Pergamon

Accid. Anal. and Prev., Vol. 30, No. 3, pp. 363–370, 1998

Printed in Great Britain
0001-4575/98 $19.00 + 0.00

PII: S0001-4575(97)00110-3

A COMPARATIVE APPROACH TO IDENTIFY UNSAFE OLDER DRIVERS

ALLEN R. DOBBS,[1]* ROBERT B. HELLER[2] and DONALD SCHOPFLOCHER[3]

[1]Department of Psychology, University of Alberta, Edmonton, Alberta, Canada T6G 2E1,
[2]Department of Psychology, Concordia University College of Alberta, Edmonton, Alberta, Canada T5B 4E4
and [3]Department of Psychology, University of Alberta, Edmonton, Alberta, Canada T6G 2E1

Abstract—The identification of unsafe older drivers is a current and important challenge. In the present research, a comparative approach was used in which the on road driving errors and expert evaluations of older drivers with clinically significant declines in mental abilities ($N=155$) were compared to the errors and evaluations of a normal elderly control group ($N=68$) and a normal younger control group ($N=30$). The results indicate that the conventional criteria used in North America for licensing new drivers is inappropriate for license removal in experienced drivers. The results also indicate that hazardous errors were the single best indicator of membership in the group of older drivers with clinical impairment. This group also differs from the two normal control groups on turn positioning errors, minor positioning errors and overcautiousness. All groups differ from each other on scanning errors. A regression analysis further indicated that the five driving errors listed above accounted for over 57% of the variance associated with global ratings provided by expert driving instructors.

Keywords – Cognitive impairment, Driving, Elderly, Road safety

INTRODUCTION

On a per person basis, older drivers have a low crash rate. However, older drivers drive less and it is important to consider exposure in order to more adequately represent the safety of older drivers when they are driving. When exposure is taken into account, several reports show that the crash rates of older drivers rise steadily after age 70 and drivers age 75+ have the highest crash rate of all other age groups except those 16–24 years of age (Evans, 1988; Carr et al., 1990; Cerelli, 1989; Lauer, 1964; Planek, 1972; Transportation Research Board, 1988; Williams and Carsten, 1989; Yanik, 1985).

For the majority of older drivers, it is unlikely that the effects of age, *per se*, are of a sufficient magnitude to account for many crashes. This is consistent with findings showing that age is a poor predictor of crash rates (Transportation Research Board, 1988). This has led to an increasing interest in subsets of the older driver population. The subsets of older drivers which have received the most attention are those that may have diminished driving abilities due to medical conditions or drug treatments. Medical conditions resulting in cognitive impairments relevant to the safe operation of a motor vehicle can occur at any age. However, the emphasis on medical conditions (or drug treatments) of older drivers is that the conditions which can affect driving (e.g. dementia) are more likely to occur with advanced age.

Given that driving is a complex and cognitively demanding task, it is not unreasonable to suggest that the cognitively impaired portion of the older driver population is accounting for a disproportionate number of crashes. The evidence is that substantial numbers of persons who have significant cognitive impairments do continue to drive. An early study by Waller (1967) indicated that 31% of the drivers in a retirement community were suffering from a dementia. Carr et al. (1990) reported that 23% of the patients seen in a geriatric clinic were active drivers, and Odenheimer (1993) reported a somewhat higher percentage for patients seen at a dementia clinic. Although a significant minority of dementia patients retain driving abilities at least through the earlier stages, dementia patients, as a group, are very much at risk for a crash as indicated by a number of retrospective studies (Cooper et al., 1993; Dubinsky et al., 1992; Friedland et al., 1988; Gilley et al., 1991; Lucas-Blaustein et al., 1988; Tuokko et al., 1995; Waller, 1967). It is undoubtedly the case that the

*Corresponding author. Tel.: 001 403 438 1507; fax: 001 403 438 1507; e-mail: adobbs@cyber.psych.ualberta.ca

same could be said for persons having cognitive impairments due to other causes, but there has been much less research.

