionnaire measures, it was hypothesised that greater confidence in difficult driving situations would be associated with higher self-ratings of abilities, greater driving space, greater driving exposure, less avoidance of difficult driving situations, and fewer previous crashes or traffic violations. It was also expected that greater avoidance of difficult driving situations (greater self-regulation) would be associated with lower self-ratings of abilities, lower driving space, lower driving exposure, a greater number of previous crashes and traffic violations, fewer barriers to self-regulation and greater regulatory self-efficacy.

9.2 Analyses

Descriptive statistics for the questionnaire measures are provided, followed by an analysis of the relationships shared by these measures with age, gender, and each other. These relationships were all assessed using Pearson's Product Moment Correlation coefficients, except for the analyses of gender differences, and differences according to previous crash involvement and traffic violations, for which independent samples t-tests were performed. For all analyses, a conservative alpha level of .01 was used rather than the conventional .05, in order to control for multiple comparisons. As noted previously, this conservative alpha level was chosen ahead of using the Bonferroni method of correcting for multiple comparisons because the former allows for a consistent alpha level across the entire thesis rather than a different one for each set of analyses, and also because it has been argued that the Bonferroni method is too conservative when the number of comparisons gets too large (Jaccard & Wan, 1996). The size of correlations and *t*-test differences was also evaluated according to Cohen's (1992) effect size classifications. According to this system of classification, correlations of between .1 and .3 are "small" (accounting for between 1 and 9% of the variance), those between .3 and .5 are "medium-sized"(between 9 and 25% of the variance) and those over .5 are "large"(over 25% of the variance). For *t*-tests, effect sizes (*d*) between 0.2 and 0.5 are regarded as small, those between 0.5 and 0.8 are medium-sized, and those over 0.8 are large (Cohen, 1992).

9.3 Results

9.3.1 Descriptive Statistics for the Driver Mobility Questionnaire

9.3.1.1 Current Driving

Of the 104 drivers surveyed, all but six preferred to meet their transport needs by driving themselves (Question 1). Four expressed a preference for travelling by taxi or public transportation and the remaining two participants preferred having someone else drive them in a private vehicle. Just over 60% of drivers reported always wearing glasses when they drove (Q2).

When asked to compare their usual driving speed with that of other traffic (Q3), 92 (88.5%) of the participants claimed that they drove at "about the same" speed as other drivers. The other 12 (11.5%) participants admitted that they generally drove more slowly than other traffic.

Only six of the participants admitted that it had been suggested to them that they cease or restrict driving (Q4). It is interesting that this accounts for only half of the participants who were referred for a driving assessment, mostly by medical practitioners.

9.3.1.2 Self-Ratings of Abilities

When asked to rate their own driving ability (Q5), only one participant claimed that they were below average ("fair"). Forty participants (38.5%) judged themselves to be average drivers, 60 (57.7%) said they were "good" drivers, and the remaining three claimed that they were "excellent". This suggests a generally positive self-assessment of driving ability among the participants.

The results for the question about self-ratings of vision (allowing for correction by glasses) (Q6) were similar to those for self-ratings of driving ability, with only three admitting their vision was below average ("fair"). Forty participants (38.5%) claimed their vision was average, 47 (45.2%) claimed that theirs was "good", and the other 14 (13.5%) rated their vision as "excellent".

The pattern of results for self-ratings of the ability to perform two tasks simultaneously (Q7) was also similar to that for the previous two questions, except that more participants rated their dual task ability as below average (10 participants or 9.6%) than rated it as "excellent" (six participants or 5.8%). Again, almost all participants judged themselves to be either average (43 participants or 41.3%) or "good" (45 participants or 43.3%).

9.3.1.3 Driving Exposure

The amount of driving done by the study participants was assessed in three ways. The participants were asked to state the number of days per week they typically drove (Q9), the number of trips they typically took per week (Q10), and the number of kilometres they drove per week (Q11). The number of days per week that the participants typically drove is displayed in Table 9.1. There was considerable variation in the number of days driven per week but few participants drove less than three days per week (6 participants or 5.8%). The most frequent response was seven days per week.

Table 9.1
Days driven per week (N = 104)

Days driven per week	Number of participants	Percentage of participants
1	1	1.0
2	5	4.8
3	10	9.6
4	14	13.5
5	25	24.0
6	17	16.3
7	32	30.8
Total	104	100.0

The number of trips typically taken per week by the participants (Q10) ranged from two to 30, with a mean of 8.6 (*SD* = 5.4). Fifty five percent of participants took seven trips per week or less (an average of one per day or less), while only 13.5% took more than 14 trips per week (an average of two per day or more). In terms of kilometres driven (Q11), the amount of driving per week ranged from 15 to 360 km, with a median of 110 km.

The majority of the participants (*n* = 61, 58.7%) reported that they had reduced the amount of driving they did in the last ten years, while the remaining 43 (41.3%) had not (Q12). When asked to provide reasons for their reported driving reduction, 55 of the 61 participants attributed it to a reduction in the need to drive. The reduction in driving, according to this attribution, was due to changes in lifestyle (probably retirement in many cases) meaning that less driving was necessary than previously. Only three participants reduced their driving to save money and one did it because of a decline in vision.

9.3.1.4 Driving Confidence

Participants were asked to rate their confidence in nine difficult driving situations, using a five point scale with five points for “completely confident” and one point for “not confident at all” (Q13-21). As stated in section 6.2.2.1, an overall driving confidence variable was calculated with a possible range from nine (not confident at all in any difficult driving situation) to 45 (completely confident in all situations). The overall confidence scores for the 104 participants ranged from 19 to 45, with a mean of 33.1 (*SD* = 6.5).

With regard to each individual driving situation, a summary of participants' confidence ratings is provided in Figure 9.1 (a table of data is provided in Appendix 9, Table 1), which shows that the situation in which participants were *most* confident was driving alone (Figure 9.1, b), while the situations in which there was the *least* confidence were parallel parking and driving at night in the rain (Figure 9.1, c and i). The most common response for six of the nine categories was "reasonably confident" and participants were more likely to report being "very" or "completely" confident than they were to report being "not confident at all" or "not very confident".

9.3.1.5 Crashes and Traffic Violations

Participants were asked to report the number of crashes they had been involved in as a driver in the previous five years (Q22). Their responses are summarised in Table 9.2, which shows that three quarters of the participants had not been involved in a crash in the previous five years. Only seven percent had had more than one crash in the five year period.

Table 9.2
Number of crashes in the previous five years (N = 104)

Number of crashes	Number of participants	Percentage of participants
0	79	76.0
1	18	17.3
2	5	4.8
3	1	1.0
4	1	1.0
Total	104	100.0

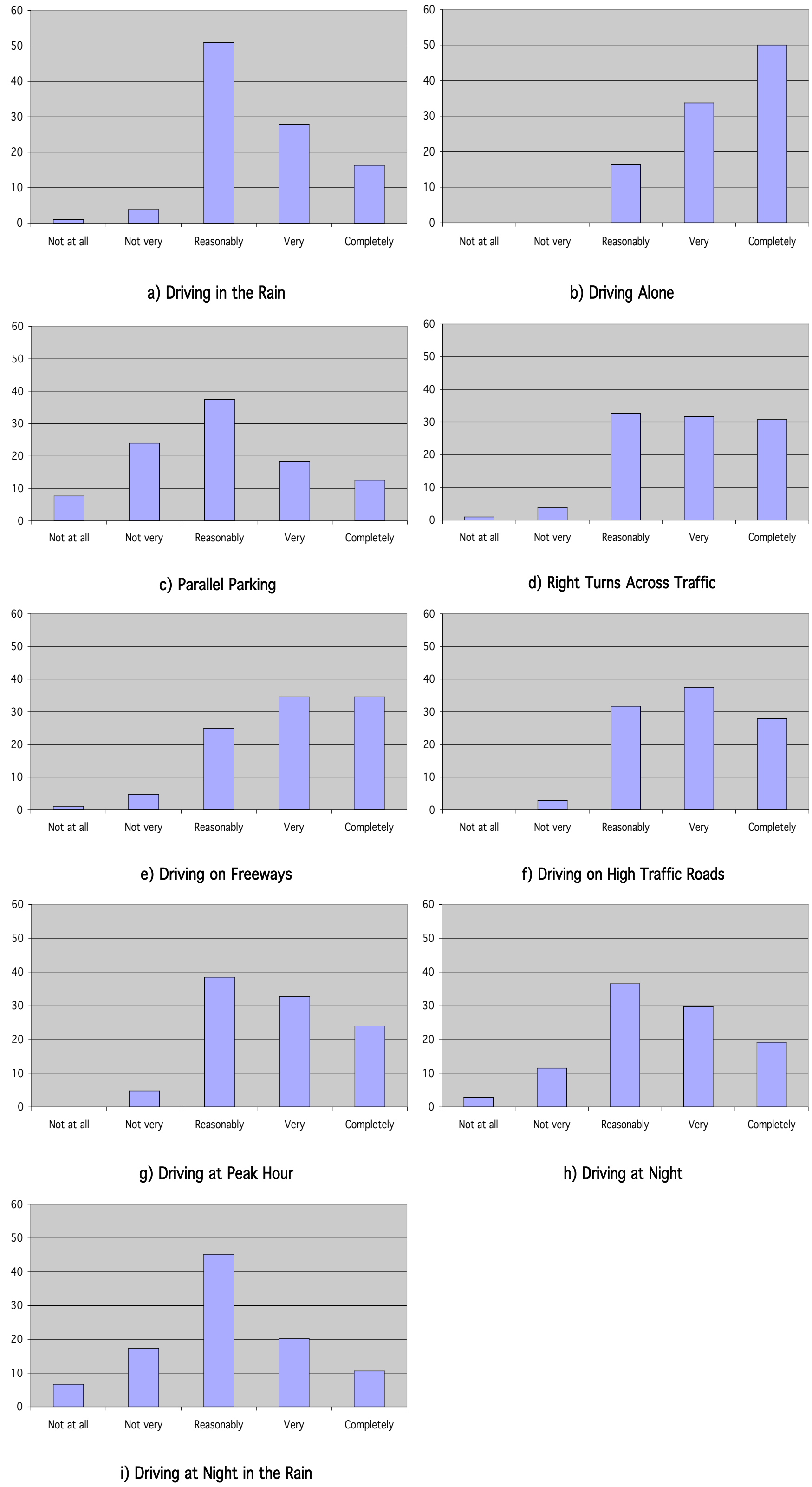

Figure 9.1. Confidence in difficult driving situations, percentages

Participants also reported the number of police-reported crashes in which they had been involved in the same time period (Q23). Ninety five of the drivers (91.3%)

had not been in a police-reported crash in the previous five years, eight (7.7%) had been in one, and only one driver had been in two, giving a total of 10 police-reported crashes for the 104 participants. An examination of TARS crash records (providing details of all police-reported crashes in South Australia) was undertaken to check the accuracy of the participants' self-reports. Five of the 104 participants declined to provide their licence number, reducing the sample for this analysis to 99. Of these 99 participants, 13 had been involved in a single police-reported crash, three had been in two, and one had been in three, giving a total of 22 crashes. The self-reports for these 99 drivers indicated a total of 30 crashes but only ten that were reported to the police. Therefore, self-reports yielded a higher number of crashes but fewer police-reported crashes than indicated by official records.

Participants were also asked whether they had been pulled over by the police when driving in the previous five years (Q24). Only seven participants reported that this had occurred and none of them reported it happening more than once.

The number of traffic violations (e.g. speeding) in the previous five years was also ascertained for the participants through self-report (Q25). Eighty five participants (81.7%) reported no traffic violations in the previous five years, 14 (13.5%) reported one, four (3.8%) reported two and one driver reported three. Therefore, traffic violations occurred slightly less often than crashes (refer to Table 9.2).

9.3.1.6 Driving Space

The geographical area in which the participants drove (their "driving space") was assessed by asking the participants if, in the previous year, they drove in their local neighbourhood (Q26), if they drove beyond their local neighbourhood (Q27), if they drove in an unfamiliar part of the city (Q28), if they drove beyond the metropolitan area (Q29), and if they drove outside the state (Q30). As stated in section 6.2.2.1, a point was awarded for each of these questions if the answer was "yes", to give a total driving space score out of five. The mean score for driving space was 4.0 (SD = 0.9), demonstrating little restriction of the geographical area in which the participants drove.

It is also instructive to look at the responses to the individual questions to give a more detailed picture of the participants' driving behaviour. The responses to each of the five questions are summarised in Table 9.3, which shows that all participants had driven in their local neighbourhood and nearly all had driven beyond it. Driving outside the metropolitan area and driving in an unfamiliar part of the city were both done by approximately 85% of participants, while approximately two thirds had also driven outside the state. Again, this suggests that the sample of drivers was very mobile.

Table 9.3
Responses to the individual "driving space" questions concerning areas driven in during the previous year (N = 104)

Area	Yes (%)	No (%)
Local neighbourhood	100.0	0.0
Beyond the local neighbourhood	99.0	1.0
Unfamiliar part of the city	84.6	15.4
Outside the metropolitan area	86.5	13.5
Outside the state	68.3	31.7

9.3.1.7 Driving Avoidance

Avoidance of difficult driving situations was scored on a five point scale (1 = 'never' to 5 = 'always') for each driving situation (Q31-39). Again, an overall score was calculated with a possible range from nine (never avoid any difficult driving situations) to 45 (always avoid all difficult situations). The range of scores for this measure of avoidance was nine to 32, with a mean of 13.9 (SD = 5.6).

Figure 9.2 shows the levels of avoidance of each of the difficult driving situations (a table of data is provided in Appendix 9, Table 2). It can be seen that there was a tendency among participants to report never avoiding these difficult situations. Only parallel parking was avoided at least rarely by over half of the participants (refer to Figure 9.2, c). Along with parallel parking, the most avoided difficult driving situation was driving at night in the rain (refer to Figure 9.2, i). The least avoided driving situation was driving alone (refer to Figure 9.2, b).

9.3.1.8 Perceived Barriers to Self-Restriction of Driving

A number of questions addressed the possibility that certain factors would act as barriers stopping participants from self-regulating their driving behaviour. These included the participants' lifestyles (Q40), whether they were relied upon by others to drive (Q41), the availability of public transport (Q42), willingness to use public transport (Q43), the availability of family or friends to provide transport when needed (Q44), and whether they felt comfortable asking family or friends to provide transport (Q45). For each type of barrier, the participants had to rate their level of agreement with a statement that the barrier made it difficult to change when and where they drive. As stated in section 6.2.2.1, this was done on a four point scale, with one point for "strongly disagree" to four points for "strongly agree". A total score for barriers to self-restriction was then calculated, ranging from a low of six to a high of 24, with higher scores indicating greater barriers to changing driving behaviour. The mean for this variable was 14.3 (SD = 4.3). A summary of the responses to each question is provided in Table 9.4, which shows that the greatest barrier to self-regulation among the participants was lifestyle. That is, many participants were used to a certain lifestyle that entailed a certain amount of driving, and maintenance of this lifestyle required maintenance of their driving behaviour. The lack of availability of others to provide transport and the participants' lack of willingness to ask others were the next greatest barriers to self-regulation.

