A multi-domain approach for predicting older driver safety under in-traffic road conditions

Joanne M Wood, PhD[1,2] Kaarin J Anstey, PhD[3] Graham K Kerr, PhD [2,4]
Stephen Lord, PhD, DSc [5] Philippe F Lacherez, BSc(Hons) [1,2]

[1]School of Optometry, Queensland University of Technology, Brisbane, Australia

[2]Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane

[3]Centre for Mental Health Research, Australian National University, Canberra

[4]School of Human Movement Studies, Queensland University of Technology, Brisbane, Australia

[5]Prince of Wales Medical Research Institute, University of New South Wales, Randwick, New South Wales, Australia

Corresponding author: Prof Joanne M Wood, PhD, School of Optometry and Institute of Health and Biomedical Innovation, QUT, Kelvin Grove, Brisbane Q 4059, Australia.

Tel: 61 7 3138 5701; Fax: 61 7 3138 5665; Email: j.wood@qut.edu.au

Alternate corresponding author: Kaarin J Anstey, PhD, Centre for Mental Health Research, Australian National University, Canberra

Tel: 61 2 6125 8410; Fax: 61 2 6125 0733; Email: kaarin.anstey@anu.edu.au

Funding support was received from the NHMRC Prevention of Older People's Injuries Partnership in Injury grant and NRMA Insurance.

Running head: Predicting older driver safety

Word count for abstract: 145

Word count for text: 4081 (excluding title, abstract, references, tables and figures)

References: 41

Tables: 3

Figures: 2

ABSTRACT

OBJECTIVES: To identify a battery of tests that predicts safe and unsafe performance on an on-road assessment of driving.

DESIGN: Prospective cohort study.

SETTING: University laboratory assessment and an on-road driving test.

PARTICIPANTS: 270 community living adults aged 70 – 88 years recruited via the electoral roll.

MEASUREMENTS: Performance on a battery of multidisciplinary tests and on a standardised measure of on-road driving performance.

RESULTS: A combination of three tests from the vision, cognitive and motor domains, including motion sensitivity, colour choice reaction time, postural sway on a compliant foam rubber surface, and a self-reported measure of driving exposure were able to classify participants into safe and unsafe driver groups with a sensitivity of 91% and specificity of 70%.

CONCLUSIONS: In our sample of licensed older drivers, a short battery of tests and a self-reported measure of driving exposure were able to accurately predict driving safety.

Key Words: driving safety, predictors, older drivers, on-road driving performance

INTRODUCTION

Older drivers comprise the fastest growing segment of the driving population[1] and they pose a risk for road safety as they have high crash rates.[2] Driving is important for maintaining independence and driving cessation is linked with isolation, depression and associated functional impairment in older people.[3,4] Thus, it is important to ensure that as many older people as possible can continue driving, while at the same time ensuring that those who are unsafe to drive are identified.

While a number of off-road testing batteries have been developed to screen older drivers, such as the GRIMPS, CALTEST and the DriveABLE screens, there has been only limited evidence in the peer reviewed literature to support their use. Studies that have rigorously evaluated these screens have demonstrated that only a sub-set of tests are useful in predicting at-fault motor vehicle crashes.[5] It is therefore imperative to develop and evaluate a screening assessment that accurately predicts unsafe driving in older adults.

Driving is a complex task involving integration of visual, cognitive and psychomotor skills, many of which are impaired with increasing age and may contribute to the increased crash risk seen in older drivers.[6] The prevalence of visual impairment increases with age[7] and age-related changes in visual function have been investigated as risk factors for crashes among older adults,[8] particularly reduced visual acuity [9,10] and visual field loss.[11] While some studies have found that visual function tests predict driving safety, others have failed to find such relationships,[12] suggesting that visual tests alone are a poor predictor of driving performance.[13, 14,15]

A range of cognitive abilities that decline with increasing age are relevant to safe driving including visual attention and processing speed,[16] and executive function,[17] and these have been shown to predict driving safety. However, many of these studies have been conducted in samples with cognitive impairment or dementia, or have been case control studies of drivers selected because of their high crash rates. There remains a need to validate cognitive tests that predict unsafe driving in adults without dementia or cognitive impairment.

Adequate lower limb proprioception, strength and coordination show age-related declines, and can be impacted further by acute and chronic medical conditions that become more prevalent in old age.[18] Age-related sensorimotor impairments also result in poor stepping reactions, altered patterns of movement coordination and slower reaching reactions in response to postural disturbances.[19] They also result in greater variability in the control of plantarflexor [20] and knee extensor muscles.[21] Lower limb strength and control may be particularly important for vehicle control, particularly in relation to coordinating and adjusting accelerator, brake and clutch pedals.

