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# ASSESSING THE OLDER DRIVER: PILOT STUDIES

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The principal objective of this project was to evaluate a selection of tests for their utility in identifying age-impaired drivers in a licensing agency setting and predicting the adequacy of their driving performance on a road test. As part of the project an extensive literature review (Janke, 1994) had already been published. Tests chosen on the basis of that review were piloted in two California sites. At one site, drivers referred for reexamination to the DMV were contrasted, in terms of performance on non-driving tests and two road tests, with volunteers. At the other site all subjects volunteered for the study, and predictions of their road test performance were made on the basis of their performance on non-driving tests. In addition, survey data from licensing authorities and older drivers themselves were collected. Based on study findings, tests or procedures are recommended for a first (brief functional screening), second (more intensive testing) and third (on-road testing) tier of assessment. Implications of the results for further research and policy issues, including graded licensing, are discussed.

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# PREFACE AND ACKNOWLEDGMENTS

This report describes pilot studies of test batteries conducted in the field pursuant to a cooperative agreement, *Evaluating Drivers with Dementia or Age-Related Frailty* (DTNH22-93-Y-05330), between the National Highway Traffic Safety Administration (NHTSA) and the California Department of Motor Vehicles (DMV). The project conducted under this agreement was a joint effort to identify and investigate the efficacy of tests that might prove to be suitable for the evaluation of driving competency in persons affected by dementia or "frailty" associated with the aging process. It began in October 1993 and terminated at the end of August 1997.

Separate test batteries were evaluated at two different sites in California, one being DMV's Santa Teresa office in San Jose and the other a research facility (the Buck Center for Research in Aging) in Novato. Non-driving and road tests were administered at the first site both to volunteers and to possibly impaired drivers referred to the office for reexamination. A different battery of nondriving tests and a road test were administered only to volunteers at the second. Part 2 describes the study at San Jose and its findings; Part 3 describes findings at Novato.

Other sections of the report relate to broader or somewhat different issues involving elderly drivers. Part 1 introduces the study and describes, through data from a document survey representing drivers aged 65 or more, the process by which DMV tests applicants and identifies those who may have impairments for driving, the types of restrictions or term limitations it imposes on the licenses of some drivers, and its post-licensure P&M program for drivers with medical impairments. Part 4 describes studies by the second author exploring the self-esteem and externality (other-direction) vs. internality (inner-direction) of individuals who kept, as compared to those who lost, their licenses after reexamination, as well as the affected drivers' and their closest associates' emotional and other reactions to loss or restriction of the license. Part 5 describes briefly the results of two surveys, answers to which are presented more fully in Appendices E through G. These surveys elicited the opinions of the project's expert advisory panel relative to elderly driver issues, and the opinions and jurisdictional practices relating to older drivers in a sample of states and one Canadian province (the "AAMVA survey"). Part 6 explores the implications of study findings for future research and licensing policy.

The authors would like to acknowledge the assistance of many people whose contributions to the completion of this project were substantial and in some cases critical, although the following will of necessity be only a partial list of those who helped us. The project could not have been accomplished, of course, without the support of the National Highway Traffic Safety Administration (NHTSA) and top management of the Department of Motor Vehicles (DMV). John W. Eberhard, the Contracting Officer's Technical Representative at NHTSA, and Raymond C. Peck, Chief of Research at DMV, provided indispensable project oversight and numerous cogent suggestions. Additional statistical analyses performed in response to the latter's recommendations, in particular, were an education in themselves and materially increased the signal-to-noise ratio of study results.

Within DMV Headquarters complex, we want to acknowledge the contributions of members of the first author's task force to develop the Area Driving Performance Evaluation or ADPE—Bruce Allen, Debbie Atkinson, Patti Caraska, Robert Hagge, David Hennessy, Mark Harling, Richard Hensley, Larry Hidalgo, Ed Imura, Pat Romanowicz, and Michele Snyder. This task force included many of the people who had earlier developed the Driving Performance Evaluation or DPE, the standard departmental test for novices now used in southern California and planned for use statewide. They represented many areas of DMV—Training, Driver Control Policy, Research and Development (R&D), Field Operations, Driver Safety, Driver Licensing Policy, and Publications and Procedures. The cooperative efforts of this task force over many weeks produced a test suitable not only for use in this study but in general for testing experienced California drivers who, because of cognitive declines, must be restricted to driving in familiar areas. Larry Hidalgo, DMV Training Officer, not only participated in this developmental effort but also trained all road test examiners administering the M(odified)DPE or ADPE for studies at the two sites. Bruce Allen, another participant in test development, also documented road test criteria and developed the test routes at San Jose and Novato. Douglas Luong of R&D set up a PC with touchscreen for us at the Santa Teresa office for use in administering Auto-Trails, and assisted us greatly in document preparation. David Hennessy of R&D trained the second author to administer the Pelli-Robson test at the Santa Teresa office in San Jose, and he both developed a testing protocol and trained volunteer test administrators to administer the Perceptual Reaction Time test at Buck Center in Novato, in addition to discovering useful literature references for the study. Among other contributors from R&D, Michael Gebers gave unfailing help in providing additional data from the tabulations cited in Part 1 of this report and William Marsh contributed a careful technical review of Part 2. Our thanks go to all of these people.