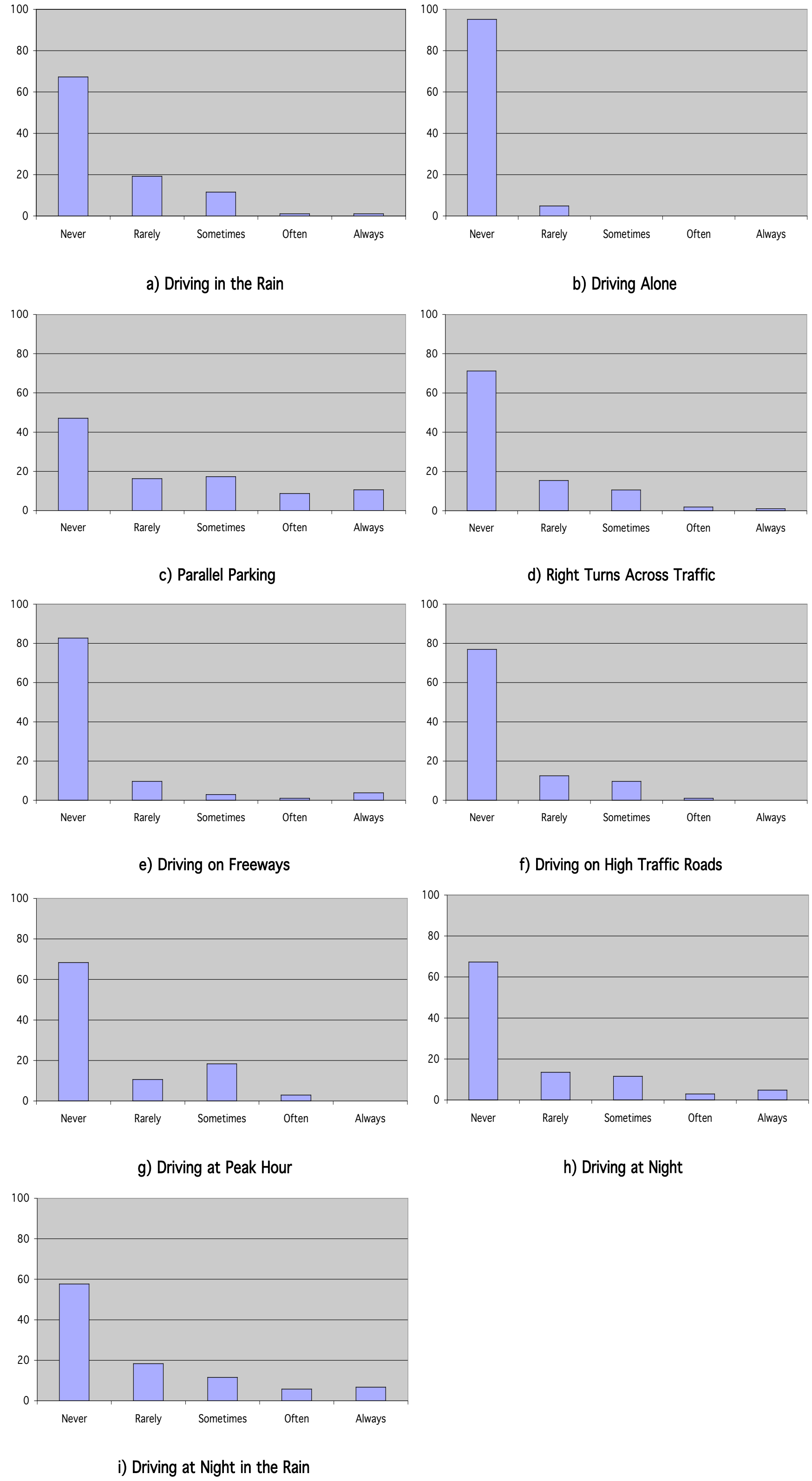

Figure 9.2. Avoidance of difficult driving situations, percentages

Table 9.4
Perceived barriers to self-regulation, percentage of participants (N = 104)

Type of barrier	Strongly disagree (%)	Disagree (%)	Agree (%)	Strongly agree (%)
Lifestyle	6.7	25.0	29.8	38.5
Relied on to drive others	23.1	38.5	23.1	15.4
No public transport	32.7	40.4	14.4	12.5
Don't like public transport	26.9	46.2	12.5	14.4
Family or friends unavailable	24.0	33.7	24.0	18.3
Would not ask family or friends	20.2	35.6	24.0	20.2

9.3.1.9 Regulatory Self-Efficacy

Another way of assessing older drivers' abilities to change their driving behaviour is to ask them how easy or difficult it would be to avoid specific difficult driving situations (Q46-53). For each driving situation, participants had to say whether avoiding it would be "very hard" (one point), "somewhat hard" (two points) or "not hard at all" (three points). As stated in section 6.2.2.1, scores for these questions were then summed to yield a score for regulatory self-efficacy ranging from eight (no ability to self-regulate) to 24 (self-regulation not hard at all). The mean for this variable was 17.4 (*SD* = 4.4). A summary of responses to each item on the scale is provided in Table 9.5. The hardest situations to avoid, according to the participants, were driving alone (the situation most often designated as very hard to avoid) and high traffic roads (the situation least often designated as not hard at all to avoid). The situations easiest to avoid were parallel parking and peak hour.

Table 9.5
Self-regulatory self efficacy, percentage of participants (N = 104)

Driving situation to avoid	Very hard to avoid (%)	Somewhat hard to avoid (%)	Not at all hard to avoid (%)
Rain	31.7	27.9	40.4
Alone	45.2	25.0	29.8
Parallel parking	13.5	20.2	66.3
Right turns	26.9	26.9	46.2
Freeways	26.0	30.8	43.3
High traffic roads	29.8	43.3	26.9
Peak hour	13.5	32.7	53.8
Night	25.0	31.7	43.3

9.3.1.10 Summary

The results from the Driver Mobility Questionnaire indicate that the sample under investigation was very mobile and confident. Very few drivers preferred someone else to drive, drove slower than other traffic, had been given suggestions to restrict their driving, or rated their abilities as being below average. There was great variation in the amount of driving done but few drivers had restricted their driving space (the geographical area in which they drove). The majority of drivers had reduced their driving in the previous ten years, mostly due to a reduced need to drive. There were high levels of confidence in, and low levels of avoidance of, difficult driving situations, with the most commonly avoided situations being parallel parking and driving at night in the rain. Around one quarter of drivers reported a crash in the last five years (although reference to official crash data suggested that participants may have under-reported their crash involvement) and slightly fewer reported having been charged with a traffic violation. The greatest barriers to self-restriction of driving were lifestyle and not having other drivers to rely on, while the driving situations thought to be most difficult to avoid, if required, were driving alone and on high traffic roads.

9.3.2 Relationships Between Questionnaire Measures, Age and Gender

This section examines the correlations between the various questionnaire measures and age, and also examines gender differences using *t*-tests. Although it was expected that self-ratings of abilities, driving exposure, and driving space would decrease with age, age was not significantly correlated with any of these variables (refer to Table 9.6).

Table 9.6
Correlations between age and driving-related variables (N = 104)

Driving variable	Correlation with age
Self-ratings	
Self-ratings of driving ability	-.18
Self-ratings of vision	-.05
Self-ratings of dual task ability	-.21
Driving exposure	
Days driven per week	-.20
Trips taken per week	-.18
Kilometres driven per week	-.20
Driving Space	
Total driving space	-.09

* $p < .01$, ** $p < .001$

With regard to gender, the only variable in Table 9.6 for which there was a significant gender difference was total driving space. As expected, males were found to have greater driving space (M = 4.3, SD = 0.7) than females (M = 3.9, *SD* = 0.9) ($t_{(102)}$ = 2.84, $p = .005$). This difference equates to a medium effect size ($d = 0.55$).

It had been expected that increased age would be associated with lower confidence in difficult driving situations but it can be seen in Table 9.7 that the only individual confidence measures that were significantly related to age, both with medium sized correlations, were confidence driving at night and confidence driving at night in the rain. In each case, lower confidence was associated with increased age. With regard to overall confidence, there was a trend towards lower confidence with age but it was not statistically significant ($p = .040$).

Table 9.7
Correlations between age and driving confidence in difficult situations (N = 104)

Confidence measure	Correlation with age
In the rain	-.17
When alone	-.00
Parallel parking	-.06
Right turns	.01
Freeways	-.15
High traffic roads	-.12
Peak hour	-.17
At night	-.36**
At night in the rain	-.34**
Overall	-.20

* $p < .01$, ** $p < .001$

There was little difference between males and females in terms of confidence in difficult driving situations. The only driving confidence score for which there was a trend towards a difference between the genders was that for confidence when parallel parking ($M_{\text{males}} = 3.4$, $SD = 1.0$, $M_{\text{females}} = 2.8$, $SD = 1.1$). This difference was not significant ($t_{(102)} = 2.52$, $p = .013$) but reflected a medium effect size ($d = 0.50$). Contrary to expectations, overall driving confidence scores were not significantly different between males and females.

The correlations between age and driving avoidance measures are shown in Table 9.8. Similar to the findings for driving confidence, the strongest associations with age among the driving avoidance measures were for driving at night and driving at night in the rain, both with medium sized correlations. Overall avoidance was also significantly correlated with age. In all cases, as expected, increased age was associated with increased avoidance.

Table 9.8
Correlations between age and avoidance of difficult driving situations (N = 104)

Avoidance measure	Correlation with age
In the rain	.23
When alone	-.02
Parallel parking	.04
Right turns	-.05
Freeways	.05
High traffic roads	.25
Peak hour	.13
At night	.38**
At night in the rain	.39**
Overall	.26*

* $p < .01$, ** $p < .001$

Females were found to show significantly greater avoidance of parallel parking ($M_{\text{males}} = 1.5$, $SD = 0.8$; $M_{\text{females}} = 2.6$, $SD = 1.5$; $t_{(100.5)} = 4.81$, $p = .000$, $d = 0.78$) and freeway driving ($M_{\text{males}} = 1.1$, $SD = 0.3$; $M_{\text{females}} = 1.5$, $SD = 1.1$; $t_{(76.4)} = 2.92$, $p = .005$, $d = 0.47$). With regard to overall avoidance, there was a non-significant trend towards females avoiding more difficult driving situations than men ($M_{\text{males}} = 12.4$, $SD = 4.5$; $M_{\text{females}} = 14.9$, $SD = 6.0$; $t_{(102)} = 2.20$, $p = .030$), corresponding to a small to medium effect size of 0.44. That there was evidence of females avoiding difficult driving situations more than males was consistent with expectations.

9.3.3 Relationships Between Questionnaire Measures

This section explores the correlations between the various measures included in the questionnaire. It focuses on the relationships of both driving confidence and driving avoidance with self-ratings of abilities, driving exposure, driving space, and previous crashes and traffic violations. The relationships between driving confidence and driving avoidance are also examined, as are those between driving avoidance, and perceived barriers to self-regulation and total regulatory self-efficacy.

9.3.3.1 Driving Confidence

Correlations were used to assess the relationship between overall confidence in difficult driving situations (the sum of confidence ratings for nine different situations) and other driving attitudes and behaviours. The correlations with self-ratings of abilities, driving exposure variables, and driving space are shown in Table 9.9. As expected, participants' self-ratings of abilities (driving, visual, dual task) were significantly correlated with their overall driving confidence, with correlations falling in the medium to large range. Greater self-ratings were associated with greater confidence. Neither driving exposure nor driving space was significantly correlated with overall driving confidence, indicating that low driving confidence did not limit the amount of driving participants did or the geographical area over which participants drove.

Table 9.9

Correlations between overall driving confidence and various driving attitudes and behaviours (N = 104)

Driving Variable	Correlation with overall driving confidence
Self-ratings	
Self-ratings of driving ability	.45**
Self-ratings of vision	.29*
Self-ratings of dual task ability	.59**
Driving exposure	
Days driven per week	.16
Trips taken per week	.11
Kilometres driven per week	.21
Driving Space	
Total driving space	.09

* $p < .01$, ** $p < .001$

Driving confidence was also expected to be related to driving avoidance, with more confident drivers reporting less avoidance and vice versa, resulting in a significant negative correlation between the two. As the confidence and avoidance questions were based on the same set of driving situations, correlations were calculated between the confidence and avoidance responses for each specific driving situation, as well as between overall confidence and overall avoidance. As seen in Table 9.10, all correlations were significant, with almost all being medium to large in size. This suggests that a lack of confidence in a specific situation was associated with avoidance of that situation. The strongest correlations between confidence and avoidance were for parallel parking, driving at night and driving at night in the rain, while the smallest correlation was for driving alone. Referring back to sections 9.3.1.4 and 9.3.1.7, it can be seen that the strongest correlations between confidence and avoidance were for situations associated with lower confidence and higher avoidance, (parallel parking, driving at night and driving at night in the rain), while the smallest correlation between confidence and avoidance was for the situation (driving alone) characterised by high confidence and low avoidance.

Table 9.10
Correlations between confidence and avoidance scores for a variety of difficult driving situations (N = 104)

Driving situation	Correlation between confidence & avoidance
In the rain	-.44**
When alone	-.28*
Parallel parking	-.67**
Right turns	-.57**
Freeways	-.64**
High traffic roads	-.43**
Peak hour	-.52**
At night	-.67**
At night in the rain	-.66**
Overall	-.67**

* $p < .01$, ** $p < .001$

The possibility that previous crashes or traffic violations were associated with lower overall confidence in difficult driving situations was assessed with independent samples *t*-tests. The results of these analyses are summarised in Table 9.11, which shows that overall driving confidence did not differ according to prior crash involvement or traffic violation.

Table 9.11
The differences in overall driving confidence between those who had been involved in crashes or been charged with traffic violations and those who had not (N = 104)

Type of crash or violation	Mean confidence (*SD*)	*n*	*t* score
Self-reports			
Had any crash	32.0 (6.9)	25	
No crashes	33.4 (6.4)	79	0.92
Had a police-reported crash	29.2 (7.6)	9	
No police-reported crashes	33.4 (6.3)	95	1.86
Pulled over by the police	29.9 (7.5)	7	
Not pulled over	33.3 (6.4)	97	1.34
At least one traffic violation	33.7 (6.8)	19	
No traffic violations	32.9 (6.5)	85	0.47
Official records ($n = 99$)			
Had a police-reported crash	33.7 (7.2)	17	
No police-reported crash	32.9 (6.6)	82	0.41

* $p < .01$, ** $p < .001$

9.3.3.2 Driving Avoidance

Correlations were used to assess the relationships between the avoidance of difficult driving situations (measured by the sum of avoidance ratings for nine different situations) and self-ratings of abilities, driving exposure, and driving space (refer to Table 9.12). It can be seen that greater avoidance of difficult driving situations was related to lower self-ratings of driving ability and dual task ability. Avoidance of difficult driving situations also correlated significantly with reduced driving space. As with confidence scores (refer to Table 9.9), driving avoidance was more strongly related to self-ratings of dual task ability (a medium sized correlation) than to the other variables (all small correlations).

Table 9.12
Correlations between overall driving avoidance and various driving attitudes and behaviour variables (N = 104)

Driving Variable	Correlation with overall driving avoidance
Self-ratings	
Self-ratings of driving ability	-.29*
Self-ratings of vision	-.06
Self-ratings of dual task ability	-.42**
Driving exposure	
Days driven per week	-.08
Trips taken per week	-.12
Kilometres driven per week	-.22
Driving Space	
Total driving space	-.26*

* $p < .01$, ** $p < .001$

The possibility that previous involvement in crashes or being charged with traffic violations was related to driving avoidance was tested by a series of independent samples *t* tests comparing the overall avoidance scores (refer to section 9.3.1.7) for those participants who had crashed or committed violations with scores for those participants who had not. These results are summarised in Table 9.13. As was the case for driving confidence (refer to Table 9.11), there were no differences in driving avoidance according to previous involvement in crashes or having been charged with traffic violations.