In this study we used a test battery that assessed visual, cognitive and sensorimotor domains selected on the basis of theoretical or empirical links with driving performance and safety. We aimed to select a parsimonious series of predictor tests that would maximise the prediction of driving performance assessed using a validated on-road driving test.[22, 23] We used driving performance as our outcome measure rather than crash rates because (i) it provides an objective assessment obtained under real-world driving conditions and (ii) because crash data have limitations in that it is difficult to verify the accuracy of self-reported crashes,[24] state records are subject to biases given that crashes are not recorded if police do not attend, and there are differences in the type of information recorded between jurisdictions.

METHODS

Participants

Community-dwelling individuals aged 70 years and above (who were living independently without walking aids) were recruited via the electoral roll to participate in a larger study of 449 older adults. Of these, 364 were current drivers and were invited to participate in this study, of whom 272 participated (75% response rate). Two participants were excluded because they scored less than 24 on the Mini Mental-Status Examination (MMSE),[25] giving a total of 270 participants and 92 eligible non-participants. To obtain a general sense of participants' driving experiences and habits, a confidential questionnaire was administered. Only findings describing general driving characteristics are reported here, including length of driving experience and an estimate of the number of kilometres driven per week on a scale of 1 (<10 kilometers per week) to 6 (> 150 kilometers per week).

Previous falls were also recorded as it has been reported that a history of falls is strongly associated with crash rates in older people.[5]

The study was approved by the Queensland University of Technology Human Research Ethics Committee. All participants were given a full explanation of the experimental procedures and written informed consent was obtained, with the option to withdraw from the study at any time.

Measures

Participants attended two laboratory-based sessions which included assessment of vision, cognitive function, sensorimotor performance and balance as part of a larger study of older people's injuries. The total testing time for those measures included in this driving study was approximately 75 minutes. A third session comprised an on-road driving assessment conducted under in-traffic conditions which was one hour in duration.

Vision Tests. Visual function was assessed using a battery of tests, which were undertaken binocularly (with the exception of visual fields). The refractive correction used habitually for driving (and worn for the driving assessment) was used in conjunction with the appropriate correcting lens for the test working distance.

Static Acuity. Static high contrast visual acuity was measured using the Australian Vision Chart 5, which uses logMAR principles, at a working distance of 4.0 m (NVRI, Melbourne). Participants were instructed to guess even when they were unsure, until a full line of letters was incorrectly read. Each letter seen was scored as -0.02 log units.

Pelli-Robson Letter Contrast Sensitivity. Letter contrast sensitivity was determined using the Pelli-Robson chart under the recommended testing conditions.[26] Participants were instructed to look at a line of letters and instructed to guess the letter when they were not sure. Each letter was scored as 0.05 log units.

Visual Fields. Automated static visual fields were measured using the Humphrey Field Analyzer (Carl Zeiss, California, US). Right and left monocular fields were measured using the central threshold 24-2 test with the SITA standard testing strategy. The mean deviation (overall depression in sensitivity) was recorded and coded in terms of the best and worse eye. Binocular visual fields were measured using the Binocular Esterman test with participants wearing the spectacles that they usually wore when driving, if any. The Esterman Efficiency Score (percentage of points seen) was recorded.

Useful Field of View. Visual attention and processing speed were assessed using the commercially available version of the Useful Field of View (UFOV®) test which is PC-based and linked to a touch screen (17 in.) for participant responses.[27] While all three subtests were conducted, only subtest 2 was included in the analysis as it has been shown to be the most predictive of driving safety in previous studies.[16] The outcome measure was given as the target duration at which the subtest was performed accurately 75% of the time.

Dot Motion. Central motion sensitivity was measured using a computer-based random dot stimuli test.[28] Within the total field of dots, a smaller central panel of dots which subtended 2.9° at the working distance of 3.2 m moved coherently in one of four directions.

Thresholds were given as the minimum displacement of motion of the dots that subjects were able to detect.

Cognitive Testing. Cognitive tests were presented using a computer-based touch screen system and where possible, the tests had formats relevant to driving, involving both hand and foot responses. Some tests in the cognitive battery had been assessed with respect to driving outcomes (Trails A and B), while others were specifically designed to assess cognitive skills important for driving.