Of staff at DMV's Santa Teresa Office in San Jose, we especially want to thank Marilyn Patterson, the office manager, who made all arrangements to facilitate our study, and Bernard Beckwith and James Nelson—the special road test examiners without whose enthusiastic participation there would have been no study.

Of staff at the Buck Center for Research in Aging in Novato, we want especially to thank three people. One of these is Catherine West, M.D., Dr. P.H., the neuroepidemiologist who secured approval for our investigation at the Buck Center site from the Marin General Hospital Internal Review Board, oversaw project operations at Buck Center, and administered the Mini-Mental State Examination, scoring its pentagon task both in the conventional manner and, pursuing a more promising approach she found in the literature, in a graded manner to yield finer distinctions. Another is Kay McMahon, who made the project preparations from contract proposal onward—managing, scheduling and coordinating the study's critical startup activities. Finally, Ruth Youngquist was indispensable to the day-to-day operations of the project, informing and scheduling study participants and coordinating (sometimes assuming) the testing duties of the volunteer test administrators, whose activities were also indispensable and are much appreciated. Apart from Buck Center staff and volunteers we especially want to thank Derrick Scott, driving school owner/instructor and, for this project, road test examiner, who commuted from San Francisco in order to road-test the Novato drivers.

Many organizations or individuals furnished tests and test data which were necessary to the conduct of the study. Our special thanks go to Ken Kittinger, Deborah Quackenbush, and Larry Carlson of Doron Precision Systems, Inc., for Cue Recognition; to Loren Staplin, Larry Decina, and Kathy Lococo of The Scientex Corporation for use of their MultiCAD data; to Frank Schieber for Auto-Trails; to Michael Cantor for WayPoint; to Kristina Berg of Visual Resources, Inc. for use of one of their UFOV software programs, the perceptual reaction time or PRT test; and to Richard Marottoli, M.D., for the traffic sign test we used at Novato.

We wish to thank the experts who attended our Berkeley conference and gave us the benefit of their knowledge bearing on the assessment and treatment of drivers with aging-related impairments by a licensing agency. The names and affiliations of these experts are listed in Appendix E. Our thanks also go to the respondents, listed in Appendix G, to our mailed AAMVA survey. The views of survey respondents in both of these groups are briefly described in Part 5 and as noted there appear in much more complete form in Appendices E, F, and G. These people played a seminal role in the project.

We also want to recognize the contributions of Rick Williams and Justin Ortiz of R&D, who furnished consistent computer hardware support. And in shaping this final report we are especially indebted to R&D's desktop publishing expert, Debbie

M. McKenzie, for putting our rough manuscript draft into a final form suitable for publication.

Finally we want to thank our subjects at San Jose and Novato, who patiently endured lengthy testing and enabled this report of findings to be written.

## EXECUTIVE SUMMARY

### Background and Methods

Under a cooperative agreement with the National Highway Traffic Safety Administration (DTNH 22-93-Y-5330) this research evaluated, in limited pilot studies, a selection of tests for their effectiveness in (a) identifying drivers with aging-related physical or mental conditions, and (b) predicting drivers' weighted error scores on a road test. Distinct batteries of nondriving tests were evaluated at two California sites, the Santa Teresa field office of the California Department of Motor Vehicles (DMV) in San Jose, and the Buck Center for Research in Aging in Novato. Two road tests were administered in San Jose, one (the Area Driving Performance Evaluation or ADPE) in a familiar environment, the driver's home neighborhood, and the other (the Modified Driving Performance Evaluation or MDPE) in a relatively unfamiliar environment, the vicinity of the Santa Teresa office. One road test, the MDPE, was administered in Novato in the vicinity of the Buck Center, also a relatively unfamiliar environment. MDPE weighted error score was used as the driving criterion measure at both sites.

Drivers with aging-related impairments, particularly visual and cognitive ones, have an enhanced likelihood of crash involvement when they drive. However, current test procedures used by licensing agencies throughout the United States are generally too cursory to identify and evaluate them. The major aim of the research reported here was to identify a battery of effective tests feasible for licensing agency use.

It was planned that the assessment system would include three measurement tiers. The first would comprise relatively brief and inexpensive screening tests to flag license applicants whose driving abilities should be explored further through more intensive testing. Second-tier tests would be administered to applicants failing the first-tier tests and also to drivers reported to the department for reexamination; this tier would be composed of more elaborate and lengthy tests designed to determine whether the driver was either not sufficiently impaired, or too impaired and hazardous, to be required to take a road test. The road test would constitute the third assessment tier.

Subjects at the San Jose site were aged 55 or more and formed two groups, 102 referrals (drivers referred to DMV for reexamination because of a possible or diagnosed health-related problem) and 33 volunteers. Within the group of referrals, a separate group of 34 subjects with probable cognitive impairment was also identified. Subjects at the Novato site were aged 70 or more and formed a much more homogeneous group of 101 elderly drivers; very few were identified as having potentially serious impairments. They were similar to volunteers at the San Jose site in that they had chosen to participate in the study, but were a decade older on the average.