Table 9.13

The differences in overall driving avoidance between those who had been involved in crashes or been charged with traffic violations and those who had not (N = 104)

Type of crash or violation	Mean avoidance (*SD*)	*n*	*t* score
Self-reports			
Had any crash	14.1 (6.3)	25	
No crashes	13.9 (5.4)	79	0.15
Had a police-reported crash	17.1 (8.0)	9	
No police reported crashes	13.6 (5.2)	95	1.28
Pulled over by the police	16.1 (7.2)	7	
Not pulled over	13.8 (5.4)	97	1.09
At least one traffic violation	12.7 (5.4)	19	
No traffic violations	14.2 (5.6)	85	1.04
Official records (n = 99)			
Had a police-reported crash	13.7 (6.0)	17	
No police reported crashes	14.2 (5.6)	82	0.39

* $p < .01$, ** $p < .001$

Finally, the correlation between overall avoidance of difficult driving situations and total perceived barriers to self-regulation was not found to be significant (r = -.09, p = .347). This finding was contrary to expectations that lower driving avoidance would be associated with greater perceived barriers to self-regulation. However, the finding of a significant correlation between overall avoidance and regulatory self-efficacy, or the ease of organising one's life so that difficult driving situations may be avoided, (r = .28, p = .004) was consistent with expectations.

9.4 Discussion

The Driver Mobility Questionnaire asked participants to provide details about their current driving status, the amount of driving they did, their self-ratings of different abilities (driving, vision, dual tasks), any reductions in the last ten years in the amount of driving they did, whether anyone had suggested they restrict or cease their driving, their confidence in difficult driving situations, crashes that they were involved in and traffic violations that they were charged with during the previous five years, their driving space (geographical extent of their driving), their avoidance of difficult driving situations, any barriers they encountered to restriction of driving, and the ease with which they could avoid difficult driving situations if they wished. Gender differences and relationships with age were investigated for these variables, and the relationships between the variables were also examined.

9.4.1 Current Driving Practices and Attitudes

The examination of current driving attitudes and behaviour revealed a clear desire for independent mobility, with all but six drivers preferring to drive themselves rather than using public transportation or being driven by someone else. This obvious preference for driving is consistent with findings that older adults remain dependent on car travel for their transportation needs (Jette & Branch, 1992). The majority of drivers also drove five days per week or more, while very few reported having restricted driving space, consistent with a previous study in the USA by Owsley et al. (1999). Nearly 70% of drivers in the present study reported driving outside the state in the previous year, indicating a high degree of mobility. However, high variability of driving behaviour was evident in the findings that trips taken by car per week ranged from two to 30, while kilometres driven per week ranged from 15 to 360. Therefore, older adults almost universally prefer independent mobility but there is considerable variability in the extent to which they exercise this mobility.

The majority of drivers reported reducing their driving in the last ten years and almost all of these drivers reported doing so because they had less need to drive. It could be that this reduced need to drive was mainly due to retirement, which has previously been linked to reduced driving among older adults (e.g. Raitanen et al., 2003). It is also notable that this explanation for reduced driving was almost universally given rather than one couched in terms of declines in functional abilities that necessitated lower levels of driving. However, Kelly (1999) cautioned that financial reasons may be given by older adults for driving cessation rather than admitting that cessation was brought about by declining abilities. It is possible that this bias in responses when older adults are asked about cessation also occurs when they are asked about reductions in driving. Furthermore, only six participants admitted that it had been suggested to them that they cease or restrict driving. This is less than half the number who were referred for a driving assessment. It is possible that some of the drivers who had been referred for an assessment omitted to mention that it had been suggested to them that they cease or restrict their driving, or it may be that referral for assessment in some cases was not specifically associated with a recommendation for restriction or cessation of driving but merely with a recommendation that driving ability be assessed.

The majority of drivers claimed that they had above average (“good” or “excellent”) driving ability and vision, with very few admitting to below average abilities (one for driving ability, three for vision). The finding of high self-ratings of vision among older drivers is consistent with a study by Kline et al. (1992) who found that over 90% of drivers aged 60 to 79, and over 70% of those aged 80 or more, reported their vision to be “good” or “excellent”. Similarly, a recent survey by Charlton et al. (2003) found that 76% of drivers aged over 55 described their vision at night as “good” or “excellent”. High self-ratings for driving ability have also been reported previously in a study by Owsley et al. (1999) in which 86% of older drivers reported being above average (“good” or “excellent”) drivers. As few participants in the present study claimed to be below average drivers, it would be expected that few would report feeling it necessary to drive more slowly than other traffic and, indeed, only 12% claimed to do so. For self-ratings of dual task ability, a slight majority of participants reported being either “average” or “fair” rather than “good” or “excellent” (53 versus 51) but the results still indicated that few drivers thought that there were any deficits in their dual task ability (none said “poor”, 10 said “fair”).

Nearly a quarter of the sample of older drivers reported having been in a crash in the past five years, with ten of these 35 crashes having been reported to the police. An analysis of the official records (the TARS database) revealed that, for the 99 participants who provided their licence number and whose self-reports indicated 30 crashes in the previous five years, there were a total of 22 crashes reported to the police. Therefore, overall self-reported crash numbers were higher than those in the official records, as previously reported by Marottoli et al. (1997) and Fildes et al. (1994), which is likely to be due to self-reports including crashes not severe enough to be reported to the police and entered into official records. However, participants under-reported crashes that were reported to the police (self-reports indicating 10 police-reported crashes rather than 22). It could be that some drivers forgot that their crashes were reported to the police but, of the 17 drivers whose crashes were included in the TARS database, there were six whose number of crashes in the official database exceeded the number of crashes they claimed to have had (i.e. self-reports), including non-police reported crashes. This indicates that some crashes must have been omitted from participants' self-reports. These findings vindicate the decision to obtain both self-reported *and* official crash data.

According to the official South Australian police crash statistics for a five year period from 1994 to 1998, examined in detail in Chapter 2, the number of crashes per 100 licensed drivers for different age groups was 21.5 for those aged 55 to 64, 20.9 for those aged 65 to 74, 18.7 for those aged 75 to 84 and 19.6 for those aged over 84 (refer to section 2.3.1.3). A total of 22 police-reported crashes among the 99 study participants equates to a rate of 22.2%. This comparison suggests that, with regard to crash involvement, the drivers in the sample were representative of the overall older driver population in South Australia.

The greatest perceived barrier to self-regulation was maintenance of lifestyle, reported by nearly 70% of participants, followed by the unavailability of family and friends to provide transport when needed (42%) or the unwillingness to ask them for help with transportation (44%). A quarter of participants claimed that public transportation was unavailable to them. For comparison, a study in the USA by Stalvey and Owsley (2000) found that inadequate public transportation was reported by three quarters of respondents to be a barrier to self-regulation, followed by the unavailability of friends or family (57%) and maintenance of lifestyle (54%). In both this and Stalvey and Owsley's study, being relied on by others for transport was reported by just over 35% of drivers. It appears that the two sets of responses are broadly comparable, except that the provision of public transportation in Adelaide, South Australia was viewed more favourably than that in the region of the USA where Stalvey and Owsley conducted their study.

When asked about the ease or difficulty of avoiding specific difficult driving situations if it was their wish to do so, driving alone and high traffic roads were reported to be the most difficult to avoid, while parallel parking and peak hour were reported to be the easiest to avoid. The need to drive alone fits with the desire for independent mobility, while the difficulty of avoiding high traffic roads is likely to be due to the fact that the study participants live in the metropolitan area, a situation in which it is difficult to travel beyond one's immediate neighbourhood without encountering an arterial road featuring heavy traffic. All participants reported driving beyond their immediate neighbourhood and so avoidance of high traffic roads would have been difficult. The relative ease of avoiding parallel parking would be due to drivers being able to find parking spaces that did not require that manoeuvre. Avoidance of peak hour, on the other hand, could be related to retirement and the ability to choose when driving is done (Eberhard, 1996).

The results for the questions about confidence in, and avoidance of, difficult driving situations were consistent with each other, with confidence scores generally at the higher end of the scale, while avoidance scores were generally at the lower end. This suggests a confident sample of drivers who did not often find it necessary to avoid difficult driving situations. Also consistent were the findings of low confidence and high avoidance for parallel parking and driving at night in the rain, while there was high confidence and low avoidance reported for driving alone. The finding that driving alone was the least avoided difficult situation and was not viewed as very difficult (high level of confidence) is consistent with previous studies examining this set of difficult driving situations (Ball et al., 1998; Owsley et al., 1999; Stalvey & Owsley, 2000). The lack of avoidance of driving alone also reflects the difficulty of doing so, as expressed by the participants, while the higher avoidance of parallel parking would be related to the reported ease of avoiding it.

9.4.2 Relationships With Age and Gender

Age was not found to be significantly related to any of the self-rated variables (driving ability, vision, dual task ability). This was contrary to expectations that, with increasing age, older adults would be more likely to perceive declines in such abilities. Furthermore, as increased age was associated with poorer vision and poorer driving performance according to objective measures (see section 8.3.3), this suggests that many older adults may be unaware of declines in these abilities. This suggestion is tested more directly in Chapter 10, when self-ratings of abilities (driving, vision, dual task) are directly compared to the objective measures of those abilities.

In terms of the amount of driving done, age was not associated with self-reported measures of driving exposure (days driven per week, trips taken per week, kilometres driven per week) or driving space (the geographical area in which driving is done). This is inconsistent with previous research, which has reported decreases in driving with age (Lyman et al., 2002; Maycock, 1997; OECD, 2001; Rabbitt et al., 2002; Ryan et al., 1998). The failure to find a relationship between age and driving exposure could be due to inaccuracies in the responses of the participants. In particular, it could be that participants had difficulties accurately estimating the number of kilometres driven per week. The lack of a relationship between age and driving space was also contrary to expectations but may be due to the fact that there were few drivers in the sample who restricted their driving space.

Increased age shared moderate relationships with both lower confidence in, and greater avoidance of, night driving and driving at night in the rain. Also, increased age shared a limited relationship with overall avoidance. A relationship between age and driving avoidance has been reported in previous research (Charlton et al., 2003; Cooper, 1990b; Forrest et al., 1997; Holland & Rabbitt, 1994; Raitanen et al., 2003; Rimmo & Hakamies-Blomqvist, 2002), whereas the relationship between age and confidence has not (Marottoli & Richardson, 1998; Rabbitt et al., 2002). The present study was consistent with the latter findings, in that overall confidence was not lower with increased age, but the present study has also demonstrated that age is associated with reductions in confidence in *specific* driving situations. That is, for the most part, confidence when driving stays intact with increased age but appears to decrease when driving at night and at night in the rain.

In regard to gender, females were found to have a smaller driving space than males, and to be more likely to avoid parallel parking and driving on freeways. Although these gender differences were minor, they were consistent with previous findings that females practise greater self-regulation of driving than males (Burns, 1999; Gallo et al., 1999; Raitanen et al., 2003; Rimmo & Hakamies-Blomqvist, 2002). It will be interesting to see if these patterns remain in the future, given that the driving behaviour of females more closely matches that of males in younger cohorts (Eberhard, 1996; Hakamies-Blomqvist, 1996; Laapotti, 1991; Weinand, 1996).

9.4.3 Relationships Between Questionnaire Measures

Overall driving confidence was related to each of the self-ratings of abilities, with the strongest relationship being with perceived dual task ability. Relationships between self-rated abilities and driving confidence have been reported before (Marottoli & Richardson, 1998; Parker, McDonald, Sutcliffe, & Rabbitt, 2001) but the present study is the first to examine perceived dual task ability. It could be that difficulties performing simultaneous tasks when driving are detected by older drivers prior to any problems with driving overall, resulting in a stronger relationship between confidence and perceived dual task ability than between confidence and perceived driving ability.

There were no significant relationships between overall confidence and driving exposure (the amount of driving done) or driving space (the geographical area in which driving was done). This was contrary to expectations, given that relationships between confidence and the amount of driving done have been found in other studies (Marottoli & Richardson, 1998; Parker et al., 2001; Rabbitt et al., 2002). As noted earlier, the failure to find significant correlations with driving exposure and driving space could be due to inaccuracies in the participants' estimates of driving exposure and the rarity of restriction of driving space among the study participants, respectively.

The failure to find differences in confidence according to previous crash involvement or traffic violations is consistent with active older drivers disregarding such incidents when assessing their capabilities, possibly regarding them as being due to external or unstable factors, such as errors by other drivers or bad luck. Age differences in attribution for crashes and violations would be an interesting area for future research. It is also possible that the confidence of crash-involved drivers was once higher prior to the crashes. Marottoli et al. (1998) also failed to find a relationship between confidence and previous crashes or violations.

With the exception of driving alone, there were moderate to large relationships (r = -.43 to -.67) between confidence and avoidance scores for the various difficult driving situations. This is consistent with drivers avoiding the situations in which they lose self-confidence or, alternatively, with confidence in situations declining if those situations are avoided. The lower, but still significant, correlation (-.28) between confidence when driving alone and avoidance of driving alone may be the result of very few drivers reporting ever avoiding it. This lack of avoidance of driving alone, as noted earlier, could have been partly the result of the difficulty, as expressed by the participants, of avoiding this situation.

Conversely, the strong correlation (-.67) between confidence when parallel parking and avoidance of parallel parking could be related to the ease, as expressed by the participants, of avoiding parallel parking if it was felt necessary. That is, drivers did not find it difficult to avoid parallel parking and so, if they lacked confidence in performing that manoeuvre, they were able to avoid it. In this way, the ease of avoiding a difficult driving situation, if a person wishes to, could have considerable bearing on whether avoidance of that situation is related to decreased confidence in it. The hardest situations to avoid, according to the participants, were driving alone and high traffic roads, while the easiest to avoid were parallel parking and peak hour. The relationship between low *overall* confidence in, and high *overall* avoidance of, difficult driving situations is consistent with the findings of Charlton et al. (2003).

Overall avoidance of difficult driving situations (a measure of self-regulation) was found to be associated with lower self-ratings of driving and dual task ability but not self-ratings of vision. Therefore, it is possible that detection of declining vision lowers confidence when driving in difficult situations but does not prompt avoidance of them. However, as vision was mostly rated by participants at the higher end of the scale, it may be that it is only when vision is believed to be below average or poor that avoidance of driving occurs among older drivers. Charlton et al. (2003) did find that those with lower self-rated vision were more likely to report avoidance of driving, although that study used avoidance of any situation as the outcome variable rather than a variable summing frequencies of avoidance of a number of situations.

Overall avoidance of difficult driving situations was also related to a smaller driving space (a smaller geographical area in which driving was done), suggesting that those practising self-regulation tend to experience some restriction of mobility. It could also be that those who reduce the geographical area in which they drive also decide to accompany this reduction in driving with avoidance of difficult driving situations. For example, someone who does not drive beyond the metropolitan area may find that they can also avoid driving on freeways. In contrast to driving space, there were no significant relationships between avoidance and driving exposure. The latter finding may provide an indication that mobility is not greatly restricted by self-regulation or, again, it could be due to inaccuracies in participants' estimates of the amount of driving they did.