Digit Symbol Matching. Processing speed was measured using a modified computer-based version of the Digit Symbol Substitution Test[29] in which subjects are presented with a digit-symbol pair and asked to identify whether the pair corresponds to one of those presented in the coding key at the top of the screen. The score was the mean reaction time of 72 trials.

Trails A and B. The Trails Part A measures motor speed and attention and involves the participant connecting consecutive numbers. Part B is a measure of executive function as it involves task-switching.[30] The time to complete each test was recorded.

Self-Ordered Pointing. Executive function and visuo-spatial working memory were assessed by the Self-Ordered Pointing Task which is sensitive to frontal lobe dysfunction associated with ageing.[31] The test involves choosing a different pattern on each of twelve consecutive screens. The same twelve patterns are shown on each screen in a different order, and the same pattern cannot be selected twice.

Complex Reaction Time for Driving. A series of reaction time tests that integrate the cognitive processes of driving (attention, vigilance, divided attention, response inhibition and complex reaction time) were used. Simple reaction time was measured in the first subtest, where targets (images of cars) appeared on the screen at random intervals, and participants responded by pressing a button with their dominant hand as quickly as possible. In the choice reaction time test, participants responded with both hands and feet to cars displayed in one of four quadrants of the screen. The third and fourth subtests (location choice reaction time and colour choice reaction time) also measured response inhibition. Participants were instructed to respond as for the choice reaction time except they were not to respond if the target appeared in the top right quadrant for the third subtest and they were instructed not to respond to blue cars in the fourth subtest. The fifth subtest measured choice reaction time in the presence of distracters. An unrelated target (stop sign) appeared randomly throughout the trial, and the participant responded to this target by pressing an additional centrally located button. Average reaction time for correct trials, and the total number of correct trials were recorded.

Motor Performance. The battery of motor tasks included a measure of proprioception, lower limb strength, and neck rotation as well as a measure of sway that has been strongly linked with the risk of falling.[32]

Total range of neck rotation. This was measured for subjects seated with their shoulders against a wall with a laser pointer mounted on the subject's head pointing forwards onto a custom-made clear acrylic cylinder (20 cm in height and 44.5 cm in diameter) marked with degrees of rotation. Subjects were instructed to rotate their head as far as they could to the right and left and the total angular range of neck rotation recorded.

Proprioception. A lower limb-matching task was used to measure proprioception with the subjects seated and blindfolded.[32] Each participant's right leg was passively raised to a random height and the participant asked to hold this pose whilst raising their left leg to match the position of the right. This was performed three times for each leg. Errors were measured in degrees using a protractor inscribed on a vertical clear acrylic sheet (60 cm x 60 cm x 1 cm) that was placed between the legs and marked in 2° increments; the mean error of measurement for each leg was recorded.

Quadriceps strength. This was measured isometrically in the dominant leg, with the participants seated and the angles of the hip and knee at 90°.[32] The participants were asked to grip the bottom of the seat to ensure that they remained in contact with it at all times and were encouraged to try to maximally extend their knee for three separate trials. The best score from the three trials was recorded in kilograms.

Postural sway. A swaymeter was used to measure displacement of the body at the level of the waist.[32] Testing was performed with subjects standing on a medium density foam mat (40 cm x 40 cm x 15 cm) with their eyes closed. During the test, the participants stood with their feet positioned 10 cm apart, arms by their sides and were asked to remain as still as possible for the 30 second duration of the trial.

Driving Performance. Driving performance was assessed under in-traffic conditions in an automatic, dual-brake vehicle using a previously validated technique[22, 23] which is sensitive enough to differentiate between drivers of different ages and visual status as well as specific disease conditions such as Parkinson's Disease.[33] Subjects were directed to drive along a 19.4 km route on the open road, which consisted of city and suburban streets, simple and complex intersections and a range of traffic densities. The driving assessment was conducted either mid--morning or mid-afternoon to avoid rush hour traffic. Driving was scored independently by an occupational therapist, experienced in driving assessment and rehabilitation, and an accredited professional driving instructor, who was responsible for vehicle safety. Both assessed driving safety, using a series of well-defined criteria on a 10-point scale based on driver licensing standards, and, as described elsewhere, their scores were highly correlated for a range of normal and patient populations.[22, 33]

An average driving safety score between 1 and 3 indicated that the driver had made a critical error, where the instructor had to take action to avoid an incident, or the driver hit a significant object. A score of 4 to 5 indicated poor driving and observation skills, while 6 to 8 indicated average driving skills but with some bad habits. Finally, a score of 9 to 10 reflected good to excellent driving and observational skills.