Tests are described in detail in succeeding chapters. Those that were evaluated in San Jose included the Snellen wall-chart test of high-contrast static acuity and a test of knowledge of rules of the road (both administered on a routine basis to all renewal applicants in California DMV field offices); structured observation and recording of predesignated impairments by the second author; a test of knowledge and perception of traffic signs; Auto-Trails (an automated test based on Trails A, part of a test called Trail Making, which requires the examinee to connect randomly arranged numbers in numerical order); the Pelli-Robson wall-chart test of low-contrast static acuity; and Doron Precision Systems' Cue Recognition test, which consists of three separate modules or subtests. Partway through the project the Scientex Corporation added its MultiCAD test battery and a manual test of neck flexibility. The MultiCAD battery contained automated tests of static and dynamic visual acuity at three stimulus levels—20/40, 20/80, and 20/200—and static and dynamic contrast sensitivity at two spatial frequency levels (corresponding to 20/40 and 20/80) and two levels of contrast. The battery also contained a realistic driving video presenting additional opportunities for getting time and error measures for response to critical situations.

Both gross and precise MultiCAD measures were used, though the latter were available for referral subjects only. The gross measures consisted of average time and total errors for each visual function test, ignoring stimulus size or contrast level, as well as total errors of any type for the driving video. The precise measures, furnished by Scientex for 82 referrals, were calculated separately for each stimulus level within a particular visual function; in calculating average response time, Scientex took into account, for a particular stimulus level/visual function combination, only trials on which the response was correct. Similarly, Scientex calculated precise measures for several different driving video exercises in terms of average response time for correct trials of each task and proportion of error trials on the task. In most analyses performed for this study, only the gross measures were used.

Tests administered at Novato included the three Cue Recognition modules and several other tests which had not been used at San Jose. These were balance and mobility exercises; the Mini-Mental State Examination of cognitive status (MMSE);

traffic sign recognition (a different test from that given at San Jose); the Perceptual Reaction Time (PRT) test, which is the first module in Visual Resources' Useful Field of View test; and WayPoint, based on Trails B. Trails B is the second part of the Trail Making test; it requires examinees to connect randomly arranged numbers and letters in a sequential manner, alternating between numbers and letters.

Subjects at both sites were also administered a survey on their driving habits and other personal driving-related information.

Through the statistical techniques of logistic regression and multiple linear regression, tests were identified which were predictive of (a) subject group in San Jose (referrals vs. volunteers) and (b) weighted errors on the MDPE at both sites. These were the primary study analyses. Supplementary logistic regression analyses using test and survey measures distinguished between cognitively impaired referrals and both cognitively unimpaired referrals and volunteers at San Jose, and between frail and nonfrail subjects at Novato. Most subjects at Novato classified for study purposes as frail had failed the balance test.

## General Findings

Based on results of the primary analyses, several non-driving tests were identified as being potentially useful for driver assessment. The task of selecting out drivers with possible impairment, who would require further testing in an operational three-tier system, involved finding tests that would distinguish between referrals (more likely to be impaired) and volunteers (more likely to be unimpaired). This could only be done using data from the San Jose site, because only at that site did we have a sample of referrals. For this first assessment tier the Pelli-Robson test and structured observation of previously listed observable problems (such as difficulty in understanding test instructions or obvious tremor) were recommended for licensing agency use, in addition to the standard California tests of high-contrast visual acuity and driving-related knowledge. It was argued that both of the recommended additional procedures are sufficiently brief to be applied either to all applicants over a given advanced age or alternatively to all applicants regardless of age, the latter alternative being preferable.

For the second purpose or assessment tier, prediction of road test performance, data from both study sites were applicable. High predictive accuracy of weighted error score on the MDPE (the criterion measure) was achieved, although this level of prediction should not be expected in the population, for reasons given below. To avoid stopwatch error and gain measurement precision it was recommended that PC-based tests be used; specifically, an automated form of Trail Making (either Auto-Trails, representing Trails A, or an automated version of WayPoint, representing Trails B) and, to supplement this, the PRT test. Despite their great predictive promise, the most technically elaborate tests investigated (Cue

Recognition, MultiCAD) were not recommended for licensing agency use at this time. Their use may become feasible in the future—especially if, through developmental research, their administration can be accomplished using a personal computer rather than more costly and cumbersome equipment; see recommendations below.

The MDPE road test was also recommended for use as a standard for evaluating older, experienced drivers for driving competency. The criterion measure used, weighted errors on this test, discriminated between referrals and volunteers at San Jose and between frail and nonfrail subjects at Novato. One specific error measure on the MDPE, concentration (or confusion) errors in finding the way back to the field office from a point some blocks past it, discriminated between cognitively impaired and cognitively unimpaired referrals.

Performance on the ADPE, a test developed specifically for this project, was not used as a criterion measure. This was partly because many (referral) subjects were considered by the examiners too hazardous, on the basis of their MDPE performance, to take it, and partly because it necessarily lacked a standardized route containing prechosen locations at which to score specific maneuvers. Thus its potential reliability was known at the outset to be less than that of the MDPE. Nevertheless, the test's interrater error score reliability, as measured using 20 drivers, was roughly equal to that of the MDPE and the correlations of ADPE total errors and weighted errors with the corresponding MDPE measures were high (both being .72) and significant.