Finally, avoidance of difficult driving situations was not related to self-reported crash or violation history, consistent with the finding for driving confidence. While Ball et al. (1998) found self-regulation to be greater among those who had previously crashed, Daigeneault et al. (2002a) did not. As noted earlier for confidence, it could be that the avoidance levels of drivers changed after experiencing crashes or being charged with violations, and came to match the levels of other drivers not involved in crashes or convicted of violations. A prospective study is needed to clarify whether adverse driving events are related to avoidance and changes in confidence. Of those studies that have evaluated the success of self-regulation using prospective crash data, Ball et al.'s

(1998) results were affected by attrition of the sample, while Lesikar's (2002) study was affected by a small sample size. In both cases, these methodological problems raise doubts about the reliability of the results.

9.4.4 Limitations and Conclusions

A limitation of this study is that the driving behaviour measures are based on self-reports. As noted previously, there may be errors in the estimates of driving exposure (amount of driving done per week) which are likely to be random. Also, as noted, there were apparent omissions in the self-reported crash data, and it is likely that there are omissions for the self-reported traffic violations as well. These could be due to oversights or deliberate omissions. Self-reported measures may also be affected by response bias and it may be that, for some questions, participants tried to give a "good" or socially desirable account of themselves, reporting high driving ability and driving confidence, and low driving avoidance. Volunteer bias may also have affected the results, with older drivers willing to participate in a study involving a driving test and access to official crash data being more likely to be a confident sample of drivers who feel little need to restrict their driving.

Overall, this chapter has demonstrated that this sample of older South Australian drivers was confident about their driving ability and, perhaps based on this confidence, reported a low level of avoidance of difficult driving situations. However, there were still a significant number who did avoid some difficult driving situations, especially parallel parking and driving at night in the rain. The issue in need of resolution is whether those who do lose confidence in their driving ability and restrict their exposure to these difficult situations are those whose health, functional ability or driving ability is in decline. Whether the self-regulation reported in this chapter was linked to an accurate assessment of capabilities by the older drivers themselves is addressed in the following chapter.

CHAPTER 10: THE RELATIONSHIPS BETWEEN FUNCTIONAL AND DRIVING ABILITIES, AND SELF-REGULATION

10.1 Introduction

If “self-regulation” of driving behaviour among older drivers is to be an effective means by which to reduce crash involvement while maintaining mobility, it is important that the older drivers who restrict their driving are those who have a higher risk of crash involvement. The present study assessed this is by investigating the relationships between the self-regulation of driving and both the functional and driving abilities of a sample of older drivers.

As reported in section 4.3.2, previous studies have found that the restriction of driving behaviour is associated with poorer general health (e.g. Kostyniuk et al., 2000), poorer vision (e.g. Owsley et al., 1999) and reduced visual attention (e.g. Ball et al., 1998). There is also some evidence (e.g. Cotrell & Wild, 1999) that the decreased mental status that accompanies dementia decreases the likelihood of appropriate self-regulation, although other studies on older drivers from the general community have found a relationship between decreased mental status and restriction of driving (e.g. Freund & Szinovacz, 2002). Studies examining either the self-regulation or self-ratings of driving ability of older drivers in relation to performance in on-road driving tests have tended not to find a relationship between these variables. However, the samples used in these have consisted of only very old drivers (Charlton et al., 2001; Marottoli & Richardson, 1998) or have featured an over-representation of drivers with dementia (Cushman, 1996). It may be that there is a stronger relationship between avoidance of difficult driving situations and actual driving ability among drivers aged over 60 who are recruited from the general community.

In light of these previous findings, it was expected that those participants who regulated their driving behaviour would be those whose health, and functional and driving abilities were poorer. Therefore, it was hypothesised that poorer general health, and lower functional and driving ability, would be associated with lower self-ratings of driving ability, lower confidence when driving in difficult situations (e.g. in the rain at night) and greater avoidance of difficult driving situations. It was also expected that self-ratings of vision would decrease with declines in performance on objective tests of vision and that self-ratings of dual task ability would decrease with declines in actual dual task performance. Finally, as was done for on-road driving performance (section 8.3.4), the best predictors of self-regulation (overall avoidance of difficult driving situations) were identified using a linear regression procedure, with health and functional measures as the predictor variables.

The questionnaire measures examined in this chapter were taken from the Driver Mobility Questionnaire (refer to section 6.2.2.1 for a detailed description) and include self-ratings of driving ability, vision and dual task ability, confidence when driving in various difficult driving situations, and avoidance of these situations. The health measures were also taken from the Driver Mobility Questionnaire and include self-reported general health (based on self-reported medical conditions and the extent to which these conditions affected daily functioning), self-reported prescription medication use, and use of medications potentially hazardous to driving. The functional measures were self-reports of depressed mood, state anxiety, and trait anxiety, and objective tests of neck mobility, visual acuity (left eye, right eye, binocular), contrast sensitivity (left eye, right eye, binocular), visual field (left, right, total), mental status, speed of information processing, spatial memory, and visual attention (reaction time and detection error scores on the CVAT) (see section 6.2.2.2 for details of the functional tests). Measures of divided attention, based on reaction time performance on the CVAT, were also developed specifically to enable comparisons with self-ratings of dual task ability. Divided attention scores for the primary task were calculated by dividing primary task reaction times in the dual task conditions by those in the single task condition. Similarly, divided attention scores for the secondary task were calculated by dividing secondary task reaction times in the dual task conditions by those in the single task conditions. These calculations were done separately for the conditions with and without visual distracters on the secondary task. This procedure gave a total of four divided attention scores. These were divided attention for: the primary task without visual distracters on the secondary task, the primary task with visual distracters on the secondary task, the secondary task without visual distracters, and the secondary task with visual distracters. Finally, driving ability was measured using the weighted error score on the on-road driving test (see section 6.2.2.3 for details).

10.2 Analyses

Pearson's Product Moment Correlations were calculated between general health, results on the functional and driving tests, and responses on the Driver Mobility Questionnaire. These correlations are presented separately for self-ratings of abilities, confidence in difficult driving situations and avoidance of difficult driving situations (Descriptive statistics for the health measures and functional and driving abilities were provided in section 8.3.1, while those for the responses on the Driver Mobility Questionnaire were provided in section 9.3.1). Hierarchical regression analyses were used to test the strength of significant relationships between avoidance of difficult driving situations and health and functional measures, after controlling for age. These analyses were only conducted for driving avoidance because this was the only questionnaire measure found to be significantly related to age (see section 9.3.2). All correlational analyses used an alpha level of .01. As noted previously, this conservative alpha level was chosen to guard against the increased likelihood of Type I errors resulting from multiple comparisons. Also, the size of correlations was evaluated according to Cohen's (1992) classifications of small (between .1 and .3, accounting for between 1 and 9% of the variance), medium (between .3 and .5, accounting for between 9 and 25% of the variance) and large (over .5, over 25% of the variance). An exploratory analysis to identify the best predictors of self-regulation (overall avoidance of difficult driving situations) was conducted using a linear regression procedure, with a stepwise method of entry and the conventional entry criterion of alpha = .05. Only those variables correlated with overall driving avoidance at the level of $p < .01$ were used in the regression analysis.

10.3 Results

10.3.1 Self-Ratings of Abilities

Pearson's Correlation coefficients were calculated between all health and functional measures and participants' self-ratings of driving ability. The findings from this procedure are provided in Table 10.1, which shows that general health and indices of depressed mood and anxiety were more closely related to self-ratings of driving ability than the majority of functional measures. Of the functional measures, only total neck mobility was significantly correlated with self-rating of driving ability. General health shared a medium-sized correlation with self-ratings of driving ability but all other correlations were in the small range.

Table 10.1
Correlations between self-ratings of driving ability and health and functional measures (N = 104)

Test	Correlation with self-rated driving ability
Health	
General health	-.37**
Medication use	-.16
Hazardous medication	-.15
Depressed mood	
Geriatric Depression Scale	-.28*
Anxiety	
State Anxiety	-.21
Trait Anxiety	-.29*
Physical functioning	
Total neck mobility	.29*
Vision	
Visual acuity, left eye	-.06
Visual acuity, right eye	-.07
Visual acuity, binocular	-.17
Contrast sensitivity, left eye	.01
Contrast sensitivity, right eye	.04
Contrast sensitivity, binocular	.11
Visual field, left eye	.10
Visual field, right eye	.13
Total visual field	.14
Mental status	
3MS	-.04
MMSE	-.05
Speed of info processing	
Symbol Digit	.08
Spatial memory	
Total Spatial Span	.16

Note: 3MS = Expanded Mini Mental State Examination, MMSE = Mini Mental State Examination
* $p < .01$, ** $p < .001$

The relationship between self-rated driving ability and attention was also determined using correlation coefficients. Table 10.2 shows the correlations between self-rated driving ability and the reaction time and detection error scores from the CVAT. Only detection errors in dual task conditions were included in the analysis because of low reliability for detection error scores in the single task conditions (see section 7.3.2). It can be seen that there were no significant correlations between visual attention and self-ratings of driving ability.

Table 10.2

Correlations between CVAT median reaction times and detection error scores, and self-ratings of driving ability (N = 104)

Test	Correlation between reaction time score and self-rating	Correlation between detection error score and self-rating
Single task		
Primary	-.06	
Secondary, no visual distracters	-.05	
Secondary, visual distracters	-.13	
Dual task		
Primary, no visual distracters on secondary	-.05	.04
Secondary, no visual distracters	-.09	.05
Primary, visual distracters on secondary	-.03	-.04
Secondary, visual distracters	-.25	-.23

Note. CVAT =Computerised Visual Attention Test
**p* < .01, ***p* < .001

It was hypothesised that self-ratings of vision would be related to objective measures of vision (visual acuity, contrast sensitivity, visual field). Contrary to expectations, no measures of vision were found to be significantly correlated with self-ratings of vision (see Table 10.3).

Table 10.3

Correlations between vision test scores and self-ratings of vision (N = 104)

Test	Correlation with self-rating of vision
Visual acuity, left eye	-.18
Visual acuity, right eye	-.18
Visual acuity, binocular	-.16
Contrast sensitivity, left eye	.03
Contrast sensitivity, right eye	.06
Contrast sensitivity, binocular	.16
Visual field, left eye	.01
Visual field, right eye	.08
Total visual field	.06

* *p* < .01, ** *p* < .001

Self-ratings of dual task ability were compared to four measures of divided attention obtained from the CVAT. Table 10.4 shows that the means and standard deviations for the four measures of divided attention were largely consistent across the four different conditions, with reaction times increasing by 10 to 20% on average when division of attention was required (i.e. divided attention scores of 1.1 to 1.2). It can also be seen that participants' self-rated dual task ability was only correlated with their actual divided attention performance for the secondary task with visual distracters. Thus, participants who were most detrimentally affected by having to perform this difficult secondary visual attention task (detecting cars embedded within visual distracters) while also performing a competing primary task (X detection) were those who were more likely to report lower self-ratings for dual task ability. This provides some support for the hypothesis that self-ratings of dual task ability would be related to actual dual task ability.

Table 10.4
CVAT divided attention scores: means, standard deviations, and correlations with self-ratings of dual task ability (N = 104)

Divided attention score	Mean (*SD*)	Correlation with self-rated dual task ability
Primary task, without visual distracters on the secondary task	1.1 (0.1)	.08
Primary task, with visual distracters on the secondary task	1.1 (0.1)	.09
Secondary task, without visual distracters	1.2 (0.1)	-.14
Secondary task, with visual distracters	1.2 (0.1)	-.36**

Note. CVAT = Computerised Visual Attention Test
* $p < .01$, ** $p < .001$

The relationship between self-ratings of driving ability and actual driving ability was also assessed using correlations. It was found that on-road driving test performance was not significantly correlated with self-ratings of driving ability ($r = -.14$, $p = .189$). Self-ratings of vision were also not significantly related to on-road driving test performance ($r = -.04$, $p = .712$) but there was a significant correlation between self-ratings of dual task ability and driving test performance ($r = -.30$, $p = .004$). This means that those whose actual driving ability was poorer tended to report poorer ability to perform two tasks simultaneously but not poorer perceived driving ability or vision.

10.3.2 Driving Confidence

It was hypothesised that lower confidence in difficult driving situations would be related to poorer health, and poorer functional and driving abilities. The correlations between overall driving confidence and functional measures are provided in Table 10.5. It can be seen that the measures most strongly correlated with driving confidence were measures of physical health and mood. Poorer general health, depressed mood, and higher trait anxiety were significantly associated with reduced driver confidence, with correlations in the medium range. In contrast, none of the functional ability measures were significantly correlated with confidence.

The prediction that reaction times and detection errors on the CVAT would be related to driving confidence was also tested using correlation coefficients. Table 10.6 shows that only two of the seven reaction time measures correlated significantly with overall driving confidence, these being reaction time on the secondary task in the two dual task conditions (both medium-sized correlations). As expected, longer reaction times were associated with lower driving confidence. Again, for detection errors, only scores in the dual task conditions were used in the analysis. Only one of the four detection error scores (secondary task in the dual task condition, featuring visual distracters) was significantly related to driving confidence. A greater number of detection errors on this task was associated with lower driving confidence.

Table 10.5

Correlations between overall driving confidence and health and functional measures (N = 104)

Test	Correlation with overall driving confidence
Health	
General health	-.30*
Medication use	-.24
Hazardous medication	-.12
Depressed mood	
Geriatric Depression Scale	-.33**
Anxiety	
State Anxiety	-.18
Trait Anxiety	-.41**
Physical functioning	
Total neck mobility	.13
Vision	
Visual acuity, left eye	-.11
Visual acuity, right eye	-.22
Visual acuity, binocular	-.20
Contrast sensitivity, left eye	.17
Contrast sensitivity, right eye	.21
Contrast sensitivity, binocular	.24
Visual field, left eye	.07
Visual field, right eye	.23
Total visual field	.18
Mental status	
3MS	.12
MMSE	.10
Speed of info processing	
Symbol Digit	.20
Spatial memory	
Total Spatial Span	.12

Note. 3MS = Expanded Mini Mental State Examination, MMSE = Mini Mental State Examination

* $p < .01$, ** $p < .001$

Table 10.6

Correlations between median reaction times and detection error scores on the CVAT and overall driving confidence (N = 104)

Test	Correlation between reaction time and confidence	Correlation between detection error score and confidence
Single task		
Primary	-.24	
Secondary, no visual distracters	-.17	
Secondary, visual distracters	-.16	
Dual task		
Primary, no visual distracters on secondary	-.18	-.07
Secondary, no visual distracters	-.30*	.01
Primary, visual distracters on secondary	-.16	-.15
Secondary, visual distracters	-.32*	-.35**

Note. CVAT = Computerised Visual Attention Test

*$p < .01$, ** $p < .001$

The relationship between confidence when driving in difficult situations and on-road driving ability was also assessed using correlations, which are shown in Table 10.7. It can be seen that performance in the on-road driving test was moderately correlated with confidence when driving at night and at night in the rain, and correlated to a lesser degree with confidence driving in the rain. There was only a trend towards lower overall driving confidence with poorer performance on the driving test (p = .015). All correlations were in the expected direction, with poorer driving test performance (more errors on the on-road driving test) associated with lower driving confidence.