Statistical analysis

Prior to analysis, outliers were treated for each variable. Outliers greater than three standard deviations were replaced with the maximum score within the three standard deviation range. Data which were missing because participants were unable to do the test were replaced with the maximum test value possible, or for measures where no maximum score was available, the maximum score obtained by participants in this study. In all, there was one missing case on each of the dot motion, Pelli-Robson and number of falls variables, two missing cases on knee extension strength, and three missing cases on postural sway and number of kilometres driven per week.

The driving performance score was dichotomised in terms of likelihood of being involved in a crash. A score of three or less was defined as unsafe driving behaviour (see definitions above). Safe and unsafe drivers were initially compared on the potential predictor variables using independent t-tests. A series of logistic regression analyses were conducted to determine the best set of predictors. Driving exposure was included as both categorical and continuous data for comparison in the analyses.

In the first stage of the analyses, all potential predictors were entered simultaneously into the regression model. In the second stage, separate models were tested for the visual, cognitive and motor variables to select the best predictors from each domain. Variables were analysed using sequential stepwise logistic regressions using a backward selection procedure with the Wald criterion. Variables were retained for the final analysis if the significance of the Wald test was less than or equal to 0.1. A parsimonious model including the best predictors from each domain was evaluated, again using a backwards elimination strategy. Predicted probabilities from the logistic regression equation were examined using Receiver Operating Characteristic (ROC) analyses to investigate the efficacy of the classification function.[34] Cross-validation runs were performed to examine the likely efficacy of the prediction model if tested on a different sample. First a leave-one-out cross-validation was performed.[35] In this form of cross-validation, each case is excluded once from the analysis, and a model is run without that case. The coefficients formed from the regression involving all other cases in the analysis are used to predict the missing value not based upon the case itself. A second cross-validation was performed using a 20% holdout sample. The data set was split into those who scored greater than three on the driving assessment, and those who scored three or less. Twenty percent of cases in each group were then withheld from the analysis. The regression coefficients derived from the analysis of the remaining 80% of cases was used to predict the scores of the 20% holdout sample.

RESULTS

Table 1 shows demographic comparisons between eligible participants and non-participants. Participants were 20-21 months younger than non-participants on average ($t(360) = 3.546$, $P < .001$), and significantly more likely to be male (standardized residual = 3.7). Non-participants were significantly more likely to have 21-30 years driving experience (standardized residual = 3.6) than participants, and were more likely to drive <10 (standardized residual = 4.2) or 10 to 30 kilometres per week (standardized residual = 4.5). Of the 270 participants, 47 (17.4%) had a driver safety rating of three or less, indicating that critical driving errors had been made, while 223 (82.6%) had a driver safety rating greater than three.

Model Including All Potential Predictors

A logistic regression model including all variables as predictors was evaluated. Driving exposure was treated as a numerical rating for purposes of analysis given that treating the rating as a categorical predictor did not noticeably improve model fit, and the numerical rating is more parsimonious.

All variables were significant for entry into the model, except for visual acuity, binocular Esterman score, proprioception and self-ordered pointing (see also Table 2 for bivariate t-tests). However, since the predictor variables were also highly inter-correlated, only three variables significantly reduced the model when excluded by themselves (driving exposure, Wald = 11.95, $P < .01$, postural sway, Wald = 11.33, $P < .01$, and best visual fields score, Wald = 2.77, $P = .1$). The overall model significantly predicted driving performance when tested against a constant-only model $\chi^2(20) = 84.31$, $P < .01$, with a strong multivariate effect size (Cox-Snell $R^2 = 0.28$).

Figure 1 shows the ROC function for the full model based on all predictors. As can be seen, the model is highly successful in predicting driving performance. The model can achieve 89% sensitivity (correctly predicting those drivers who had a near accident or critical error during the on-road assessment) and 77% specificity (correctly predicting those drivers who did not have an incident or make a critical error).

Model Developed by Selecting Best Predictors from Visual, Cognitive and Motor Domains

A series of stepwise regressions was conducted using variables from each domain (vision, cognitive, sensorimotor). Table 3 shows the results of the individual regressions. From the vision domain, UFOV® test 2 and dot motion sensitivity were both significant. Of the sensorimotor tests, knee extension strength and postural sway were both significant, while of the cognitive tests the Trail-making test part B and colour choice reaction time were significant.

The reduced set of variables thus obtained was then combined with the number of kilometres driven to create a parsimonious model including all domains. This model was then also examined using a backwards elimination strategy to further reduce the number of predictors necessary to include in the model.