Study samples, consisting of referrals and volunteers at San Jose and volunteers at Novato, were relatively small and not representative of the full range of either renewal applicants or reexamination referrals. Because of this, caution must be used in generalizing the findings to the larger population in California—not to mention other states. The high predictive accuracy of first- and second-tier test batteries was attributable in great part to the small sample size, the fact that the referral and volunteer samples in San Jose were highly contrasted groups, the large number of statistical tests made—which may have increased the probability that a difference would be declared significant when it was not, although corrections were made for this—and the absence of cross-validation samples. Use of the latter would have enabled us to verify whether, and to what extent, the relationships found in the original samples would hold for other samples. A much broader programmatic research effort will be necessary to identify the 'best' test battery for the purposes named here (and in fact one is presently being conducted by The Scientex Corporation). Nevertheless, adoption of the tests recommended on the basis of these pilot studies would, we believe, constitute a step forward in licensure testing.

## Specific Findings

Several comparisons which were made will be briefly described. Those contrasting test performance of referrals and volunteers could be made only at San Jose, since the Novato subjects were all volunteers.

*A. Predicting Group Membership*: *Volunteer vs. Referral* (San Jose only)

Only relatively brief and inexpensive measures were investigated for their ability to discriminate between volunteers and referrals, corresponding to the screening purpose of the first assessment tier. The measures found to discriminate best between the groups were the number of observed problems (the observer being the study's second author), the number of errors made on the Pelli-Robson test of low-contrast acuity, and Snellen test failure. Referrals had more observed problems (in fact, no volunteer had any) and also performed more poorly on the Pelli-Robson and Snellen tests.

It was considered particularly important for a licensing agency not to misidentify an unimpaired person as being impaired (i.e., in this study, identify a volunteer as a referral), since this would imply further testing and obvious public relations problems, not to mention inconvenience to the unimpaired driver. It was considered of secondary importance to correctly identify each impaired person since, especially in California, there are many other avenues by which impaired drivers come to the attention of the department. In the San Jose sample it was possible, combining the three measures listed above, to correctly identify the group membership of 97% of volunteers and 64.5% of referrals. However, this level of predictive performance holds only for this particular (unrepresentative) sample, and it cannot be generalized to the total older driver population.

*B. Correlates of Driving Performance* (San Jose and Novato)

In the San Jose sample, when referrals and volunteers were combined, poorer scores on the following nondriving tests were significantly associated with poorer performance on the road test:

First-tier tests
- Snellen failure
- Auto-Trails time
- Pelli-Robson errors
- Knowledge test errors
- Number of observed problems

In addition, drivers identified—through their medical evaluation form, their action reason code, or their difficulty in understanding test instructions—as having probable cognitive impairment performed more poorly on the road test. These were all in the referral group.

Second-tier tests

- Average choice reaction time on a Doron familiarization exercise
- Doron total errors (over all Cue Recognition modules plus the familiarization exercise)
- Doron Cue Recognition 1 score (corresponds to recognition time)
- Doron Cue Recognition 2 score (corresponds to recognition time)
- Doron Cue Recognition 3 score (corresponds to recognition time)
- Gross MultiCAD static acuity response time
- Gross MultiCAD static contrast sensitivity response time
- Gross MultiCAD dynamic acuity response time
- Gross number of MultiCAD static contrast sensitivity errors
- Gross number of MultiCAD dynamic acuity errors
- Gross number of MultiCAD dynamic contrast sensitivity errors
- Gross number of MultiCAD driving video errors

Within the group of referrals only, the following nondriving measures were significantly associated with poorer performance on the road test:

First-tier tests

- Auto-Trails time
- Knowledge test errors
- Number of observed problems

In addition, referrals with probable cognitive impairment performed more poorly than cognitively unimpaired referrals on the road test.

Second-tier tests

- All Doron measures listed above, except average choice reaction time
- Gross MultiCAD static acuity response time
- Gross MultiCAD dynamic acuity response time
- Gross number of MultiCAD driving video errors
- Precise MultiCAD static acuity response time for correct trials, 20/80 stimulus
- Precise MultiCAD static contrast sensitivity response time for correct trials, 20/80 stimulus at higher contrast level

Regression models which combined second-tier tests to form a test battery led to a high level of predictability of MDPE weighted error score. It has been explained above why the level of predictability achieved in this sample is somewhat misleading, although the tests which proved promising might well remain promising in a cross-validation sample.

In the Novato sample of volunteers, poorer scores on the following tests were either significantly associated with poorer performance on the road test, or they approached significance:

Number of MMSE domains in which an error was made (or conventional MMSE correctness score)
Perceptual response time (PRT)
Average time per WayPoint exercise (or its near-equivalent, channel capacity)
Number of WayPoint exercises on which an error occurred
Doron Cue Recognition 2 score
Doron Cue Recognition 3 score

The strongest relationships of the criterion, weighted errors on the road test, with individual measures were with scores on WayPoint. Prediction of this criterion using combinations of test measures (two different combinations being investigated) was not as good as in San Jose, but was moderate and statistically significant. The lesser degree of prediction obtained with the Novato sample was partly attributable to its homogeneity.

## Conclusions

- Drivers with age-related medical conditions, including cognitive impairment, can be differentiated from healthy older drivers with a substantial degree of accuracy on the basis of tests measuring sensory, perceptual, psychomotor, and cognitive functions, as well as driving performance itself.

- Performance on the road test (MDPE) can be predicted at least moderately by a number of nondriving tests which could be administered by licensing agencies.

## Policy Implications and Recommendations

- The three-tier assessment model, a generalized version of which is shown in Figure 1, and test batteries developed in the present study should be cross-validated in a licensing agency field trial involving a large probability sample of drivers. This research should include establishing age norms and pass-fail cutoffs for validated tests.