Table 10.7
Correlations between confidence in difficult driving situations and driving performance (n = 90)

Confidence measure	Correlation with driving ability
In the rain	-.29*
Alone	-.04
Parallel parking	-.10
Right turns	-.07
Freeways	-.11
High traffic roads	-.17
Rush hour	-.22
At night	-.36**
At night in rain	-.40**
Overall confidence	-.26

* $p < .01$, ** $p < .001$

10.3.3 Driving Avoidance

The relationship between functional abilities and the avoidance of difficult driving situations (a measure of driver self-regulation) was also examined using correlations (refer to Table 10.8). It can be seen that driving avoidance was only related to three variables, such that increased avoidance was reported by those with poorer general health, greater medication use, and worse right eye visual acuity, with the relationships being small to moderate in size. This suggests that avoidance of difficult driving situations was related to health and some aspects of vision.

Table 10.8

Correlations between overall driving avoidance and health and functional measures (N=104)

Test	Correlation with overall driving avoidance
Health	
General health	.32**
Medication use	.27*
Hazardous medication	.06
Depressed mood	
Geriatric Depression Scale	.08
Anxiety	
State Anxiety	.13
Trait Anxiety	.21
Physical functioning	
Total neck mobility	-.09
Vision	
Visual acuity, left eye	-.06
Visual acuity, right eye	.25*
Visual acuity, binocular	.08
Contrast sensitivity, left eye	-.13
Contrast sensitivity, right eye	-.23
Contrast sensitivity, binocular	-.12
Visual field, left eye	.12
Visual field, right eye	-.14
Total visual field	-.02
Mental status	
3MS	-.03
MMSE	.02
Speed of info processing	
Symbol Digit	-.18
Spatial memory	
Total Spatial Span	-.07

Note. 3MS = Expanded Mini Mental State Examination, MMSE = Mini Mental State Examination
* $p < .01$, ** $p < .001$

As age was found to be related to driving avoidance (see section 9.3.2), it was necessary to investigate whether the functional measures that were related to driving avoidance remained so after controlling for age. This was done with hierarchical regression analyses, using overall driving avoidance as the dependent variable, and age (entered at step 1) and the significant variables from Table 10.8 (entered at step 2) as predictors. Table 10.9 shows that general health and medication use both predicted overall driving avoidance, independently of age. However, right eye visual acuity only approached significance as a predictor of driving avoidance after the effects of age had been controlled.

Table 10.9
Results of hierarchical regression analyses examining the contributions of functional measures to the prediction of overall driving avoidance, after controlling for age (N = 104)

Variables	*B*	Adj R^2	ΔR^2	ß	*t*
Age	0.19	.058	.058	.219	2.36
General health	0.79	.132	.074	.289	3.11*
Age	0.22	.058	.058	.246	2.66*
Medication use	0.79	.117	.059	.260	2.80*
Age	0.18	.058	.058	.203	2.07
Visual acuity, right eye	0.17	.084	.026	.196	1.99

* $p < .01$, ** $p < .001$

It was hypothesised that difficult driving situations would be avoided more by those with poorer visual attention abilities. To test this, correlations were calculated between driving avoidance and CVAT performance, using all seven reaction time scores but, again, only the detection error scores from dual task subtests. Table 10.10 reveals that two of the seven reaction time scores and one of the four detection error scores on the CVAT were significantly correlated with driving avoidance, with longer reaction times and greater detection errors, as expected, being associated with greater overall driving avoidance. Two of the measures significantly correlated with driving performance were for secondary task performance on the CVAT subtest requiring dual task performance (divided attention), with visual distracters on the secondary task (selective attention). These correlations were in the small to moderate range.

Once again, hierarchical regression analyses were conducted to assess whether the apparent link between visual attention and driving avoidance existed independently of the confounding effects of age, with avoidance of difficult driving situations as the dependent variable, and age (entered at step 1) and the CVAT measures (entered at step 2) as predictor variables. Table 10.11 shows that two of the three CVAT measures continued to predict driving avoidance after the effects of age had been taken into account. Therefore, there is evidence that visual attention was related to driving avoidance, independently of age.

Table 10.10
Correlations between overall driving avoidance and median reaction times and detection error scores on the CVAT (N = 104)

Test	Correlation between reaction time and confidence	Correlation between detection error score and confidence
Single task		
Primary	.25	
Secondary, no visual distracters	.28*	
Secondary, visual distracters	.14	
Dual task		
Primary, no visual distracters on secondary	.14	.04
Secondary, no visual distracters	.21	.10
Primary, visual distracters on secondary	.11	.01
Secondary, visual distracters	.28*	.35**

Note. CVAT = Computerised Visual Attention Test
*$p < .01$, ** $p < .001$

Table 10.11
Results of hierarchical regression procedures examining the contributions of CVAT measures to the prediction of overall driving avoidance, after controlling for age (N = 104)

Variables	B	Adj R^2	ΔR^2	ß	t
Age	0.21	.058	.058	.236	2.53
Reaction time to cars, single task, no visual distracters	0.03	.114	.056	.254	2.73*
Age	0.16	.058	.058	.183	1.81
Reaction time to cars, dual task, visual distracters	0.01	.087	.029	.209	2.07
Age	0.16	.058	.058	.178	1.87
Detection errors for cars, dual task, visual distracters	0.20	.135	.077	.302	3.17*

Note. CVAT = Computerised Visual Attention Test; cars = stimulus to be detected in the CVAT secondary task
* $p < .01$, ** $p < .001$

A linear regression analysis was performed to identify the functional measures that best predicted driving avoidance. A stepwise method of entering the variables was used, with the candidate predictor variables including age and all of the functional variables that were significantly correlated with overall driving avoidance, these being: general health, medication use, right eye visual acuity, CVAT reaction time for the secondary task in the single task condition without visual distracters, and both CVAT reaction time and target detection errors for the secondary task in the dual task condition with visual distracters. The results of this analysis are summarised in Table 10.12, while an inter-correlation matrix for the predictor variables is provided in Appendix 10. It can be seen that poorer target detection for the secondary task in the dual task condition with visual distracters (a measure of selective and divided attention) was a better predictor of overall driving avoidance than any other functional measure. Another score from the CVAT (reaction time for the secondary task in the single task condition, without visual distracters - a measure of simple visual attention for peripheral stimuli) also made an independent, significant contribution to prediction of driving performance. Greater medication use and poorer right eye visual acuity were also independent, significant predictors of driving avoidance. Notably, age was not found to make a significant contribution. The total proportion of variance in overall driving avoidance accounted for by the regression equation (using the Adjusted R squared value) was 24%.

Table 10.12
Multiple regression predicting overall driving avoidance using functional measures as predictor variables (N=104)

Variables in the model	B	Adj R^2	ΔR^2	ß	t
Percentage of detection errors for the secondary task in the dual task condition, with visual distracters[1]	0.17	.114	.114	.252	2.80**
Medication use	0.74	.161	.047	.244	2.80**
Visual acuity, right eye	0.22	..218	.057	.262	3.03**
Reaction time for the secondary task in the single task condition, without visual distracters[1]	0.02	.241	.023	.181	2.01*

[1] Subtest from the Computerised Visual Attention Test
* $p < .05$, ** $p < .01$

The relationship between on-road driving ability and self-regulation of driving was ascertained by calculating correlations between driving test performance and the avoidance of difficult driving situations. Table 10.13 shows that overall avoidance was not significantly correlated with on-road driving test performance. However, significant correlations were found for the avoidance of specific driving situations, namely driving in the rain, driving at night, and driving at night in the rain.

Table 10.13
Correlations between avoidance of difficult driving situations and driving test performance (n = 90)

Avoidance measure	Correlation with driving ability
In the rain	.33**
Alone	-.01
Parallel parking	.05
Right turns	.09
Freeways	-.02
High traffic roads	.00
Rush hour	-.10
At night	.34**
At night in rain	.35**
Overall avoidance	.20

* $p < .01$, ** $p < .001$

10.4 Discussion

The analyses presented in this chapter have provided some evidence that older drivers adjust their driving in response to deficits in functional and driving ability. However, the relationships between avoidance of difficult driving situations and functional and driving abilities were not strong, suggesting that the self-regulatory practices of older drivers may be less than optimal.

10.4.1 Self-Ratings of Ability

Participants' perceptions of their own driving ability were more strongly related to general health and mood (depressed mood and anxiety) than functional abilities. Indeed, total neck mobility was the only functional variable that was related to perceived driving ability. Furthermore, perceived driving ability was not related to *actual* driving ability. Thus, lower self-ratings of driving ability are not given by those with poorer functional or driving abilities but by those who have been diagnosed with more medical conditions, or who are more anxious or depressed. This finding that older drivers' perceived driving ability is not related to their actual driving ability is consistent with previous studies by Marottoli and Richardson (1998), which was based on an older sample, and by Cushman (1996), which was based on a sample that included a large proportion (35%) of drivers with dementia. If drivers are unable to detect declines in driving ability, then self-regulation in response to declining ability would be unlikely.

Self-ratings of vision were found to be unrelated to measures of actual vision. This is consistent with a study by Stalvey and Owsley (2000), in which participants were not able to detect declines in their visual functioning. Specifically, they found that 70% of participants with deficits in vision or visual attention reported that their vision was “good” or “excellent”. Holland And Rabbitt (1992) also found no correlation between self-rated and actual vision among a sample of adults aged over 50. However, there were very few drivers in the present study whose vision would be regarded as “impaired”. This may be because drivers over the age of 70 in South Australia must obtain a yearly medical certificate establishing fitness to drive, one of the requirements of which is adequate visual acuity (the legal level in Australia is 6/12 or better). These screening procedures would decrease the likelihood of older adults driving when they have a visual impairment. Any drivers who did have visual impairment, and were aware of it, would be less likely to volunteer to participate in a driving study that included vision testing. Caution must be exercised, therefore, in the interpretation of the finding of no relationship between self-rated and objectively-measured vision. A better test of the relationship between self-ratings of vision and actual vision could be conducted with a sample including participants whose vision is poor enough to preclude holding a driver’s licence.

Interestingly, the strongest relationship between a self-rated and an actual ability was for dual task performance. Perceived ability to perform more than one task simultaneously was related to the objectively-measured ability to divide attention on a CVAT subtest that required the detection of stimuli in the peripheral visual field in the presence of visual distracters. This was the most difficult of the visual attention tasks and so it is encouraging that it was the one most closely related to self-assessments of dual task ability. Furthermore, perceived dual task ability was the only self-rating measure that was significantly related to on-road driving ability. It may be that drivers with declining driving ability first notice deficits in their ability to perform more than one task simultaneously. This is an important finding, particularly as perceived dual task ability has not been studied previously in research on older drivers.

10.4.2 Driving Confidence

Another way of looking at drivers' self-evaluations is to look at confidence when driving. The Driver Mobility Questionnaire included a question in which participants had to rate their confidence when driving in a number of difficult driving situations. If older drivers are responsive to declining abilities, it would be expected that driving confidence would be related to functional and driving abilities. As with perceived driving ability, the variables most strongly related to overall confidence were general health, depressed mood, and trait anxiety. This indicates that the drivers with lower confidence in difficult situations were those with more medical conditions, those who were more depressed, and those with an anxious disposition.

A small number of significant relationships were also found with the visual attention variables, especially for the CVAT subtest involving both selective and divided attention to stimuli in the peripheral visual field (secondary task performance in a dual task condition featuring visual distracters). Overall driving confidence was found to be moderately related to both the speed and accuracy scores for this task. This was the most complex component task of the CVAT and its relationship with driving confidence suggests that older drivers may lose confidence in their driving in response to the types of driving difficulties caused by declines in attentional abilities. The finding that there were significant relationships between driving confidence and measures of visual attention contradicts the findings of a study by Stalvey and Owsley

(2000) in which 82% of drivers with poor vision or visual attention reported no difficulty with challenging driving situations.

The relationship of most interest, namely that between driving confidence and on-road driving ability, was not found to be significant. This finding is consistent with that of Marottoli and Richardson (1998), although the correlation in their study of .11 ($p < .05$) was smaller than that found in the present study ($r = -.26$, $p=.015$). (Note: the difference in the direction of these correlations was artefactual). The present study additionally considered specific driving situations, and it was found that poorer driving ability was associated with lower confidence when driving in the rain, at night, and at night in the rain. Thus, the apparent lack of a relationship between overall driving confidence and driving ability conceals relationships between driving ability and confidence *in specific situations*. This is the first study to investigate driving confidence in sufficient depth to find these relationships with driving ability.

10.4.3 Driving Avoidance

The variable of most interest to an investigation of self-regulation is the avoidance of difficult driving situations. If self-regulation occurs in response to declines in functional and driving ability, then performance on functional and driving tests would be expected to correlate with measures of driving avoidance. One of the strengths of this study was that it provided a test of the relationships between functional and driving measures and self-regulation using a sample of drivers with a wide age range and largely recruited from the general community.

Driving avoidance shared moderate relationships with general health and a measure of selective and divided attention to stimuli in the peripheral visual field (detection errors for the secondary task in the dual task condition with visual distracters on the CVAT). Small correlations were found with medication use, right eye visual acuity, and two CVAT reaction time scores: these being simple attention to stimuli in the peripheral visual field (reaction times on the secondary task in the single task condition without visual distracters), and selective and divided attention to stimuli in the peripheral visual field (reaction times on the secondary task in the dual task condition with visual distracters). Therefore, self-regulation was found to be linked, albeit not strongly, with health, vision, and visual attention. These findings are consistent with those reported previously between self-regulation and health (Kostyniuk et al., 2000; Raitanen et al., 2003), vision (Ball et al., 1998; Hennessy, 1995; Owsley et al., 1999) and visual attention (Ball et al., 1998; Hennessy, 1995). The lack of a relationship between mental status and self-regulation is consistent with suggestions that those with lower mental status lack insight and so do not respond to their impairment by regulating their driving behaviour (e.g. Adler et al., 1999; Ball et al., 1998; Eberhard, 1996).

When attempting to identify those variables that best predict overall driving avoidance, the variables with the highest predictive power were: a detection error measure of selective and divided attention for stimuli in the peripheral visual field, medication use, visual acuity for the right eye, and a reaction time measure of simple visual attention to stimuli in the peripheral visual field. Of interest is the finding that driving avoidance was predicted more by health and functional measures than it was by age. This suggests that self-regulation is more likely to be a response to a decline in functioning than to advancing age. This is consistent with Stutts (1998) who found reduced driving exposure and avoidance of difficult driving situations were better predicted by cognitive and visual measures than by age. That two of the four variables that predicted overall driving avoidance were attention measures suggests that declining attention may play an important role in the self-regulatory practices of older drivers, while the significant relationship between medication use and driving avoidance could have been due to the association of medication use with the number and severity of medical conditions.

The finding that visual acuity in the right eye was the visual measure most strongly related to driving avoidance is also of interest, given findings by Ivers et al. (1999) that self-reported crashes were more common among Australian drivers with lower visual acuity in the right eye. This was explained by the authors as being a result of the importance of the right eye for detecting hazards on the right side of the visual field in a jurisdiction where people drive on the left-hand side of the road. It could be that difficulties associated with detecting hazards on the right, associated with lower right eye acuity, lead to older drivers losing confidence in driving and instigating self-regulation. Consistent with this interpretation is that the visual attention measures related to driving avoidance in the regression equation were for the task of detecting targets (cars) in the right periphery rather than responding to targets (Xs) in the central field of vision, although this could also be related to the car detection task being the secondary task in the visual attention test.