The reduced model was highly significant ($\chi^2(4)= 79.294$, $P < .01$, Cox-Snell $R^2 = .26$). Four variables were included in the final model, colour choice reaction time (Wald = 14.54, $P < .01$), number of kilometres driven (Wald = 11.8, $P < .01$), postural sway (Wald = 13.45, $P < .01$), and motion sensitivity (Wald = 2.92, $P = .09$).

ROC analysis of the regression predicted probabilities showed highly useful classification with the reduced set of variables (see Figure 2). The model can achieve 91% sensitivity and 70% specificity. The regression equation was also highly effective in predicting the driver safety classification in the cross-validation runs. In the leave-one-out sample a sensitivity of 87% and a specificity of 71% was achieved. Similarly in the holdout sample, a sensitivity of 92% and a specificity of 71% was achieved.

DISCUSSION

In a sample of licensed older drivers, all of whom had corrected visual acuity better than 20/40, and a MMSE score of 24 or higher, we were able to predict safe and unsafe driving performance on an on-road test with a sensitivity of 91% and specificity of 70% with a multidisciplinary test battery consisting of three tests and a measure of self-reported driving exposure.

The tests selected for this study were drawn from vision, cognitive and motor domains based on a theoretical understanding of the sensorimotor and cognitive factors that decline with age, and a substantial body of previous research into injury in later life. We also referred to previous research on factors predicting road safety outcomes[6] as a basis for selecting those tests that have been shown to predict crash rates/ driving assessment outcomes.

The tests were assessed against a validated on-road driving assessment which provides a standardized procedure for all participants with sufficient duration and complexity to allow assessment of a variety of driving situations and manoeuvres, and is sufficiently challenging to allow manifestation of visual or cognitive deficits or both.[36]

The tests in the final predictor battery involve a wide range of abilities and incorporate both upper and lower limb responses, visual and cognitive function and would take approximately 15 minutes to complete.

The key cognitive predictor measure involved both foot and hand responses to a choice reaction time task, mirroring the requirement of drivers to respond with foot pedals and hand movements. Tests such as Trails A and B that have been identified in previous studies as being predictive of driving outcomes did not emerge as significant predictors in multivariate models. This may arise because the abilities that they measure (processing speed and executive function) were assessed by the colour choice reaction time task which is a better measure of the cognitive abilities required for driving.

Of the vision variables, visual fields were the best measure in the full logistic model, while motion sensitivity was the best in the stepwise model. Motion sensitivity has previously been shown to be the strongest visual predictor of driving performance on a closed road circuit,[37] and has face validity in a driving context given that it involves contrast and movement which are relevant cues for driving. This test of motion sensitivity can be easily administered and does not require specialised equipment. Given that our aim was to identify a battery of predictors of driving safety, with the ultimate goal of implementation of this battery in driver licensing, the motion sensitivity test is recommended as it is easy, convenient and reliably predicts driver safety in this study. Interestingly, while the UFOV® subtest 2 was one of the best predictors of driving safety from the vision domain, it did not emerge as a significant predictor in the models including the three domains, indicating that the contribution of this test was fully explained by the other measures. Some authors have argued that the UFOV® test may be more related to cognitive, than to visual functioning,[38] and so it may be that the correlations between the UFOV® and the battery of cognitive tests make the UFOV® redundant in these models. Models were also examined in which the UFOV® was included together with the cognitive predictors, and the same final model resulted.

Postural sway is an indicator of the integration of sensorimotor function. When performed on a compliant surface, sway depends on both lower limb sensation and muscle strength[39] and provides a global measure of stability that is strongly related to the risk of falling.[32, 40] Our finding that increased sway is also a predictor of unsafe driving performance is thus in accord with previous studies which have found a link between propensity for falling and crash risk in older drivers.[5]

The results are also consistent with an emerging body of evidence suggesting a relationship between distance driven per year and crash rates, such that those older drivers who drive fewer kilometres per year are less safe – the so called “low mileage bias.” [41]

The outcomes of this research are unique in the context of driving research because they involve a multidisciplinary approach, a standardised measure of real-world driving performance and a large population of community living older adults. Importantly, the sample was recruited on a voluntary basis and included individuals who drove more regularly and for longer distances than those who were eligible but chose not to participate. Hence it is likely that a greater number of older drivers from an unselected population would fail our screening battery. This study clearly shows that it is possible to predict safe and unsafe driving in older adults with an adequate degree of sensitivity and specificity. Importantly, performance on objective measures rather than age predicted driving safety. However, before any recommendations for implementation of such a battery can be made, it is imperative that this battery including colour choice reaction time, postural sway, motion sensitivity and self-reported distance travelled be trialled in a large prospective study of crash risk in older adults.