Identifying older drivers who are safety risks is a current and important challenge. Since physicians are well positioned to identify older persons whose driving abilities have been compromised by medical conditions, it is not surprising that they have shouldered much of the responsibility (Coopersmith et al., 1989; Persson, 1993; Odenheimer, 1993) Moreover, recent surveys indicate that the majority of physicians feel they have a responsibility to make assessments of their patients' driving competence (Drickamar and Marottoli, 1993; Miller and Morley, 1993). Unfortunately, physicians have not had the appropriate tools and guidelines to assist them in identifying which of their patients may be unsafe drivers (Association for the Advancement of Automotive Medicine, 1991; Drickamar and Marottoli, 1993; Miller and Morley, 1993; Odenheimer et al., 1994; O'Neill et al., 1992).

Several approaches have been taken to identify unsafe older drivers. One approach has been to establish a list or compendium of illnesses and drugs which would make an older driver unsafe. In principle, however, except in more extreme cases, it is unlikely that either medical conditions or drug treatments considered on their own will be shown to be acceptable predictors of driving competence *for individuals*. In part, this is because elderly drivers tend to have multiple medical conditions and drug treatments. The number of possible interactions among illnesses, severity levels, drug treatments and dosages is too large to make it practical to develop a compendium of conditions and drugs for physicians or others to use as a 'look-up' table for predicting an individual's driving competence.

A second approach has been to use tests of mental competence. The most popular of these has been the Mini Mental Status Examination (MMSE) (Folstein and Folstein, 1975) which Miller and Morley (1993) report to be the one most widely endorsed by physicians. Several studies have examined the relationship between MMSE scores and on-road performance measures and reported reliable correlations (Odenheimer et al., 1994; Fitten et al., 1995). However, retrospective studies have reported less than one point difference in MMSE scores of dementia patient groups that were crash free and groups that had been involved in at least one crash (O'Neill et al., 1992; Friedland et al., 1988; Gilley et al., 1991; Lucas-Blaustein et al., 1988). Although, neither tests of mental competence nor diagnoses are sufficient stand alone approaches to identify individuals who are unsafe drivers, those approaches may prove helpful as screens to be followed by a more in-depth evaluation for positive cases.

The third approach has been to evaluate the actual driving performance of older drivers who have medical conditions that might affect their driving. Usually this has been accomplished with patients who have a dementia. Most studies have either reported performance in terms of pass/fail or a listing of the driving errors. Since almost all of these studies have been in the context of a clinical driving assessment given for licensing goals, there rarely has been a same aged control group against which the driving errors could be evaluated. This is an important shortcoming. Without an appropriate control group, one can not know whether the errors are ones which indicate a decline in competence or they are simply errors commonly made among experienced drivers. The small sample sizes (2–30) of current reports is also a factor limiting the analysis of driving performance (Cushman, 1992; Fitten et al., 1995; Hunt et al., 1993; Kapust and Weintraub, 1992; Odenheimer et al., 1994; Shemon and Christensen, 1991).

In developing a driving evaluation appropriate for experienced older drivers, we have emphasized a comparative study of the driving errors of 'normal' older drivers and those made by drivers who have clinically significant declines in mental abilities. We also have included a young 'normal' driver group to examine possible age-related changes in driving errors. The research began with a road test constructed to emphasize the driving maneuvers reported to be associated with the crashes of older drivers (e.g. turns, lane changes, merges), and a scoring system typical of North American licensing exams. This scoring system is based on the rules of the road, with demerit points given for all errors that could result in a traffic violation citation, and demerit points for unsafe maneuvers even if they do not contravene the regulations. At the conclusion of the road test, the driving evaluator rated the person's overall performance (driving skill overall, accident risk, defensive driving skills), and a number of facets of driving (e.g. observation skills, impulsiveness, planning).

In our initial analyses, it readily became apparent that there was an unacceptable difference between the person's on-road score and the expert judgment of their ability. Too often drivers, especially those in the normal older control group, were rated as very good drivers with good defensive driving skills, and a low crash risk, but they still committed errors sufficient to fail them using conventional North American scoring methods. In the opinion of our expert evaluators, these errors were not dangerous ones and are typical of experienced drivers.