Although measures of health, vision and attention were found to predict driving avoidance, the amount of variance that was explained by these variables was only 24% (using the adjusted R^2). Given the breadth of measures used in this study, this finding demonstrates the complexity involved in a person's decision to regulate his or her driving behaviour. It also seems that functional variables only play a limited role in such behaviour. It may be that additional variance could be explained by factors related to lifestyle (e.g. extent of social activities) and personality (e.g. conscientiousness).

The central issue of the thesis is whether older drivers limit their driving in a manner consistent with their driving abilities. This study was designed to address this issue by providing an assessment of the relationship between self-regulation and on-road driving ability in a sample of community-dwelling older drivers. The result of this assessment was that on-road driving ability was *not* significantly correlated with overall driving avoidance, suggesting that older drivers, as a group, do not appropriately self-regulate their driving. Previous studies of self-regulation (Charlton et al., 2001; Cushman, 1996; Marottoli & Richardson, 1998) have also found that self-regulation and driving ability are not related but these studies have been based on samples either of very old drivers or have included a large proportion (over 30%) of drivers who had been diagnosed with dementia. Therefore, one important result of the present study is that these previous findings have now been replicated in a sample of generally healthy, community dwelling drivers aged over 60.

Another important finding was that stronger correlations between driving ability and avoidance were found for a number of specific driving situations (rain, night, night in the rain). Therefore, as with driving confidence, the apparent lack of a relationship between driving avoidance and driving ability appears to conceal significant relationships for specific situations. Older drivers *do* self-regulate in a manner consistent with driving ability *but only for a small number of specific situations*. These driving situations (rain, night, night in the rain) were those for which driving ability was related to driving confidence, and so it could be that these situations are those in which older drivers with poorer driving ability are most likely to experience difficulty, and that they respond to this difficulty with avoidance. This finding, that driving ability is related to the avoidance of a number of specific difficult driving situations, is a new one in the road safety literature, as previous research has not investigated self-regulatory practices in the same depth.

10.4.4 Limitations

There were some limitations of this study that necessitate some caution when interpreting the findings. First, the confidence and avoidance measures were self-reported and it may be that some participants tried to give a 'good' or socially desirable account of themselves, reporting high perceived driving ability, high driving confidence and low driving avoidance. This may have affected the analyses of relationships between these variables and the functional and driving measures. Also, cross-sectional findings for the relationships between functional measures and driving behaviour may not be the same as would be found in a longitudinal study.

Another limitation is that the assessment of on-road driving ability did not assess performance in a number of the difficult driving situations that were the focus of Driver Mobility Questionnaire items regarding driving confidence and driving avoidance. Specifically, the driving test did not asses driving in the rain, alone, on freeways, at peak hour, at night, or at night in the rain. It also did not assess reverse parallel parking. It is likely that the driving performance scores of participants who often avoided difficult driving situations would have been poorer if their driving was assessed in these situations. Therefore, the likely result of this limitation of the driving test is that the relationships reported in this study between driving ability and both confidence in, and avoidance of, difficult driving situations under-estimate the strength of the true relationships. However, the driving tests did assess performance in a wide variety of traffic conditions, ranging from quiet streets to busy main roads. Assessing driving performance in all of the difficult driving situations would have been impractical. Also, as noted by Lundberg et al. (1997, p34), given that some older drivers do restrict their driving in difficult driving situations, it would be "inappropriate to demand more of the elderly than they do of themselves" when assessing their on-road driving ability.

A final limitation is that the results may be affected by volunteer bias. Those volunteering for a study involving an assessment of on-road driving performance may be more likely to be confident about their driving ability. Drivers volunteering for the study who have deficits in driving ability may, therefore, mainly be those who are unaware of these deficits. This would, in turn, reduce the relationships between on-road driving ability and variables such as self-reported driving ability, driving confidence, and driving avoidance. The correlations between these variables reported in this study may again, therefore, under-estimate the strength of the real relationships. As noted previously (refer to section 8.4.2), the problem of volunteer bias is difficult to control for, as random sampling in tests of on-road driving ability is impractical (Lee et al., 2003).

10.4.5 Conclusions

Measures of general health and selective and divided attention were the variables in the present study that were most strongly related to self-regulation of driving behaviour. However, functional measures were limited in the extent to which they predicted self-regulation, and self-regulation was not significantly related to driving ability. Although the nature of the driving test and volunteer bias may have contributed to the latter finding, it must be concluded that self-regulation is not closely related to drivers' abilities. Therefore, it would be useful to compare the relationships between functional measures and driving ability with those between functional measures and self-regulation. Such a comparison would assist in identifying the factors that negatively influence driving ability but which are not associated with the avoidance of difficult driving situations. This, in turn, would indicate some of the factors that older drivers need to consider more carefully when making decisions about their driving practices. This comparison is conducted in the final chapter of this thesis, as part of an overall summary of the findings.

CHAPTER 11: SUMMARY AND CONCLUSIONS

11.1 Introduction

The aim of this thesis was to examine the extent, and correlates, of self-regulation of driving behaviour among a sample of South Australian older drivers (aged 60 or more). The first study involved an analysis of official crash statistics in South Australia over a period of five years, focusing on age differences for crash numbers, crash characteristics, and the conditions in which crashes occur (Chapter 2). This was done to find out whether the patterns of crash involvement for older drivers in South Australia were similar to those previously reported in the literature for other regions (as described in Chapter 1).

Following a review of the literature on older drivers (Chapters 3 and 4), the second study, described in Chapter 5, involved pilot testing a measure developed specifically for assessing the visual attention of older adults (the Computerised Visual Attention Test - CVAT). This test assesses visual attention by measuring target detection and reaction time for central and peripheral stimuli, and in conditions requiring selective and divided attention. The third study involved assessing the test-retest reliability, construct validity and predictive validity of the CVAT in a sample of 20 older drivers (Chapter 7). CVAT measures were found to have good test-retest reliability and to be more closely related to on-road driving ability than standard measures of attention.

The fourth study involved an examination of the driving behaviour and attitudes of 104 drivers aged over 60, with avoidance of difficult driving situations providing an index of self-regulation. These drivers also completed a battery of functional tests measuring psychological factors, vision, physical functioning, various cognitive abilities and attention (the CVAT). Ninety participants additionally completed an on-road assessment of driving ability. All of these measures were described in Chapter 6. This comprehensive study of older drivers enabled an assessment of the relationships between functional and driving abilities (Chapter 8), the extent of self-regulation practised by older drivers (Chapter 9), and the relationships between self-regulation and both functional and driving abilities (Chapter 10).

This final chapter begins with a brief summary of the findings of the first study, in which the crash involvement of older drivers in South Australia was analysed. Following this, the driving attitudes and behaviour of a sample of older drivers in South Australia, fully described in Chapter 9, are briefly summarised. Finally, there will be a comparison, for each of the functional measures, between the extent to which they were related to on-road driving ability and the extent to which they were related to the self-regulation of driving behaviour. This comparison of the findings from Chapters 8 and 10 is designed to determine whether there are functional measures that are related to driving ability but which do not seem to have any influence on the driving decisions of older drivers. Such a comparison is unique in the road safety literature.

11.2 Older Driver Crash Involvement in South Australia

In Chapter 2, it was shown that the patterns of crash involvement for older drivers in South Australia were similar to those found previously in other comparable regions (elsewhere in Australia, USA, UK, Europe). In terms of the *number* of crashes, it was found that older drivers were involved in fewer crashes than young (16-34) and middle-aged (35-54) drivers but that older drivers had higher crash rates than middle-aged drivers on a per kilometre driven basis. However, the latter finding must be treated with some caution because of limitations of the travel distance data used for this analysis. Specifically, the data provided by the Australian Bureau of Statistics were from a vehicle-based, rather than a driver-based, survey and were too unreliable to use for drivers aged over 84. Despite these problems, the findings were consistent with those previously reported in the literature (Frith, 2002; Lyman et al., 2002; Maycock, 1997; OECD, 2001; Ryan et al., 1998), suggesting that South Australian older drivers are typical of older drivers in terms of crash involvement.

The *characteristics* of the crashes that South Australian older drivers were involved in were also analysed. It was found that, relative to crash-involved drivers in younger age groups, older crash-involved drivers were *more* likely to be involved in crashes that resulted in serious or fatal injury; be seriously or fatally injured themselves; be involved in right turn collisions; be turning at the time of the crash; be turning right in right turn collisions; disobey a traffic signal, Give Way or Stop Sign prior to the crash; and be deemed responsible by police for their crashes. Older drivers were *less* likely to have been exceeding the legal blood alcohol limit or the legal speed limit when involved in crashes. These findings are all similar to those reported previously in Australia (Ryan et al., 1998), the USA (Council & Zegeer, 1992; Eberhard, 1996; Partyka, 1983; Preusser et al., 1998), Canada (Cooper, 1990a; Daigneault et al., 2002b) and Europe (Fontaine & Gourlet, 1992; Hakamies-Blomqvist, 1993; Maycock, 1997), again showing that South Australian older drivers are typical of those in other regions; in this context, with respect to the types of crashes they experience.

The third part of the crash database analysis was concerned with the *situations* in which crashes occur. Here, it was found that crash-involved older drivers were less likely than crash-involved drivers in younger age groups to have crashed during peak traffic periods, hours of darkness, or wet weather. These findings replicate those of other studies (Cooper, 1990a; Eberhard, 1996; Fildes, 1997; Hakamies-Blomqvist, 1994; OECD, 2001) and suggest that older drivers may restrict their exposure to these difficult driving situations. This, in turn, suggests the possibility of "self-regulation" of driving behaviour by older drivers. The remainder of the thesis was designed to provide a detailed examination of the self-regulatory driving practices of older drivers.

11.3 Driving Attitudes and Behaviour of Older Drivers

In order to ascertain the extent of self-regulation that is practised by South Australian older drivers, a sample of 104 participants aged over 60 completed a questionnaire (the Driver Mobility Questionnaire) about their driving attitudes and behaviour. This revealed that the older drivers in the study were very mobile, and valued their independence and the maintenance of their lifestyles. There was considerable variation in the amount of driving done by the participants but few drivers restricted the geographical area in which they drove. The majority of drivers had reduced the amount of driving they did in the previous ten years, which was mainly attributed to a lower need for driving. Participants generally perceived their driving ability, vision and dual task ability to be good and reported high levels of confidence in difficult driving situations and low levels of avoidance of these situations. This pattern of results for the questionnaire was broadly consistent with previous research in the area (Burns, 1999; Jette & Branch, 1992; Kline et al., 1992; Owsley et al., 1999; Rabbitt et al., 2002; Stalvey & Owsley, 2000). It was also found that the level of crash involvement of drivers in the sample in the previous five years was typical of older drivers in general, based on the crash statistics analysis presented in Chapter 2. This suggests that the sample of drivers participating in the study was likely to be representative of South Australian older drivers.

Increased *age* was associated with greater avoidance of difficult driving situations (self-regulation) but was not related to self-reported abilities (driving, vision, dual task), driving exposure (days driven per week, trips per week, kilometres driven per week), the geographical area in which driving was done, or overall driving confidence. A relationship between lower confidence and increased age was found only for a small number of specific situations (night driving and driving at night in the rain). The finding of a relationship between age and overall avoidance but not between age and overall confidence is consistent with previous results (Charlton et al., 2003; Forrest et al., 1997; Holland & Rabbitt, 1994; Marottoli & Richardson, 1998; Rabbitt et al., 2002). The lack of a relationship between age and driving exposure is inconsistent with previous findings (Forrest et al., 1997; Maycock, 1997; OECD, 2001) but could be due to inaccurate participant estimates of the amount of driving they did per week.

Gender differences were also apparent, with female drivers having a smaller driving space (geographical area in which driving was done) and being more likely to avoid parallel parking and driving on freeways. Therefore, gender differences were minor but in the expected directions (Burns, 1999; Gallo et al., 1999; Rimmo & Hakamies-Blomqvist, 2002). It will be interesting to see if gender differences are found in future studies, as the driving behaviour of females in more recent cohorts is becoming more like that of their male counterparts (Eberhard, 1996; Hakamies-Blomqvist, 1996; Laapotti, 1991; Weinand, 1996). Gender differences in the cessation of driving have been found to be related to gender differences in lifetime driving experience rather than gender *per se* (Hakamies-Blomqvist & Siren, 2003), and it could be that current gender differences in self-regulation will disappear among newer cohorts in which males and females have shared similar driving patterns throughout their lives.

The relationships between the driving attitudes and behaviour assessed by the questionnaire were also examined. These analyses revealed that overall *confidence* when driving in difficult situations was related to self-ratings of vision and driving ability, the latter consistent with previous findings (Marottoli & Richardson, 1998; Parker et al., 2001), but was most strongly related to self-rated dual task ability. This finding that driving confidence and perceived *dual task* ability were more strongly related than confidence and perceived *driving* ability could be due to older drivers detecting problems with performance of simultaneous tasks when driving prior to detecting any *overall* problems with driving. Confidence was unrelated to driving exposure, contrary to previous findings (Marottoli & Richardson, 1998; Parker et al., 2001; Rabbitt et al., 2002) but, again, this could have been due to inaccurate self-reports of the amount of driving done by participants. Consistent with an earlier study by Marottoli et al. (1998), confidence was unrelated to previous crashes or violations, which may be due to older drivers attributing such events to external or unstable factors. Alternatively, confidence levels may have been higher than average prior to the crashes or violations but may have been reduced after these events to match the levels of drivers not involved in crashes or convicted of violations. Confidence in difficult driving situations was related to avoidance of these situations, with the strongest correlations being for those situations that were reportedly the easiest to avoid (e.g. parallel parking) and the weakest for the situations that were reportedly the most difficult to avoid (e.g. driving alone). The relationship between overall confidence and avoidance had been shown before (Charlton et al., 2003) but the possible mediating effects of the ease of avoidance of specific situations is a new finding.

Greater overall *avoidance* of difficult driving situations (an index of *self-regulation*) was related to lower perceived driving ability and dual task ability but not to perceived quality of vision. This may mean that lower self-ratings of vision affect driving confidence but do not influence self-regulation. Alternatively, it may be that there is a threshold of perceived visual impairment that must be reached before self-regulation of driving occurs. Overall avoidance of difficult driving situations was related, albeit not strongly, to reduced driving space, suggesting that self-regulation may be related to reduced mobility. It could be that avoidance leads to this reduced mobility, or that those who drive less also choose to avoid difficult driving situations.

However, avoidance was not related to reduced driving exposure, suggesting no loss of mobility with self-regulation, although, again, this could be due to inaccurate self-reports of driving exposure. As with confidence, overall avoidance was not related to previous crashes or violations. This finding is difficult to interpret because avoidance may have increased following these crashes or violations, and reached the same level as that of drivers who were not involved in crashes or charged with traffic violations. The most useful test of the relationship between self-regulation and experience of adverse driving events would be one using prospective data. Two studies of this sort (Ball et al., 1998; Lesikar et al., 2002) produced contradictory findings but both were affected by methodological problems that raise doubts about the reliability of the results.

11.4 Relationships Between Functional Measures, Driving Performance and Self-Regulation: A Synthesis of the Findings

The 104 participants who completed the Driver Mobility Questionnaire also completed a battery of functional tests and 90 participants completed an on-road driving assessment. This enabled an assessment of whether driving attitudes and behaviour, particularly self-regulatory practices, were related to health and functional measures, and actual driving ability (see Chapter 10). On-road driving ability was related to perceived dual task ability, confidence when driving in certain situations (in the rain, at night, at night in the rain), and avoidance of these same three situations. Driving ability was *not* related to perceived driving ability, perceived vision, overall confidence in difficult driving situations, or overall avoidance of these situations. The finding that overall avoidance of difficult driving situations was unrelated to performance on the driving test suggests that self-regulation does not occur reliably in response to deficits in driving ability.