- Even before this is accomplished, addition of the Pelli-Robson test and adoption of structured and objective observation methods for use by DMV staff (already authorized though infrequently used) should be considered in California. These would be applied either to renewal applicants of any age or to those above a certain advanced age—perhaps 70, since at this age drivers are no longer eligible for renewal by mail—in addition to the knowledge and vision tests presently used.

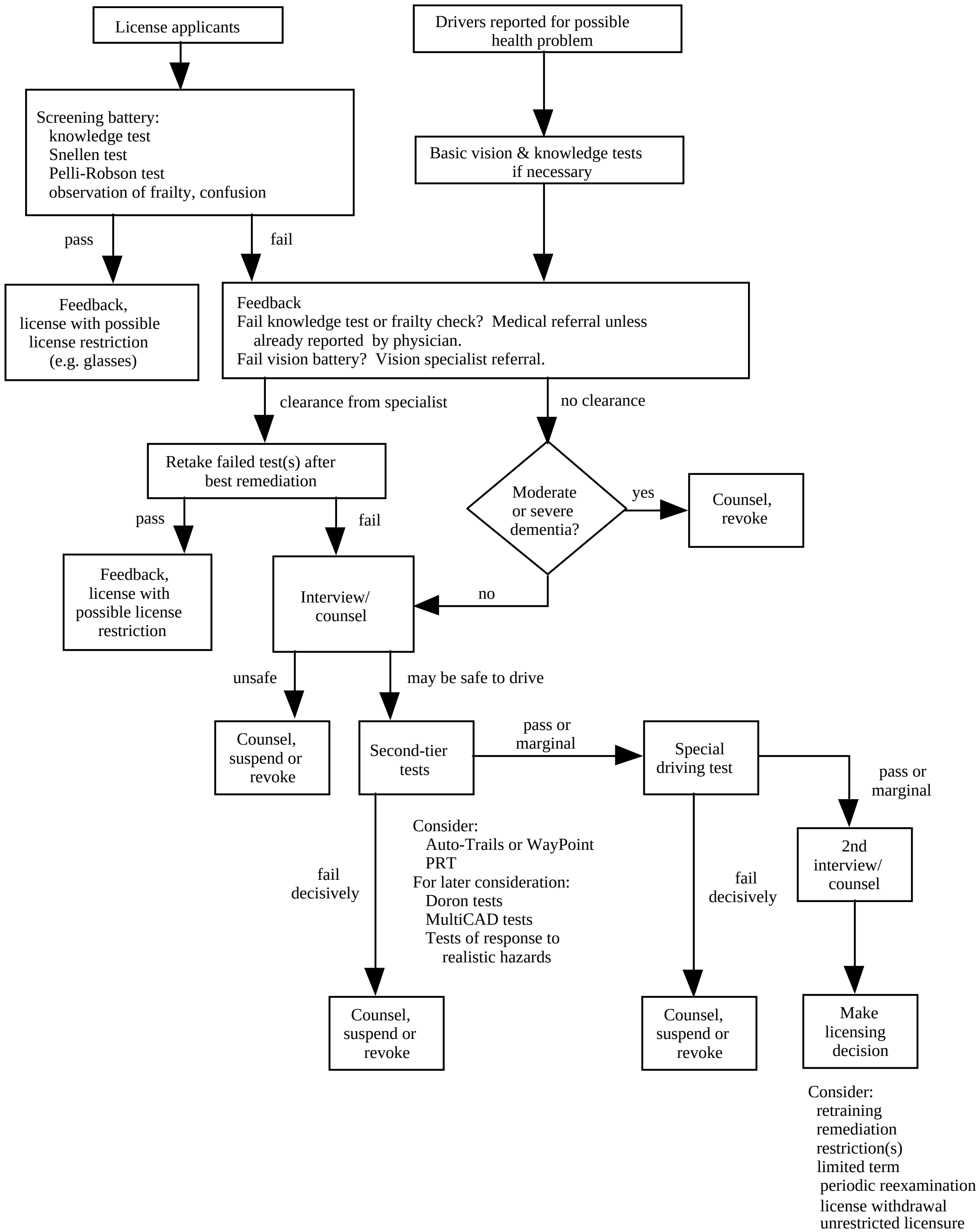


Figure 1 . Suggested elderly driver/medically impaired driver assessment system.

- All states should require knowledge and vision testing as a condition of license renewal for applicants of all ages.

- Participation in the recommended field trial should not be limited to subjects of advanced age, at least initially. The utility of first-tier tests for younger people as well as older ones may be considerable, and this should be determined through research comparing the performance of different age groups. Also, drivers who might undergo second-tier testing in an operational system because of impairment, including cognitive impairment, need not be old.

- Research should be undertaken (probably by the companies owning the tests) to convert tests involving relatively costly simulation or quasi-simulation of the driving task to a personal-computer format. This would encourage their adoption by licensing agencies. (If possible, a low-contrast version of the PRT, which has already been successfully adapted to a PC, should be developed as well.)

- If the above is accomplished, agencies should consider adopting such tests, because of their ecological validity (close similarity to aspects of the driving task) and predictive promise. It would be desirable, and may become possible in the future, to administer all licensing tests—or at least all nondriving tests for impaired reexaminees—on personal computers.