The lack of agreement between the on-road performance scores and expert ratings of driver competence led us to make explicit what an evaluation of older drivers should accomplish, and how this might differ from the goals of evaluating novice drivers. In brief, our position is that the goal of evaluating experienced older drivers is to identify *declines in competence*. Defining the types of errors that reflect declining competence is an empirical question that might best be answered with a comparative approach. By comparing the driving performance of normal experienced drivers with that of persons who have documented declines in driving-relevant mental abilities, the driving errors that are unique to declines in driving competence may be identified.

In our comparative approach, we examined in detail the driving errors of the three groups, the cognitively impaired, the 'normal' older and 'normal' young drivers. The first task was to categorize the driving errors in terms of type and severity. We then began analyses to identify the driving errors which, either quantitatively or qualitatively, differentiated the on-road performance of the three groups. Using this information, we then re-scored the on-road performance and evaluated the fit between the empirically derived scores and the expert ratings using regression techniques.

METHOD

Participants

The 155 patient participants were consecutive referrals to a Clinical Driving Consult of the Northern Alberta Regional Geriatric Program. All were currently driving and were referred for the consult because of a recently diagnosed medical condition that could affect driving. Most of the diagnoses were probable Alzheimer disease. On a case by case basis, the referrals to the Clinical Driving Consult were approached requesting their participation in the research project. All patients and their primary caregiver consented to participation in the research and signed consent forms after hearing a description of the project. They understood that the information gained in the research could be made available to their physician.

The 30 young and 70 older 'normal' drivers were recruited through newspaper and radio advertisements and posted solicitations from seniors groups. The advertisements for young participants requested currently driving volunteers between the ages of 30 and 40 years. Drivers age 65 and over were requested for the older group. None of the community volunteers were professional drivers. All young and older community volunteers had to have a person knowledgeable about their driving agree to participate in the research in order to be eligible for participation. Group means for age, years of driving, reported amount of driving and mental status scores for the three groups are presented in Table 1.

Protocol

All driving participants completed a Clinical Driving Consultation and a battery of research tasks. The driving consult consisted of an evaluation by the Neuropsychology and Rehabilitation Medicine Departments. The neuropsychology evaluation required approx. 6 hours of testing. The tests evaluated short-term memory, semantic memory, attention, language and a variety of other mental functions. Rehabilitation Medicine assessed sensory and motor functions, and administered several driving knowledge tests (e.g. traffic sign recognition test). This testing required approx. 2 hours. Each person then came to the Neurocognitive Research Unit and completed a 2 hour battery of research tests designed or selected because of their relevance to the prediction of driving performance. They also completed a questionnaire about their driving. The caregivers of the patients or persons knowledgeable about the community volunteer's driving completed a comparable driving questionnaire, but responded in terms of the participant's driving. The protocol culminated in the completion of a specially designed road test. Only

Table 1. Demographics

	Group					
	Patients		Old controls		Young controls	
Demographics	Mean	*SD*	Mean	*SD*	Mean	*SD*
N	155		68		30	
Men/women	109/43		38/33		10/20	
Age	72.7	9.1	69.4	6.8	35.6	3.2
Years of driving	49.6		46.0		19.9	
Km driven/week	92.4		128.9		141.7	
3MS	77.9	13.1	96.2	2.9	98.1	2.3

data from the specially designed road test will be reported herein.

Road test

The in-car driving evaluation was given in a mid-sized automobile with power steering, power brakes and an automatic transmission. The vehicle was equipped with dual brakes. The in-car driving evaluation was given in two parts. The first part was a closed course given in an area of the city which had paved streets with curbs, but was an undeveloped area without buildings. Permission was obtained to close the area to external traffic. Findings from the Closed Course will be reported elsewhere. The open-road test consisted of 37 maneuvers (e.g. turns, yields) and was approx. 40 min of driving time on commercial and residential streets and an urban freeway. The maneuvers selected were ones that have been implicated in crashes of older drivers (e.g. left hand turns, merges and lane changes).

Global judgements

Immediately after the road test, the Driving Evaluator provided ratings of global performance: accident risk (1 = highest, 10 = no risk); driver skill (1 = very poor, 4 = excellent); and defensive driving (1 = no problems, 5 = very severe problems). Facets of driving (e.g. competence for left turns, merging, lane changes) also were rated but will not be reported here.