Given this lack of a relationship between self-regulation and on-road driving ability, it would be useful to compare the relationships between functional measures and driving ability with those between functional measures and self-regulation. This would identify the factors that negatively influence driving ability but which are not associated with the avoidance of difficult driving situations. These factors would therefore be those that older drivers may need to consider more carefully when making decisions about their driving practices.

The following section considers each of the health and functional measures that were used in the present study, with respect to its relationship with driving ability (full details provided in Chapter 8) and with driving attitudes and behaviour (full details in Chapter 10). If deficits in a health or functional measure are related to poorer driving ability but not self-regulation of driving behaviour, then older adults with deficits in that type of functioning may be a group of drivers who self-regulate *less* than they need to. Conversely, if declines in a health or functional measure are unrelated to driving ability but are related to greater self-regulation, then older adults with deficits in that type of functioning may restrict their driving *more* than they should. The following section makes the above comparisons for health (general health, medication use), mood factors (depressed mood, anxiety), physical functioning (neck mobility), vision (visual acuity, contrast sensitivity, visual field), mental status, speed of information processing, spatial memory, and complex visual attention.

11.4.1 Health and Medication

The correlation between general health and driving ability only approached significance, contradicting claims by a number of authors (Dobbs et al., 1998; Klavora & Heslegrave, 2002; Marottoli, 2002; Wallace & Retchin, 1992; Waller, 1992) that the combination of different medical conditions would be a risk factor for driving difficulties among older drivers. The finding of stronger relationships with driving ability for functional measures, rather than for health, provides empirical support for the argument that functional abilities, rather than medical diagnoses, are of greater importance in the re-licensing process for older drivers (Marottoli et al., 1998; OECD, 2001; Sims et al., 1998; Wallace & Retchin, 1992; Waller, 1992; White & O'Neill, 2000). However, poorer health was moderately related to lower perceived driving ability, lower confidence in difficult driving situations, and greater avoidance of these situations (self-regulation). The finding that poorer health was related to self-regulation of driving is consistent with the literature (Forrest et al., 1997; Kostyniuk et al., 2000; Rabbitt et al., 2002; Raitanen et al., 2003).

These results demonstrate that health is more closely related to driving behaviour than to driving ability. It may be that older adults respond to declining health with alterations of driving behaviour even though these declines in health are, at most, only weakly related to their ability to drive. Although this may mean that older drivers are over-reacting to diagnosed medical conditions, it is still encouraging that poorer health status is related to driving behaviour. Acknowledgement of the presence of medical conditions and their associated symptoms may be a proxy for the evaluation of functional capabilities - evaluations that older adults would have great difficulty undertaking themselves - and so greater self-regulation with poorer health would indirectly provide some degree of relationship between self-regulation and poorer functioning.

Use, at least once per month, of prescription medications was not found to be related to driving ability, nor was use of potentially hazardous medications, although the latter came close to significance. Use of medications, however, was related to confidence when driving in difficult situations and also to avoidance of these situations. Furthermore, medication use was one of four variables to independently predict overall avoidance of difficult driving situations. These results suggest that older drivers may regulate their driving behaviour in response to medication use to a greater degree than is necessary, replicating the results for general health. The relationship between medication use and self-regulation may, in part, be explained by association between greater medication use and a greater number and severity of medical conditions.

When interpreting these findings, it must be remembered that the measures of general health and medication use were based on self-reported information. If participants omitted medical conditions or prescription medications, or understated the extent to which conditions affected their daily functioning, the non-significant trends reported here may underestimate the strength of the true relationships between health measures and driving ability. Given this possibility, and given that acknowledging the symptoms of medical conditions may be a proxy for evaluation of functional capabilities, the appropriate conclusion is that the relationship between self-regulation and health measures is a promising indication of appropriate adjustments to driving behaviour by older drivers.

11.4.2 Mood-Related Factors

None of the mood-related measures (depressed mood, state anxiety, trait anxiety) were related to driving ability, although there was a trend for those with higher depressed mood scores to perform more poorly on the driving test. As there were few participants with scores indicative of depression, it could be that the relationship between depression and driving ability was underestimated by this study. There have been studies conducted previously that have found a relationship between crash involvement and depression among older drivers (Foley et al., 1995; Sims et al., 2000).

With regard to driving attitudes and behaviour, lower perceived driving ability and lower confidence in difficult driving situations were both related to a more depressed mood and an anxious disposition (higher trait anxiety), while avoidance of difficult situations was unrelated to any mood-related measures. There was only a trend for greater driving avoidance by those with an anxious disposition. These results suggest that older drivers who are typically anxious or have a more depressed mood tend to view their driving unfavourably and lack confidence when driving but, despite this, are no more likely to restrict their driving.

It appears that a more depressed mood and anxious disposition are both related to lower perceived driving ability and confidence but are unrelated to actual driving ability and self-regulation. This suggests that these negative mood-related factors may make older drivers think their driving is worse than it is but are not sufficient to prompt alteration of driving behaviour. However, the non-significant trends for the relationship between depressed mood and poorer driving ability, and for the relationship between an anxious disposition and greater driving avoidance, may be worthy of investigation using samples of drivers specifically chosen for higher levels of anxiety and depression than were found in the sample in the present study.

11.4.3 Physical Functioning

The only measure of physical functioning used in the present study was neck mobility, which had previously been found by Marottoli et al. (1998) to be related to the crash involvement of older drivers and by McPherson et al. (1988) to be related to poorer performance by older drivers in an on-road driving assessment. In the present study, however, neck mobility was not found to be related to driving ability, consistent with studies by Odenheimer et al. (1994), Staplin et al. (1998b) and Tarawneh et al. (1993). It was also unrelated to driving confidence and avoidance but was related to perceived driving ability. The latter finding suggests that older drivers may notice restrictions to neck mobility and may think that these restrictions negatively affect their driving ability. However, restrictions in neck mobility do not affect confidence when driving or prompt older adults to restrict their driving. The fact that neck mobility was not related to self-regulation is appropriate given that it was not related to driving ability. It appears that, although restrictions of neck mobility are common among community-dwelling older adults, they are not of great importance in determining driving ability and behaviour. It is possible that only profound deficits in physical functioning that cannot be compensated for with changes to the vehicle one drives prove to be problematic for older drivers.

11.4.4 Vision

Vision was assessed using measures of visual acuity, contrast sensitivity and visual field, with only contrast sensitivity being related to driving ability. Both binocular and left eye contrast sensitivity shared moderate relationships with driving ability and the former was one of four variables to independently predict on-road driving test scores. The importance of contrast sensitivity to driving has been shown previously (Janke & Eberhard, 1998; Wood, 2002a). It is recommended that, if a battery of tests is to be used for the purpose of re-licensing older drivers, a measure of contrast sensitivity should be included. Currently, there is no mention of contrast sensitivity in the Australian guidelines for assessment of fitness to drive (Austroads, 2001).

None of the measures of vision was related to perceived driving ability or driving confidence but there was a relationship between overall driving avoidance and right eye visual acuity. Furthermore, visual acuity in the right eye was one of four variables to make independent contributions to the prediction of driving avoidance. This is consistent with previous findings of relationships between vision and self-regulation (Ball et al., 1998; Hennessy, 1995; Owsley et al., 1999).

Although these findings demonstrate that measures of vision were related to both driving ability and self-regulation of driving among older adults, contrast sensitivity was more important for driving ability whereas visual acuity was of greater importance for self-regulation. Greater use of contrast sensitivity tests in medical assessments, as is recommended given its relationship with driving ability, could possibly increase awareness of contrast sensitivity, which could, in turn, possibly increase the likelihood that self-regulation coincides with declines in this aspect of vision. However, it may be necessary for medical practitioners to take a more active role in discussing vision and driving behaviour, given the finding in the present study that there was no relationship between self-ratings of vision and *actual* vision. That is, older adults may not be capable of detecting declines in their vision, or of evaluating the importance of these declines, and may need guidance from medical practitioners in acknowledging problems with vision and responding to them appropriately.

11.4.5 Mental Status

Deficits in mental status have previously been found to work against appropriate self-regulation of driving due to its association with lack of insight into the loss of driving abilities (e.g. Adler et al., 1999; Ball et al., 1998; Eberhard, 1996). Consistent with this, the present study did not find a relationship between mental status and perceived driving ability, driving confidence, or driving avoidance. However, contrary to expectations, the relationship between mental status and driving ability was only a non-significant trend. The likely explanation for this lack of a relationship between mental status and driving ability is that mental status may be more important among clinical samples, especially drivers with dementia, than among a sample of largely healthy, community dwelling adults.

Given the lack of drivers with dementia in the study sample, conclusions regarding mental status and self-regulation are difficult to draw from the present study. Previous studies using clinical samples have found that drivers do not respond to declines in mental status with self-regulation, despite the fact that such declines are related to losses of driving ability (e.g. Clark et al., 2000; Cushman, 1996; Fitten et al., 1995; Rizzo et al., 2001). This means that drivers with dementia or cognitive impairment comprise a group that needs to be targeted by any interventions aiming to promote self-regulation. These drivers are likely to experience losses of driving ability that they will not detect or respond to without intervention by a carer or medical practitioner.

11.4.6 Speed of Information Processing

Speed of information processing was measured with the Symbol Digit Modalities Test and, as expected, was related to driving ability, although the relationship was not significant after the effects of age were controlled. This suggests that, among a sample of drivers with little cognitive impairment, this measure largely provides an index of age-related slowing in information processing.

Speed of information processing was unrelated to driving attitudes and behaviour. The avoidance of difficult driving situations and speed of information processing were both related to age but not each other.

Therefore, slowed information processing was related to poorer driving ability but not to greater avoidance of difficult driving situations, and so may be indicative of drivers who do not respond to reduced driving ability with self-regulation. The Symbol Digit Modalities Test is quick and easy to administer and so appears to be a good test for assessing speed of information processing in this context, and for identifying drivers who may need to alter their driving behaviour. Additionally, the Symbol Digit tends to be associated with cognitive impairment (Spreen & Strauss, 1997), which is also related to poorer driving ability but not greater self-regulation.

11.4.7 Spatial Memory

Spatial memory, as measured by Total Spatial Span, was related to driving ability and also made an independent contribution to its prediction. The relationship between visuospatial memory and on-road driving ability has been shown before among older drivers (De Raedt & Ponjaert-Kristoffersen, 2000), while Lundberg et al. (1998) showed that poorer visuospatial memory was associated with crash involvement.

In contrast, spatial memory and driving attitudes and behaviour were not related. Specifically, spatial memory was not related to perceived driving ability, confidence in difficult driving situations, or avoidance of these situations. Therefore, poorer spatial memory is related to poorer driving ability among older drivers but is not associated with self-regulation of driving. This means that those older drivers with deficits in visuospatial memory may be a group whose self-regulation of driving is inadequate to compensate for their poorer driving ability.

11.4.8 Visual Attention

Visual attention was found to be very important for the ability to drive: all reaction time scores and two of the detection error scores on the CVAT shared moderate relationships with driving ability. Furthermore, two of the four variables that made independent contributions to the prediction of driving ability were visual attention measures. These were both measures of reaction time to stimuli in the peripheral visual field, with one measure assessing selective and divided attention, and the other assessing simple attention. This emphasises the importance for driving of being able to quickly detect stimuli in the visual periphery. The importance of visual attention for driving ability has been reported previously in studies of older drivers (e.g. Clark et al., 2000; De Raedt & Ponjaert-Kristoffersen, 2000; Hunt et al., 1993; Richardson & Marottoli, 2003).

Visual attention was also related to driving attitudes and behaviour. Although CVAT measures were unrelated to perceived driving ability, two of the reaction time scores and one of the detection error scores were related to confidence in difficult driving situations. Two of these scores were for the CVAT task requiring selective and divided attention to stimuli in the peripheral visual field, which was the most complex task on the CVAT. The other was a measure of simple attention to stimuli in the peripheral visual field. The results for avoidance of difficult driving situations were similar to those for confidence, with avoidance being related to two reaction time scores and one detection error score. Once again, two scores came from the CVAT task that assesses selective and divided attention to stimuli in the peripheral visual field, and the other score came from a task that assesses simple attention to peripheral stimuli. Furthermore, two of the four best predictors of avoidance of difficult driving situations were visual attention measures: detection errors for the task requiring selective and divided attention to stimuli in the peripheral visual field, and reaction times for the task requiring simple attention to stimuli in the peripheral visual field. These results are consistent with previous findings of a relationship between visual attention and self-regulation (Ball et al., 1998; Hennessy, 1995).

Therefore, the relationship between visual attention and driving ability was similar to that between visual attention and driving behaviour. Both driving ability and self-regulation were best predicted by measures of selective and divided attention for stimuli in the peripheral visual field, and by a measure of simple attention for peripheral stimuli. This suggests that the declines in attention that are related to deficits in driving ability among older drivers are also associated with self-regulation of driving. The possibility that older drivers are able to detect and respond to deficits in attention is further suggested by a moderate relationship between *perceived* dual task ability and a measure of *actual* dual task ability (an index of divided attention). Perceived dual task ability was also related to on-road driving ability, confidence in difficult driving situations, and avoidance of these situations. This may mean that older drivers detect declines in their ability to attend to multiple stimuli when driving, lose confidence in difficult driving situations, and respond with self-regulation. Such a causal sequence, however, must remain conjectural and it must also be noted that the relationships between attention and driving ability were slightly larger (mostly moderate) than those between attention and avoidance of difficult driving situations (mostly small). Therefore, although the results suggest a promising relationship between declines in attention and alteration of driving behaviour by older adults, this relationship may not be optimal.

11.4.9 Summary

The functional measures used in the present study can be categorised according to their relationships with driving ability and self-regulation. If a measure was related to both driving ability and self-regulation, then this suggests that deficits in that type of functioning are associated with appropriate self-regulation. If a measure shared a relationship with driving ability but not with self-regulation, then that suggests that older adults with deficits in that type of functioning may be a group who restrict their driving less than they should. If a measure was associated with self-regulation but not with driving ability, then older adults with deficits in that type of functioning may be a group who restrict their driving more than is necessary. If a measure was related to neither self-regulation nor driving ability, then it is not relevant to the issue of self-regulation.

Functional abilities related to both driving ability and self-regulation included vision measures and visual attention, suggesting that drivers with worse vision or visual attention had deficits in their driving ability but were more likely to avoid difficult driving situations. However, these conclusions need to be qualified. Although vision was related to both driving ability and self-regulation, driving ability was more closely related to contrast sensitivity, while self-regulation was more closely related to visual acuity. Therefore, although vision was indeed related to driving ability and older adults with deficits in vision did restrict their driving, these restrictions to driving were not associated with the specific aspect of vision that would have produced appropriate self-regulation. With regard to visual attention, driving ability and self-regulation were both most closely related to divided and selective attention for stimuli in the peripheral visual field but the association was stronger for driving ability, suggesting that the association between self-regulation and visual attention was not optimal.