- Further research into tests of hazard perception and response, specifically, should be carried out; the only such test investigated in this study was the MultiCAD driving video. However, if hazard tests are to be administered to older and/or medically impaired people it should be ensured that these are not so stressful as to cause exacerbation of preexisting health problems.

- California's DPE as modified for this study (the MDPE) should be adopted as a standard road test for evaluating the competency of older, experienced drivers. The ADPE developed for this study should be considered for testing impaired drivers within a limited, familiar area. Appropriate restrictions can be developed on the basis of performance on these and nondriving tests.

- Research should be undertaken to develop a graded licensing system for drivers with medical and/or aging-related impairments, in which licensing decisions and license restrictions to reduce risk can be based on objective test performance and mobility needs.

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# PART 1
# California's Identification of Impaired Drivers

The need for safe transportation to necessary destinations persists throughout life. For most adults, driving one's own private motor vehicle is the primary way to satisfy that need. As adults age and incur disabilities related to aging, some continue to drive as before, though in many cases less safely; others—perhaps a majority—modify their driving habits in a way that makes the task less demanding and thereby safer. Still others give up, or are impelled by some organization or individual to give up, driving entirely. These must find other solutions to their transportation needs.

The driver licensing agency is responsible for license withdrawal, when that is seen as necessary. For less unsafe drivers, the agency may simply seek to modify driving habits and reduce risk through imposing restrictions on the driving privilege. Such restrictions may be identical to those the drivers have already adopted through their own volition, but in their specificity (e.g., use only particular roadways at particular times) and generality (e.g., never drive at night) they may go beyond these. Both license withdrawal and license restriction are best done on the basis of a valid testing process.

The licensing agency can also certify that drivers remain competent to drive, by renewing their licenses on the basis of some relevant form of renewal testing or, in some cases, allowing them to retain their licenses on the basis of reexamination results. Most of the present report will deal with the forms that relevant tests might take in order to verify the competency of the competent, suggest restrictions for those whose competency to drive under some types of conditions is questionable, and justify action against the driving privilege of those who are so incompetent as to be definitely unsafe. It is possible that members of the last group may regain sufficient competence to drive—e.g., through instruction or therapy—and request license reinstatement. In such cases licensing agencies can reexamine the drivers and determine the appropriateness of restoring their licenses.

Of course testing is not limited to licensing agencies. Many tests of functional abilities necessary for safe driving can be administered by health care professionals; one category of health care professional, the occupational or rehabilitation therapist, often administers actual road tests in addition to nondriving tests. But only the licensing agency bears statutory responsibility for the competence of drivers licensed by a particular state.

Motivated in part by an emerging trend toward an increasingly older driver population and consequently an anticipated increase in drivers with age-related disabilities (e.g., Eberhard, 1996), the National Highway Traffic Safety Administration (NHTSA) and California DMV entered in 1993 into a cooperative agreement to develop a model testing system for evaluating drivers with age-related disabilities, particularly cognitive impairment and "frailty." For study purposes, frailty was defined as a combination of medical conditions, the effects of which collectively impair activities of daily living. The present report is the final element called for by that agreement, as modified by circumstances to be described below.

The task as originally conceived was to construct and to some degree validate a model assessment system suitable for nationwide use, including test protocols and "system guides" for use by driver licensing agencies and "other practitioners in the field." A project literature review (Janke, 1994) describes in Part 1 the original goals or phases of the study as defined, and follows this introduction by reviewing extensive literature on (1) age-related impairing conditions and how they affect driving safety and/or competency, (2) assessment techniques—both nondriving and road tests—that might be used to measure the functional abilities of impaired drivers, and (3) licensing programs and policies in California and other jurisdictions which affect older drivers. On the basis of that review, promising tests were selected for administration in a DMV field office setting to drivers referred, because of various impairing conditions, to the department for reexamination. Subsequently another site, not a DMV office but a private research center, was added to the study in order to increase the diversity of tests and, if possible, the number of cognitively impaired drivers in the sample. As will be seen, the latter aim was not accomplished. Nevertheless addition of a second site did enable use of a different nondriving test battery, which proved to be of value in suggesting alternative testing options.

During the data collection phase the study's direction changed. Difficulties in gaining access to a sufficient number of elderly impaired drivers, particularly the cognitively impaired, led to a reduction in project scope but, at the same time, the addition of the second testing site mentioned above. Prior to completion of testing at the first site, NHTSA awarded a contract to a private research organization to develop the model driver screening and evaluation program, now to be applicable to drivers with any functional disability, including age-related conditions. Therefore the primary goal of the present study was redefined to place major emphasis on developing a valid road test and a battery of nondriving tests designed to predict performance on that test.

In considering how a model testing procedure for the older driver might be operationalized, a three-tier assessment system was envisioned and is described in Janke (1994, Part 6). In the first tier, brief and inexpensive screening tests would identify license applicants whose driving was likely to be affected by functional impairment. These tests, administered in a licensing agency field office by well trained driver licensing technicians, would serve to flag drivers not reported to the agency by other sources. Testing in the first tier would be relatively unobtrusive; it could not be too arduous for the driver or costly to the agency, and only those identified as being at high risk would be subjected to additional tests in a second tier.