Road test scoring

The score sheet for the road test was organized according to the sequence of the course. During the road test, the driving evaluator provided short descriptions of the type and severity of each driving error on a coding sheet. No attempt was made to restrict the nature of these notations. Each error was assigned 5, 10 or 51 (automatic fail for traffic violation or an extreme error) points depending on the rated severity of the error. An accumulation of >50 points resulted in a failing score. The Canadian Automobile Association (Alberta) Provincial Chief Driving Instructor served as the primary driving evaluator for evaluating the performance on the road test. He is highly experienced in the evaluation of driving performance and well trained in crash avoidance. The secondary driving evaluator was also a Canadian Automobile Association (Alberta) driving instructor trained by the primary evaluator for the research.

RESULTS

Global measures

The first three rows of Table 2 show the group means for the global ratings of the driving performance. The results of a multi-variate analysis of variance (MANOVA) on the three ratings was significant, Hotellings T Approximate $F=26.27$ ($S=2$, $M=0$, $N=120$). Univariate analysis indicated significant differences between groups for each rating as shown in Table 3. Student–Newman–Keuls post comparisons on each rating indicated that young normals were consistently rated better than old normals on all three measures and both rated better than the patient group.

The proportion of drivers who failed the driving evaluation using conventional North American scoring criteria were 0.72, 0.41 and 0.43 for the patient group, the old control group and the young control group, respectively. The high proportion of patients failing the driving evaluation was expected. However, that almost half of the normal older and younger drivers failed is disturbingly high. In order to evaluate why this might be occurring, global measures were calculated separately for those who passed and those who failed the road test within each group. A series of t-tests within each group indicated that patients who failed the road test were rated differently from patients who passed on Defensive Driving ($t=5.93$, df = 146, $p<0.001$), Accident Risk ($t=-5.68$, df = 149, $p<0.001$) and Driver Skill ($t=-5.89$, df = 148, $p<0.001$). Normal old drivers who passed were only rated differently from normal old drivers who failed on Defensive Driving ($t=2.25$, df = 69, $p<0.05$). Normal young drivers who passed were rated no differently than normal young drivers who failed the road test (all t's <2). In general, then, normal drivers

Table 2. Group means and standard deviations (*SD*) for the global ratings of driving performance

	Group							
	Patients		Old controls		Young controls			
Rating	Mean	*SD*	Mean	*SD*	Mean	*SD*	*F*	*p*
Defensive Driving	3.0	0.9	2.2	0.7	1.7	0.5	44.77	0.00
Accident Risk*	4.29	1.75	6.24	1.17	7.53	0.82	79.19	0.00
Driving Ability	2.21	0.76	2.99	0.50	3.37	0.37	58.68	0.00

*Low score = high risk.

Table 3. Global scores for those who passed and those who failed the road test by conventional North American licensing criteria

	Group					
	Patients		Old controls		Young controls	
Rating	Mean	*SD*	Mean	*SD*	Mean	*SD*
Pass						
Defensive Driving	3.22	0.83	2.37	0.75	1.73	0.53
Accident Risk*	3.83	1.47	6.03	1.43	7.54	0.97
Driving Ability	2.01	0.68	2.88	0.51	3.27	0.33
Fail						
Defensive Driving	2.32	0.75	2.03	0.54	1.74	0.44
Accident Risk*	5.48	1.86	6.40	0.91	7.53	0.72
Driving Ability	2.74	0.70	3.06	0.38	3.44	0.39

*Low score = high risk.

were rated as good drivers, having good defensive driving skills, and being at low risk for an accident, despite failing the road test. This discrepancy indicated that there was a problem with the scoring system used to evaluate the driving errors displayed during the on-road evaluation. A re-assessment of the scoring system required a detailed examination of the driving errors.