Functional measures that were related to neither driving ability nor self-regulation included an index of physical functioning (neck mobility), mood-related factors (depressed mood and anxiety) and mental status, suggesting that these functional measures are not relevant to the issue of older driver self-regulation. However, non-significant trends for the relationships between worse driving ability and higher depressed mood scores, and between greater self-regulation and an anxious disposition (trait anxiety) suggest the need for a study specifically designed to examine the self-regulation of older adults with a broader range of scores on indices of anxiety and depressed mood. In regard to mental status, the lack of a significant relationship with on-road driving ability may be due to the use of a largely healthy, community-dwelling sample rather than one featuring a high representation of drivers with cognitive impairment. Given previous research findings relating cognitive impairment to poorer on-road driving ability but not greater self-regulation, drivers with mental status scores suggestive of impairment would be a candidate group for interventions promoting restrictions of driving behaviour.

Visual acuity (as noted above) and health measures (general health and medication use) were more closely related to self-regulation than driving ability. Although the latter finding suggests the possibility that older adults restrict their driving too much in response to medical conditions, it must be borne in mind that the medical conditions examined here, and their associated symptoms, may be easier for older adults to detect and respond to than the declines in functional abilities most closely related to driving ability. As declines in health are often associated with declines in functioning, self-regulation in response to declining health may be a useful proxy for self-regulation in response to declining functional abilities.

There were three functional measures that were related to driving ability but not to self-regulation, indicating that poor results on these measures may identify drivers who are likely to have driving difficulties but not respond to them by restricting their driving. These measures were contrast sensitivity, speed of information processing, and spatial memory. Therefore, drivers with poor contrast sensitivity (but adequate visual acuity), slowed information processing and poorer spatial memory would be good candidates for any educative interventions aiming to encourage self-regulation of driving.

11.5 Overall Conclusions

This thesis was concerned with the self-regulation of driving behaviour by older adults in South Australia. The investigation of self-regulation involved a background study of the crash involvement of older drivers in South Australia across a five year period; a survey of driving attitudes and behaviour among a sample of drivers aged 60 or more; and an examination of the relationship between driving attitudes and behaviour, and performance on tests of functioning and driving ability. One of the main strengths of the study was that actual on-road driving ability was compared with driving behaviour, which had been done very rarely in previous older driver research, and never before using a sample of generally healthy adults aged over 60. In addition, the measurement of various types of functioning (mood-related, physical functioning, vision, mental status, speed of information processing, spatial memory, visual attention) for the same set of participants enabled comparisons between the variables that are most related to driving ability and the variables most related to driving behaviour. These comparisons, in turn, enabled the identification of the functional variables that are related to driving deficits but for which drivers are not adequately compensating. Such an analysis had not previously been conducted in older driver research.

The analysis of crash statistics over a five year period confirmed that South Australian older drivers are typical of those in other jurisdictions. Their level of crash involvement is only higher than drivers in younger age groups when expressed in terms of crashes per kilometre driven. There was some evidence in the crash data of self-regulation, with older drivers being less likely to crash in peak hour traffic, in hours of darkness, in the rain, or on wet roads. The remainder of the thesis was designed to examine the self-regulatory driving practices of older drivers in more depth.

The picture that emerged from the survey of driving attitudes and behaviour used in this study was that community-dwelling active older drivers tend to be confident in their driving abilities and chiefly restrict their driving in response to reductions in the *need* to drive (e.g. retirement). Maintenance of lifestyle was reported as being very important for the drivers in the study and restriction of driving tended to only occur to the extent that their lifestyles allowed for it. As future cohorts of older drivers are likely to be increasingly active (OECD, 2001), it is likely that the desire to maintain lifestyle will continue to reduce self-regulation of driving.

Older drivers also reported positive self-assessments of their abilities (driving, vision, dual task), high confidence when driving in difficult situations, and little avoidance of these situations. A new finding was that the relationship between confidence in a specific driving situation and avoidance of that specific situation was stronger for situations that older drivers found easier to avoid. That is, how easy it is to avoid a specific difficult driving situation was related to the degree to which lower confidence when driving in that situation was translated into avoidance of the situation.

Of concern was the rarity with which older drivers reported avoidance of right turns across traffic, despite the finding that right turn crashes, especially when as the driver of the turning vehicle, are common among older drivers. This rarity of avoidance of right turn crashes does not appear to be due to difficulty avoiding them, as nearly half of the sample reported right turns as not hard to avoid - only parallel parking and peak hour were more likely to be designated as not hard to avoid. Any program designed to encourage older driver self-regulation should include discussions of right turns across traffic.

As noted earlier, one of the main strengths of the study was the use of a measure of on-road driving performance in order to analyse the relationships between driving attitudes and behaviour, and driving ability. One of the interesting findings from these analyses was that *actual* on-road driving ability was unrelated to *perceived* driving ability but was related to perceived *dual task* ability. This suggests that older drivers detect declines in the dual task aspects of driving prior to detecting any overall deficits in driving ability. Furthermore, it suggests that an older adult's self-assessment of their ability to carry out simultaneous tasks may give a better indication of his or her driving ability than a self-assessment of driving ability. The usefulness of *perceived* dual task ability as a measure is also illustrated by its relationship with *actual* dual task ability, as measured by an index of divided attention. Therefore, there appears to be a degree of accuracy to perceived dual task ability that is lacking in perceived driving ability and perceived vision (found to be unrelated to performance on vision tests).

Another finding of interest was that, although there were no relationships between driving ability and *overall* confidence in, or avoidance of, difficult driving situations, this concealed relationships between driving ability and confidence in, and avoidance of, *specific* driving situations. Poorer on-road driving ability was associated with lower confidence in, and greater avoidance of, driving in the rain, driving at night, and driving at night in the rain. Therefore, it is possible that these are situations in which older drivers most notice declines in driving ability, and respond to these declines with avoidance.

As noted earlier, another of the strengths of the study was that it enabled a comparison of the relationships between functional measures and both driving ability and self-regulation. It was found that driving ability was better predicted by functional measures than was self-regulation. When the various functional measures were examined separately, in order to determine which of these measures might best identify drivers least likely to be self-regulating in accordance with their abilities, the variables that were found to be related to driving ability but not self-regulation were contrast sensitivity, speed of information processing, and spatial memory. This suggests that older drivers with low scores on tests of these abilities may be appropriate targets for interventions designed to encourage self-regulation. Two of these measures, contrast sensitivity and spatial memory, were among the best predictors of driving ability, and their limited relationship with self-regulation suggests that they may also be useful as part of re-licensing assessments. Contrast sensitivity, in particular, would be preferable in re-licensing assessments to the more typically assessed visual acuity, which was not found to be related to driving ability in the sample of participants assessed in this study.

The measure of visual attention developed for the study, the Computerised Visual Attention Test, was found to be related to both driving ability and self-regulation. Of all the functional measures, it was the best predictor of performance on the driving test, making it a useful measure for driver re-licensing assessments. In addition, the length of time required for test administration could be greatly reduced by only using the subtest assessing both selective and divided attention. Measures from this subtest were found to be the best predictors of both driving ability and avoidance of difficult driving situations. The use of only this subtest would reduce the time of administration to approximately 15 minutes, including test demonstration and practice, rather than approximately 35 minutes for the full test. However, the CVAT does need further validation. Specifically, its predictive validity has not been established among samples of impaired drivers and its predictive validity for prospective crash involvement has yet to be assessed. Moreover, to be a candidate for re-licensing assessments, its predictive validity would need to be compared with that of other tests of attention, such as the UFOV. If the CVAT is found to have predictive validity that is superior or comparable to the UFOV, then the CVAT may be a good alternative to it. The CVAT, unlike the UFOV, does not require special, expensive equipment and does not require that test takers sit uncomfortably close to the computer screen.

Having established that self-regulation among older drivers is not optimal, it may be useful to consider implementation of a program to encourage self-regulation. One such program has already been reported in the literature. Owsley, Stalvey and Phillips (2003) examined an educational intervention in the USA in which older drivers with visual impairment who had crashed in the previous year were informed about how visual impairment affects driving. The participants were also given advice about reducing driving through the avoidance of difficult driving situations. Following this intervention, drivers were more likely to acknowledge their visual impairments and were more likely to avoid difficult situations (Owsley et al., 2003). It is possible, however, given the use of self-reports of behaviour as an outcome measure after the intervention, that these results were affected by response bias, with participants reporting the behaviour changes the intervention was advocating. The authors indicated that the safety benefits of the program will be evaluated.

Any implementation of programs designed to encourage self-regulation would ideally be combined with a service providing assessments of driving ability. There was no relationship between *perceived* driving ability and *actual* on-road driving ability, and it would be useful if drivers of all ages could refer themselves for a driving assessment and get objective feedback from appropriately qualified personnel about their driving (Stutts, 2003). This feedback could be combined with a discussion about methods of self-regulating driving, in cases where it was felt by the driving assessors to be useful. Such programs would have to be undertaken with a great deal of care, however, as Holland and Rabbitt (1992) found that giving older drivers feedback about their sensory abilities and self-regulation caused a small number of participants to experience anxiety.

11.6 Limitations and Future Directions

Previous chapters have made reference to various limitations of the present study. These have included the lack of validation of the measure of driving ability, the measures of driving confidence and driving avoidance being based on questions regarding driving situations that were not assessed in the driving test, the self-reported nature of the health measures and the measures of driving attitudes and behaviour, and the possibility of volunteer bias.

The absence of validation data for the on-road driving test means that it has not been shown that this measure is related to routine driving performance when a driver is not being assessed, or to actual crash risk. It could be that the validity of the driving test is reduced by being conducted in an unfamiliar car and, for many drivers, on streets that they did not normally drive on. However, the driving tests used in the study were very detailed and used the expertise of both occupational therapists and professional driving instructors. Also, the alternative of using crash involvement as an indicator of deficits in driving ability is problematic because crashes are rare, multi-determined events (refer to section 8.4.2). Nonetheless, the access to participants' official records means that their crash involvement can be monitored and the relationship between driving performance, as assessed in this study, and subsequent crash risk examined in the future. This will be an important ongoing part of establishing the validity of the conclusions of this study because claims that self-regulation is less than optimal, based on the lack of strong relationships between self-regulation and driving test performance, rely on driving test performance being predictive of crash risk.

Another study limitation related to the on-road driving test is that the test did not assess driving performance in many of the situations that were the focus of the questions concerning driving confidence and driving avoidance. The on-road assessment did not require participants to drive in the rain, when alone, on freeways, at peak hour, at night, or at night in the rain. It also did not assess reverse parallel parking. It is likely that the driving performance scores of participants who often avoided difficult driving situations would have been poorer if their driving was assessed in these situations. Therefore, the likely result of this limitation of the driving test is that the relationships reported in this study are under-estimates of the true relationships between driving ability and self-regulation. However, the driving tests did assess performance in a variety of traffic conditions, ranging from quiet streets to busy main roads and, as noted by Lundberg et al. (1997, p34), it would be inappropriate to test the driving ability of older drivers in situations they usually avoid.

With respect to using self-reported measures of a number of variables, it is possible that the information derived from these measures was not accurate. Specifically, there could be inaccuracies in the number of medical conditions and medications reported by study participants, and in reports of the weekly amounts of driving done, and recent crash involvement and traffic violations. Inaccuracies in estimates of weekly driving done are likely to be random but omissions of crashes or medical conditions in self-reports could have been either accidental or deliberate. Of these self-reported measures, only crash involvement could be checked against official records in this study and, indeed, it was found that some participant self-reports omitted reference to recent crashes. Participants may also have tried to give a ‘good’ or socially desirable account of themselves, reporting high driving confidence and driving ability, and low driving avoidance. This may have affected the analyses of relationships between these measures and on-road driving ability.

Finally, volunteer bias could have affected the results because older drivers volunteering for a study that included an on-road driving assessment, for which poor results would be reported to the participant’s general practitioner, could have been more likely than the average older driver to be confident about their driving ability. If this was the case, the participants in the study who had deficits in their driving ability would have been more likely to have been those who were unaware of these deficits. This, in turn, would have reduced the relationships between on-road driving ability and perceived driving ability, driving confidence and driving avoidance, leading, again, to an under-estimation of the strength of the real relationships. As noted by Lee et al. (2003), the problem of volunteer bias in driving studies involving healthy participants is unavoidable.

The study also points to a number of avenues of future research. One is an investigation of the means by which to obtain better travel distance data than are currently available in Australia. The Australian Bureau of Statistics Travel Surveys are vehicle-based rather than driver-based and so are unsuited to analysis of crash rates for drivers of different ages. One possible method of obtaining useful travel data is recruiting a large sample of drivers to fill in detailed travel diaries.

Another avenue of future research is investigation into the relationships between medical conditions, use of medications, driver age and driving ability. The separation of the effects of medical conditions from those of the medications taken to treat them is difficult but a study using carefully chosen control groups matched for illness severity may prove informative. Also, it would be useful for such a study to utilise official medical records rather than self-reported information.

It would also be interesting to see if the results of the present study can be repeated in a prospective study using future crash involvement, rather than on-road driving performance, as an outcome measure. Specifically, it could be ascertained whether performance on the Computerised Visual Attention Test predicts future crash involvement better than other functional variables. As noted previously, access to participants' official records will enable a prospective study of participant crash involvement. Such a prospective study is also necessary to evaluate the relationships between future crash involvement, and driving confidence and driving avoidance. The use of retrospective crash data is not ideal because past crashes could affect currently reported confidence in, and avoidance of, difficult driving situations. It needs to be assessed whether currently reported confidence and avoidance are related to levels of future crash involvement. The conclusion that self-regulation may need to be encouraged among older drivers relies on self-regulation being linked with lower subsequent crash risk.

Future research should also look at the personality and lifestyle factors that play a role in self-regulation. There was a substantial proportion of variance in self-regulation unexplained by the functional measures used in the present study and it may be that personality traits (e.g. conscientiousness) and lifestyle factors (e.g. extent of social activities) could account for some of this variance in self-regulatory behaviour. One study looking at driving attitudes and personality found that high confidence in difficult driving situations among drivers aged over 50 was associated with low neuroticism and high extroversion (Parker et al., 2001).

A final suggestion for future research is to look at the driving ability and behaviour of drivers with depression and high anxiety. It appears that these two mood-related factors may have very different effects on driving-related measures. A study designed to look specifically at such drivers would help clarify the results of the present study.

11.7 Final Conclusion

Overall, the present study has demonstrated that older drivers do engage in a degree of self-regulation of driving behaviour, and that this self-regulation does have a relationship with driving ability. However, the relationship between self-regulation and driving ability was not strong, suggesting that many older adults with deficits in their driving ability do not avoid difficult driving situations. One of the strengths of the study was that it made it possible to identify the factors that may decrease the likelihood of older drivers self-regulating in accordance with their abilities. These findings could be used to guide re-licensing assessments and educative interventions designed to encourage self-regulation, both of which may be of importance in years to come, as the number of older drivers on Australian roads increases. These increases in the number of older drivers will occur in combination with cohort differences that will give rise to better health and greater driving experience among future older drivers than was the case for earlier cohorts. It may be that these cohort differences will result in a lower need for self-regulation of driving behaviour. It could also be that a greater dependence on driving throughout the lifespan may result in less acceptance of the need to alter driving behaviour if necessary (Rosenbloom, 2003) and, thus, a lessening of the relationships between self-regulation and the deficits in functional and driving abilities that would ideally prompt it. Therefore, continuing research will be needed to follow the changing trends in the abilities, behaviour and crash experience of older drivers, and to shape transport policies relating to their safety and mobility.