In the second tier of assessment, longer and more elaborate tests would be used to determine whether passing a road test should be required for relicensure or license retention. Such tests could be administered by qualified licensing agency staff or, alternatively, by private service providers if the space and time requirements for lengthier assessment made it more advantageous to do so. In an operational system second-tier tests would be appropriate for drivers who performed poorly on the first tier (though perhaps not for those whose performance was so poor that no further evidence on which to base a licensing decision was needed). Second-tier tests would also be appropriate for drivers referred to the department for reexamination by physicians, law enforcement, concerned family members, or others, and thus already identified as having a functional impairment that might affect their driving. It might, for example, be the policy of a particular licensing agency to excuse drivers performing well on second-tier tests from taking a road test, to withhold or withdraw the driving privilege from those performing extremely poorly, and to give a road test to the middle group of drivers. This road test would constitute the third tier of assessment; it might eventuate in unrestricted licensure, restricted licensure, or delicensure.

For purposes of the present project, both study sites were in the Bay Area; that is, the region of California within the general vicinity of San Francisco. Part 2 of the report will describe results of an exploratory study at DMV's Santa Teresa office in the South Bay (Santa Clara County) community of San Jose. Part 3 will then describe results of exploratory testing at the second study site, the Buck Center for Research in Aging, in the North Bay (Marin County) community of Novato. The Discussion section of Part 3 will attempt to tie together results found at both study sites. In Part 4, results of two related studies by the second author, dealing with the self-esteem and inner-directedness of reexamined elderly drivers and also with the practical and emotional effects of restriction or loss of licensure on them, their family, and their friends, will be described. Part 5 will describe data from a survey of 11 jurisdictions regarding their elderly driver licensure practices and opinions from an expert panel regarding elderly driver assessment and the roles to be played in it by various professional groups. Part 6 discusses the research and policy implications of study findings.

But first, in order to illustrate the screening process that takes place at (re)license application, a review of printouts of test results (computer screen printouts) for drivers aged 65 or more will be described. These drivers applied for license renewal during a 2-week period in one of 25 DMV field offices; their records were available because the application had not been completed in one visit. Through extrapolation to DMV's 176 field offices the findings of this review may help to suggest how many older drivers fail to complete their applications in one trip to the field office (most commonly because of a renewal test failure), how the number of drivers failing various types of tests varies by age, and what use is made of license restrictions of different types.

Unfortunately, the *percentage* of older drivers who fail to complete the renewal process in one visit to the office cannot be estimated from these data. If a driver license application is completed on the first visit no entry is made on the test results screen; instead the information is updated directly to the automated driver record masterfile. This is a study limitation; however, previously published data are available regarding performance on the knowledge test—failure of which was responsible for most three-time test failures in this sample—as a function of age. Large-sample studies—though far from recent—indicate that in California older drivers make more errors on the knowledge test than younger ones and that the percentage of drivers passing the test on their first attempt decreases as a function of age (Carpenter, 1976; Dreyer, 1976).

Carpenter evaluated performance on both the DMV written knowledge test and the University of Michigan's Highway Safety Research Institute (HSRI) item pool (Pollock & McDole, 1973), based on a driving task analysis. On the DMV test the number of errors was a function of education, better educated drivers performing better, and also of age, the fewest errors being made by drivers aged 30-39 and their number increasing with advancing age over 39. The correlation between errors and age was low (.10) but statistically significant in Carpenter's sample of 48,000 license applicants. On the average, renewal applicants aged 30-39 made between two and three errors; those aged 50-59 made nearly three, and those aged 60 or more made between three and four errors, a passing score being five or fewer. All test forms consisting of items from the HSRI pool correlated significantly with age, younger renewal applicants again making fewer errors than older ones. The relationships of performance with age for specific content areas (correlations of .10 to .30) were not as strong as the corresponding relationships with education (correlations of -.25 to -.43). In answer to an obvious question raised by these results, a correlation matrix presented by Carpenter for one 45-item form, stated to be typical of results obtained on all forms administered to renewal applicants, showed a statistically significant correlation of -.16 between age and education, indicating (not unexpectedly) that younger people in the sample also were, on average, better educated. DMV test forms were significantly related to driving record, persons with fewer crashes and traffic convictions doing better, but forms created using HSRI items were less so—driving record correlations with number wrong were low in magnitude and inconsistent in direction.

In his study of test data from a sample of almost 9,000 renewal applicants, Dreyer found that the percentage of drivers of all ages eventually licensed who passed the written knowledge test on the first attempt was 78%, while for the subsample aged 50 or more it was 67%. He also found that, as number of errors on the knowledge test increased, the frequency of crashes and traffic convictions increased "moderately." Dreyer discussed limitations of his study, perhaps the most serious one being that the relationships found were not based on all applicants but only on ultimately successful ones. He also acknowledged that changes in the tests had occurred even between the time of his data collection and report publication. Since 1976, of course, many other changes have taken place in the tests and in society as a whole, but in broad outline the relationships found by Carpenter and by Dreyer may well still hold.