Driving errors

There were a large number of freely recorded driving errors. Once minor differences in wording were adjusted, a list of 150 different errors remained. This represents only a sample of the number of different errors which might conceivably be observed on a road course. In order to provide numerical indices of performance, and to provide a means of classifying future errors not yet observed, these error descriptions were sorted into categories which reflected the same general type of driving error. This grouping was accomplished by a procedure in which initial groupings were examined, and then altered on the basis of the results. Initially, each of the 12 persons in the research group performed an independent sort of the descriptions of the driving errors, and an empirical cluster analysis was performed on the combined matrix of sorts. Results were examined and changes were made to category membership on the basis of discussion and the results of the data analysis. This sequence went through a number of iterations, and the raters were blind to the group membership of the person making the errors. During this process, it readily became apparent that both the type of error and the severity needed to be accommodated in more than just a quantitative way. A turning error of quantitatively different severity levels did not capture the qualitatively different nature of turning errors (e.g. crossed multiple lanes in a turn but otherwise was competent versus a turning error which left the person going the wrong way on the freeway). To accommodate this distinction, a separate category (Hazardous Errors) was developed for errors which included, exclusively, the clearly dangerous errors regardless of the type of maneuver involved. In order for an error to be placed in the Hazardous Error category, the driving evaluator had to take control of the vehicle or the traffic had to adjust to accommodate the error. The result was a set of 13 categories of driving errors which satisfactorily grouped the observed errors and allowed for the placement of new errors within one of the categories. The labels for the remaining 12 categories and some representative examples are provided as follows:

(1) Extreme Positioning Error: driving on the shoulder;
(2) Minor Positioning Error: driving too close to lane markings;
(3) Turning Position Error: wide turns or cut turns;
(4) Stop Positioning Error: stopping too close or too far back;
(5) Scanning Error: no shoulder checks;
(6) Overcautiousness: driving too slow;
(7) Aggressive Maneuver: risky turns;
(8) Rolled Stop: failing to come to a complete stop at a sign/signal;
(9) Speed Error: driving over the posted speed limit;
(10) Vehicle Control: shaky steering;
(11) Poor Habits: one hand steering;
(12) Signal Error: late/early to signal.

Although some category labels (e.g., Overcautiousness, Aggressive) might sometimes imply a causal source such as a personality trait, this is not intended here. The labels are intended only as category descriptors for identifiable clusters of behaviors.

The scores for the various error categories were calculated by summing the severity scores of the errors within each category. The group means for each of the error categories are shown in Table 4.

Table 4. Group means for the error categories

	Group							
	Patients		Old controls		Young controls			
Error type	Mean	*SD*	Mean	*SD*	Mean	*SD*	*F*	*p*
Hazardous error	71.3	82.1	19.4	43.4	0.0	0.0	22.80	0.00
Extreme positioning error	1.1	6.2	0.4	2.1	0.0	0.0	0.85	NS
Minor positioning error	2.6	5.3	1.4	3.8	0.8	2.3	2.75	0.07
Turning position error	9.6	9.5	6.0	7.9	4.0	5.8	7.57	0.00
Stop position error	3.6	6.7	2.6	8.0	4.0	4.9	0.60	NS
Scanning error	5.5	5.9	3.7	5.1	0.5	2.0	11.90	0.00
Overcautiousness	3.3	6.8	1.1	2.7	0.2	0.9	6.47	0.00
Aggressive maneuver	0.6	3.1	0.4	2.6	0.0	0.0	0.66	NS
Rolled stop	14.1	30.5	17.9	30.7	13.6	29.8	0.43	NS
Speed error	20.8	38.1	16.3	34.0	15.3	23.8	0.56	NS
Vehicle control	0.1	1.0	0.1	0.6	0.0	0.0	0.37	NS
Poor habit	0.6	2.5	0.3	1.7	1.3	4.3	1.73	NS
Signal error	4.7	8.4	3.8	8.4	1.2	3.1	2.50	0.08

The results of a multivariate analysis of variance on all error categories was significant, Hotellings T Approximate $F=3.26$ ($S=2$, $M=5.5$, $N=117.5$). Uni-variate analyses of variance on each error category were also conducted and the results are shown in the final columns of Table 4. Examination of the data shows that the occurrence of a Hazardous Error is the best single indicator of membership in the patient group. Student–Newman–Keuls post comparisons confirmed that the patient scores were reliably higher than those for either the older and younger normal groups, which did not differ. Several of the other categories of driving errors also showed reliable or nearly reliable group differences (Minor Positioning Errors, Turning Position Errors, Scanning Errors, and Overcautiousness). Further post comparisons showed that the Patient group differed from both control groups on Minor Positioning Errors, Turning Position Errors and Overcautiousness. All groups differed from each other on the severity scores for Scanning Errors.