ACKNOWLEDGEMENTS

The authors would like to thank Alex Black, Mei Boon, Michael Cole, Roger Martin, Melissa Newton, Matthew Roodevelt, Jocelyn Stewart, Oren Tirosh and Paul Turner for assistance in laboratory-based data collection and Ivor Booker and Kerry Mallon for assessing driving performance. The authors would also like to thank all of the participants who gave so generously of their time.

CONFLICT OF INTEREST

Financial Disclosure(s):

Joanne M. Wood: No conflict of interest

Kaarin J. Anstey: No conflict of interest

Graham K. Kerr: No conflict of interest

Stephen Lord: No conflict of interest

Philippe F. Lacherez: No conflict of interest

Author Contributions:

Joanne M. Wood: Conceptualised and coordinated overall driving study, designed strategy for analyses, and was primarily responsible for writing the manuscript.

Kaarin J. Anstey: Conceptualised overall driving study and cognitive assessments with regard to driving, contributed to the data analysis and had a significant role in writing the manuscript.

Graham K. Kerr: Coordinated and conceptualised motor function assessments in conjunction with Stephen Lord, and assisted with manuscript preparation.

Stephen Lord: Coordinated and conceptualised motor function assessments in conjunction with Graham Kerr, and assisted with manuscript preparation.

Philippe F. Lacherez: Responsible for statistical analyses, interpretation and draft of results. Assisted with manuscript preparation.

Sponsor's Role:

Neither the NHMRC nor NRMA insurance played any role in the collection, interpretation or publication of these findings other than to provide financial support for the project.

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Table 1. Demographic characteristics of drivers in the sample who agreed to undertake the driving assessment (participants) and those who did not (non-participants).

Variable	Response	Non-participants	Participants
Sample (n)		92	270
Age		77.54 (4.26)	75.82 (3.95)
Gender	Male	39%	71%
	Female	61%	29%
Number of years driving experience	21-30	6%	0%
	31-40	10%	7%
	41-50	32%	20%
	>50	52%	73%
How many kms would you drive per week?	<10km	16%	2%
	10-30km	26%	6%
	31-60km	17%	21%
	61-100km	19%	22%
	101-150km	9%	21%
	>150km	13%	28%

Table 2. Bivariate independent samples t-test of each predictor variable from model. Criterion is whether on-road driving score was three or less. All tests are run in SPSS using the "equal variances not assumed" option.

Variable	Unsafe drivers mean (sd)	Safe drivers mean (sd)	Range	t(df)
How many kms would you drive per week? (category)	3.39 (1.27)	4.58 (1.28)	1 - 6	5.77(65.41)**
High contrast VA (logMAR) ↓	0.06 (0.08)	0.04 (0.08)	-0.2 - 0.34	-1.3(66.06)
UFOV® score test 2 (ms) ↓	205.57 (141.68)	125.9 (104.66)	16 - 500	-3.65(57.03)**
Dot Motion log threshold score ↓	-0.5 (0.3)	-0.68 (0.21)	-1.22 - 0.36	-3.81(55.42)**
Visual fields mean deviation better eye ↑	-1.98 (2.38)	-0.98 (1.63)	-8.56 - 2.66	2.75(55.41)**
Esterman (% score) ↑	95.49 (4.75)	95.78 (4.46)	81 - 100	0.39(64.29)
Pelli-Robson contrast sensitivity score (log units) ↑	1.63 (0.15)	1.68 (0.12)	1.3 - 1.95	2.03(58.24)
Number of falls in past year ↓	0.89 (1.96)	0.34 (0.75)	0 - 10	-1.88(47.74)
Total neck range of motion (degrees) ↑	127.74 (25.85)	137.11 (23.05)	63 - 200	2.3(62.35)*
Average proprioception score (degrees) ↓	3.74 (1.29)	3.71 (1.34)	1.17 - 8	-0.18(68.55)
Knee extension strength score (kg) ↑	30.28 (11.31)	38.4 (12.76)	5 - 69.57	4.37(73.16)**