The severity scores for the groups did not differ on several of the measures. Two of these errors contributed highly to the total severity scores. These are rolled stops and speed errors. Rolled stops are a failure to come to a complete stop at a stop sign or red light before turning right, and most speed errors were failures to reduce speed in time when there was a change in speed zones. Although these are driving errors which could result in citations, they seem to be typical of driving errors made by experienced drivers. In any case, the lack of group differences indicate that they are not errors which signal a decline in competence and should not be used when detecting declines in competence is the goal. Consequently, Rolled Stops and Speed Errors were downgraded from a failing 51 points to 11. A recalculation of the severity scores for each of the groups was done to re-evaluate the number of passing and failing scores according to conventional North American criteria. This resulted in 68% of the patients, 25% of the older normals, and 3% of the younger normals failing the road test. These results are much more in line with expectations.

Prediction of global ratings

One way of evaluating the adequacy of the revised scoring is to use a regression analysis to examine how well the driving error scores predict the global ratings.The three global ratings (Defensive Driving, Accident Risk and Driving Ability) were analyzed using a principal components analysis. The result was a single factor which accounted for 90.2% of the variance (eigen value = 2.71). The factor score from the principal components analysis was saved and used as the criterion measure in a stepwise regression analysis with driving error scores used as the predictor variables. Based on the results of the analyses of the driving error scores, the scores from five error categories [Hazardous Errors, Minor Positioning Errors, Overcautiousness, Turns (positioning) and Scanning Errors] were used as predictor variables. The results of this analysis is presented in Table 5. As can be seen, all variables were significant predictors.

DISCUSSION

What is the meaning of a driving error? It is not unreasonable to suggest that this question needs to be addressed prior to the development of any scoring scheme which is to be used for evaluating driving competence. This seems especially important when the goal is to develop a driving evaluation that is to

Table 5. Prediction of global scores from driving performance measures

Error type	Multiple R	R^2
Hazardous error	0.686	0.470
Minor positioning error	0.717	0.514
Overcautiousness	0.732	0.536
Turn positioning error	0.746	0.557
Scanning error	0.754	0.569

detect declines in driving competence of experienced drivers which might render the person unsafe to drive. The goal of this report was to provide an initial step toward understanding the meaning of driving errors as they relate to assessing the competence of experienced drivers. The approach went beyond identifying the various errors that are displayed by persons who were from an at-risk driver (cognitively impaired) group. Simply identifying the errors does not provide information about the interpretation of the specific errors. Any error might be very important in identifying the person as unsafe, or it might be the type of error that is characteristic of experienced drivers and not indicative of declining competence. One could speculate about which are the important errors and which are the errors that should be discounted. The two groupings of errors could then be differentially weighted and an intuitive scoring scheme developed. We believe, however, that decisions about driving competence and de-licensing are much too important to rely on that level of justification.

Our approach was to compare the driving of younger and older 'normal' drivers with that of a large group of drivers who have cognitive declines that put them at-risk of being unsafe drivers. Comparing the road-test performance against expert ratings revealed serious shortcomings of typical North American scoring procedures. This is an important outcome to communicate, because those procedures are widely used in real world decision making about driver competence. Comparisons of driving errors of the three groups enables a differentiation of the types of errors that could be effective in identifying persons as being from the cognitively impaired (unsafe driver) group. The relevant analyses include both identifying the types of errors made by the cognitively impaired drivers, *and* identifying and discounting the types of errors that do not differentiate cognitively impaired drivers from normal drivers. Both are important and indispensable steps toward the development of an evaluation to assess declining competence.

The present findings indicated that older drivers with cognitive impairment made many more hazardous errors than did the two control groups which did not differ from each other. Further investigation of the hazardous errors indicated that half of the errors (50%) occurred while the vehicle was changing lanes, merging and approaching intersections. A significant number of hazardous errors occurred during left turns (21%) and failing to stop (15%). The remaining errors occurred in right turns (6%) and in stopping maneuvers (8%).

Older drivers with cognitive impairment also differed to a lesser extent from the two control groups in the number of turn positioning errors, minor positioning errors and overcautiousness. All three groups differed from each other in the number of scanning errors. It should be noted, however, that hazardous errors, and to a lesser extent scanning errors, turn positioning errors, minor positioning errors and overcautiousness, are errors that are indicative of declines in driving competence. This conclusion seems justifiable because of the high incidence of these errors among cognitively impaired drivers as compared to normal younger and older drivers. The remaining errors were made more or less equally by all groups and thus should be regarded as errors of experienced drivers. These errors are potentially correctable and should not be interpreted as indicators of declining competence.

The findings reported herein provide initial information about the meaning of driving errors, at least for the types of drivers included in the research. More detailed analyses of the errors, the cognitive status of the drivers, and the conditions of the driving errors may help to further refine the meaning of the errors for the purposes of developing an empirically based scoring scheme. We believe the approach outlined here is much preferred to one based on either expert judgment or rational grounds. We have used expert judgments in the some stages in the development of our understanding of different error types. In this regard, it is probably important that the outcomes of scoring schemes agree with the judgments of highly experienced evaluators. However, for the pragmatic goals of accomplishing the evaluations that are becoming increasingly important as the older driver population increases, it must be acknowledged that evaluators with high levels of expertise in assessing older drivers are relatively rare. Moreover, the consistency among those from different centers is not known and justifying decisions in cases of appeal may prove difficult. For these and other reasons, further work toward the development of an empirically based scoring scheme are needed to meet the challenges of identifying unsafe drivers older drivers while ensuring that those who are safe are allowed to retain driving privileges.

Acknowledgements—The authors gratefully acknowledge funding from the Health Services Research and Innovation Fund and the

Alberta Mental Health Research Fund administered by Alberta Heritage Fund for Medical Research. Barbara Carstensen coordinated the research project. Patricia Story, William Bland, Robert Frerichs, Serena Mah and Stacey Cunningham assisted in the project. James Hauptmann and Jim Chapman from the Canadian Automobile Association (Alberta) were the driving evaluators. The Canadian Automobile Association (Alberta) also provided expertise from Walter Barta and Rick Lang and funding in-kind for the research. The authors also wish to acknowledge Dr Peter McCracken, Dr Jean Triscott, Dr Ivan Kiss and Linda Barrett from the Northern Alberta Regional Geriatric Program who were especially helpful to the project.

REFERENCES

Association for the Advancement of Automotive Medicine (1991) Screening and licensing criteria for the older drivers. *AAAM Bulletin* **4**.

Carr, D., Jackson, T. and Alquire, P. (1990) Characteristics of an elderly driving population referred to a geriatric assessment center. *JAGS* **38**, 1145–1150.

Cerelli, E. (1989) *Older Drivers: The Age Factor in Traffic Safety*. US Department of Transport, National Highway Traffic Safety Administration, Washington DC.

Cooper, P. J., Tallman, K., Tuokko, H. and Beattie, B. L. (1993) Vehicle crash involvement and cognitive deficits in older drivers. *J. Safety Res.* **24**, 9–17.

Coopersmith, H. G., Korner-Bitensky, N. A. and Mayo, N. E. (1989) Determining medical fitness to drive: physcians' responsibilities in Canada. *Canadian Medical Association Journal* **140**, 375–378.

Cushman, L. A. (1992). The effect of cognitive decline and dementia on driving in older adults. Performed under a grant from AAA Foundation for Traffic Safety, Washington, DC.

Drickamar, M. A. and Marottoli, R. A. (1993) Physician responsibility in driver assessment. *The American Journal of the Medical Sciences* **306**, 277–281.

Dubinsky, R. M., Williamson, A., Gray, C. S. and Glatt, S. L. (1992) Driving in Alzeimer's Disease. *Journal of the American Geriatric Society* **40**, 1112–1116.