Sway path length - eyes closed on foam (mm) ↓	627.49(185.76)	447.98(162.23)	110.22 - 880.75	-6.14(61.87)**
Trail-making test part B Time (s) ↓	49.93 (23.29)	38.7 (16.09)	13.12 - 118.47	-3.15(55.6)**
Digit Symbol mean RT of correct responses (s) ↓	2.71 (0.57)	2.4 (0.4)	1.72 - 3.99	-3.59(56)**
Self-ordered Pointing score (number of repeats out of 12) ↓	2.65 (1.07)	2.36 (1.17)	0 - 6	-1.66(71.21)
Simple Reaction Time ↓	0.36 (0.11)	0.32 (0.07)	0.19 - 0.61	-2.67(55.88)**
Choice Reaction Time ↓	0.8 (0.14)	0.7 (0.11)	0.48 - 1.09	-4.5(57.39)**
Location Choice Reaction ↓	0.85 (0.16)	0.74 (0.12)	0.48 - 1.18	-4.55(56.77)**
Colour Choice Reaction Time ↓	0.90 (0.15)	0.78 (0.1)	0.55 - 1.32	-5.42(55.02)**
Distractor Choice Reaction Time ↓	0.94 (0.19)	0.81 (0.12)	0.51 - 1.41	-4.64(54.45)**

↑higher scores indicate higher performance, ↓higher scores indicate lower performance

* $P < .05$, ** $P < .01$

Table 3. Regression coefficients and model fit for the stepwise regressions for the three functional domains assessed (vision, motor, cognitive). Regression coefficients are from the final step for each model (criterion for retention: *P* (Wald) < .1).

Domain	Variables	B	S.E.	Wald	Df	Sig.	Model fit
Vision	UFOV® score test 2	<0.01	<0.01	10.63	1.00	<0.01	$\chi^2(2) = 28.45$, $P < .01$, Cox-Snell $R^2 = .1$
	Dot motion threshold score	2.49	0.80	9.65	1.00	<0.01	
	Constant	-0.81	0.58	1.92	1.00	0.17	
Motor	Knee extension strength score	-0.04	0.02	6.82	1.00	0.01	χ^2 (2) = 43.22, $P < .01$, Cox-Snell $R^2 = .15$
	Sway path length - eyes closed on foam	<0.01	<0.01	24.49	1.00	<0.01	
	Constant	-2.67	0.80	11.00	1.00	<0.01	
Cognitive	Trail-making test part B time	0.02	0.01	3.23	1.00	0.07	χ^2 (2) = 41.72, $P < .01$, Cox-Snell $R^2 = .14$
	Colour choice reaction time	7.39	1.50	24.30	1.00	<0.01	
	Constant	-8.40	1.26	44.29	1.00	<0.01	

Figure 1 - ROC curve showing the sensitivity and specificity of the test battery for each possible cut-off value from the full logistic regression model including all predictors. Dependent measure is unsafe driving behaviour during on-road assessment, criterion is whether the participant scored ≤ 3 on driving test. Sensitivity is the proportion of unsafe drivers correctly classified as unsafe by the model, while specificity is the proportion of safe drivers correctly classified as safe.