Evans, L. (1988) Older driver involvement in fatal and severe traffic accidents. *Journal of Gerontology* **43**, S186–S193.

Fitten, L. J., Perryman, K. M., Wilkinson, C. J., Little, R. J., Burns, M. M., Pachana, N., Mervis, R., Malmgren, R., Siembieca, D. W. and Ganzeil, S. (1995) Alzheimer and vascular dementias and driving A prospective road and laboratory study. *Journal of the American Medical Association* **273**, 1360–1365.

Folstein, M. F. and Folstein, S. E. (1975) "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research* **12**, 189–198.

Friedland, R. P., Koss, E., Kumar, A., Gaine, S., Metzler, D., Haxby, J. V. and Moore, A. (1988) Motor vehicles crashes in dementia of the Alzheimer's type. *Ann Neurol.* **4**, 782–786.

Gilley, D. W., Wilson, R. S., Bennett, D. A., Stebbins, G. T., Bernard, D. A., Whalen, M. E. and Fox, J. H. (1991) Cessation of driving and unsafe motor vehicles operation by dementia patients. *Arch. Intern Med.* **151**, 941–946.

Hunt, L., Morris, J. C., Edwards, D. and Wilson, B. S. (1993) Driving performance in persons with mild senile dementia of the Alzheimer type. *Journal of the American Geriatric Society* **41**, 747–753.

Kapust, L. R. and Weintraub, S. (1992) To drive or not to drive: preliminary results from the road testing of patients with dementia. *Journal of the Geriatric Psychiatry and Neurology* **5**, 210–216.

Lauer, A. R. (1964) Age and sex in relation to accidents. In: *Accident Research: Methods and Approaches*, eds. W. Haldon, E. A. Suchman and D. Klein. Harper and Row, New York, 1964.

Lucas-Blaustein, M. J., Filipp, L., Dungan, C. and Tune, L. (1988) Driving in patients with dementia. *JAGS* **36**, 1087–1091.

Miller, D. J. and Morley, J. E. (1993) Attitudes of physicians toward older drivers and driving policy. *JAGS* **41**, 722–724.

Odenheimer, G. L. (1993) Dementia and the older driver. *Clinics Geriatric Medicine* **9**, 349–364.

Odenheimer, G. L., Beaudet, M., Jette, A. M., Albert, M. S., Grande, L. and Minaker, K. L. (1994) Performance-based driving evaluation of the elderly driver: Safety, reliability, and validity. *Journal of Gerontology* **49**, M153–M159.

O'Neill, D., Neubauer, K., Boyle, M., Gerrard, J., Surmon, D. and Wilcock, G. K. (1992) Dementia and driving. *Journal of the Royal Society of Medicine* **85**, 199–202.

Persson, D. (1993) The elderly driver: deciding when to stop. *The Gerontologist* **33**, 88–91.

Planek, T. W. (1972) The aging driver in today's traffic. In Aging and highway safety, the elderly in a mobile society: North Carolina Symposium on highway safety, eds. T. W. Planek, W. A. Mann and E. I. Weiner, vol. 7, pp. 3–38. University of North Carolina, Chapel Hill.

Shemon, K. and Christensen, R. (1991). Automobile driving and Alzheimer's disease. *The American Journal of Alzheimer's Care and Related Disorders and Research* **Sept./Oct.**, 3–8.

Transportation Research Board (1988) *Transportation in an Aging Society*, Special Report No. 218, Vols 1 and 2. NRC, Washington, DC.

Tuokko, H., Tallman, K., Beattie, B. L., Cooper, P. and Weir, J. (1995) An examination of driving records in a dementia clinic. *Journal of Gerontology: Social Sciences* **50B**, S173–S181.

Waller, J. (1967) Cardiovascular disease, aging, and traffic accidents. *J Chronic Dis.* **20**, 615–620.

Williams, A. P. and Carsten, O. (1989) Driver age and crash involvement. *American Journal of Public Health* **79**, 326–327.

Yanik, A. J. (1985) What accident data reveal about elderly drivers (Society of Automotive Engineers Technical Paper Series No. 851688): Society of Automotive Engineers, Warrendale, PA.