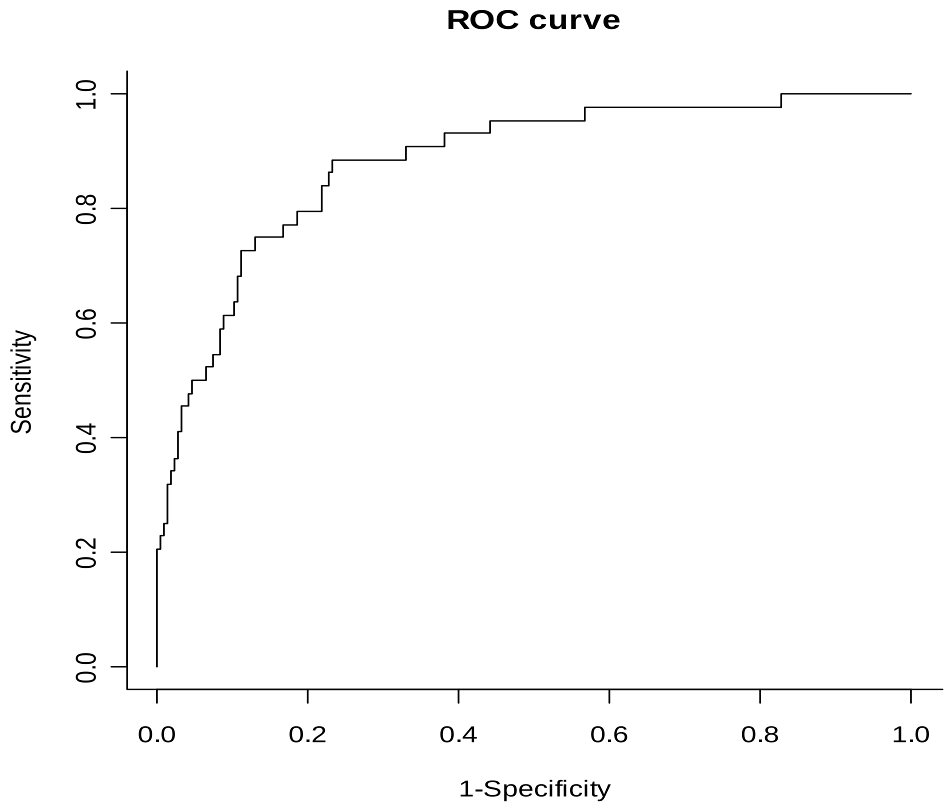
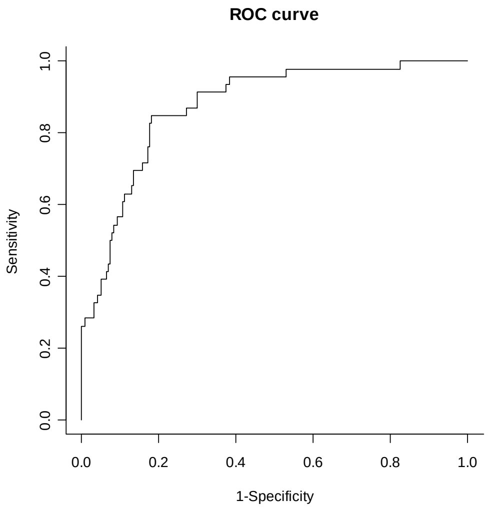
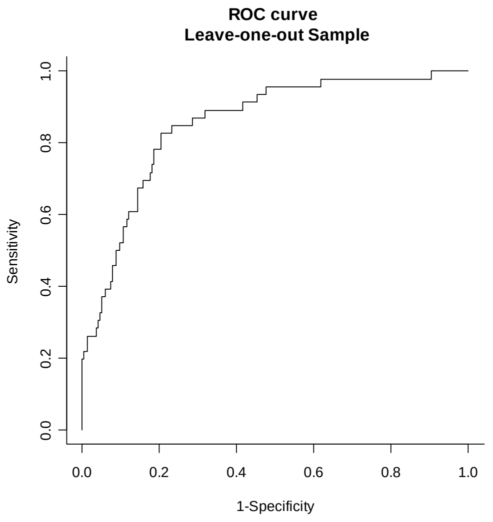

ROC curve
Sensitivity
0.0
0.2
0.4
0.6
0.8
1.0
1-Specificity
0.0
0.2
0.4
0.6
0.8
1.0

Figure 2 - ROC curve showing the sensitivity and specificity of the test battery for each possible cut-off value from the four-variable model including dot motion sensitivity, sway with eyes closed on foam, colour choice reaction time and number of kilometres driven per week. Dependent measure is unsafe driving behaviour during on-road assessment, criterion score of ≤ 3 on driving test.


ROC curve
Sensitivity
1-Specificity
0.0
0.2
0.4
0.6
0.8
1.0


ROC curve
Leave-one-out Sample
Sensitivity
1-Specificity
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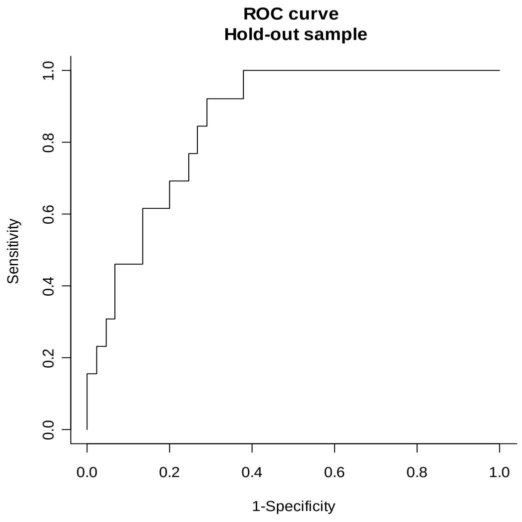
0.2
0.4
0.6
0.8
1.0


ROC curve
Hold-out sample
Sensitivity
1-Specificity
0.0
0.2
0.4
0.6
0.8
1.0