In almost all jurisdictions, license renewal impacts many more elderly drivers than does reexamination, which is typically motivated by concerns regarding the driving competence or safety of particular individuals. In fact Levy, Vernick, and Howard (1995) wrote that state driver's license renewal requirements represent one of the few public policies with the potential to have a direct effect on senior traffic safety. They found that, in 1991, 38 states required vision tests while 4 required in addition a driving-related knowledge test for drivers of all ages at license renewal. Sixteen states imposed additional tests or reduced the length of the license term for drivers above some age. Only eight states required no tests at renewal. In California, drivers below the age of 70 may renew their licenses by mail, avoiding all field office testing, so long as their driving records are relatively free of incidents. At age 70 and above, however, they are required to come to a field office to renew and to do this must pass tests of high-contrast static acuity (the Snellen chart) and driving-related knowledge (traffic laws, signs, safe driving practices). These are the same tests that must be passed by drivers of any age who do not qualify for renewal by mail.

Lange and McKnight (in press) investigated the effect of age-based skill testing on the road for license renewal, in states (Illinois, Indiana) having this policy. Illinois administers vision, knowledge, and road tests every 4 years from ages 75 through 80, every 2 years from age 81 through 86, and every year beginning at age 87. Indiana administers vision, knowledge, and road tests every 3 years beginning at age 75. Motor vehicle accident data of drivers aged 75 or more from these states were contrasted with similar data from Ohio and Michigan, geographically contiguous states. In addition, accident data for drivers aged 70-74 in testing and non-testing states were used for comparison purposes. Comparisons were based on crash rates per licensed driver, and it was hypothesized that the ratio of older to younger crash rates would be smaller for the states using age-based testing. For total accidents this hypothesis was confirmed—implying that, overall, age-based testing prevents crashes by selectively removing from the driving population drivers likely to be involved in a crash. No difference appeared for injury, or property-damage-only accidents, specifically. And while fatal accidents appeared to show an effect, the number of such crashes was small and the results to some extent lacked stability. Lange and McKnight raised a question as to whether the effect found was due to the removal of unsafe older drivers or to a reduction in the amount of driving by older people in general. Since the dependent variable in all of their analyses was crashes per licensed driver, this would seemingly not be a matter of fewer older people being licensed—if that number declined, the denominator would be reduced and the fraction increased. But Lange and McKnight pointed out that older people intimidated by the prospect of being tested might, though licensed, reduce the amount of their driving. Whether or not this seems psychologically likely, a culpability analysis was undertaken to decide between the alternatives. As an indicator of culpability Lange and McKnight inspected single-vehicle crashes, finding that the proportion of such crashes was not lower in states with age-based testing. On the contrary a significant increase was found, with a relative rate greater than 1. The appropriateness of single-vehicle crashes as an index of culpability caused by a test-discoverable lack of skill may be questioned. (Janke, Peck, and Dreyer [1978], in agreement with Waller and Goo [1969], found a relative excess of accidents involving collisions with a fixed object, rather than another vehicle, among drivers with medical conditions. This suggested that episodes of illness rather than lack of skill were the primary causal factor.) But the question as to whether unsafe drivers only, or also nonconfident drivers, are weeded out by age-based testing requirements is one that has been raised in other studies.

For instance, Levy et al. (1995) discovered that mandatory renewal vision testing (applicable either to all drivers or only to senior drivers) was associated with fewer fatal crashes for those aged 70 or above. They found weaker evidence that mandatory renewal driving-knowledge tests, given to senior drivers only, were associated with fewer fatal crashes for this group. While the enhanced safety of older drivers was clearly a positive effect, the authors noted that in part the crash reduction effect may have been attributable to a reduction in the rate of licensure for older but not necessarily unsafe drivers, in addition to screening out those who were demonstrably unsafe. This raises concerns, as the authors recognized, regarding restricted mobility for older people if licensure testing is—or is feared by the public as being—unduly stringent.

Such concerns were echoed by Hakamies-Blomqvist, Johansson, and Lundberg (1996), studying the safety effects of periodic medical screening (general health status and vision) of older drivers for licensure in Finland. They found that this screening system does not lead to enhanced safety for older drivers and vehicle occupants in Finland as compared with Sweden, which has no age-related licensure screening, medical or otherwise. In fact, although Swedish physicians must report patients who have health problems that make them unfit to drive (unless the patient promises to stop driving), there is no routine testing connected with renewal of a driver's license, which is granted for life. Sweden's age trend in crash and fatality rates of drivers and passengers was found to be similar to Finland's, but the traffic fatality rate of unprotected older road users—pedestrians, moped riders, and cyclists—was more than twice as high in Finland as in Sweden, suggesting to Hakamies-Blomqvist et al. that the screening itself produces a shift to a more risky method of transportation, indirectly leading to higher fatality rates among older road users. The authors postulated that, first, drivers who give up their licenses in Finland may primarily be those who do little driving anyway, so the collective mileage of the older driving population may not significantly change; second, screening may eliminate the wrong subgroup from the driving population. It may eliminate, they wrote, drivers who are especially sensitive to social pressure and aware of risk, persons probably belonging to a low-risk fraction of the driving population. On the contrary, they continued, some high-risk subgroups with little symptom awareness like persons with dementing illnesses may pass the medical screen; these are unlikely voluntarily to give up driving.

Table 1 presents information about license testing practices in various jurisdictions, derived from National Highway Traffic Safety Association/American Association of Motor Vehicle Administrators (1990) and from Petrucelli and Malinowski (1992).

Some idiosyncratic licensing features could not be included in the table. For example, Georgia and Kansas allow home completion of the knowledge/traffic-signs test for license renewal, a provision which might be especially convenient for elderly applicants. In Georgia the test is not scored; in Kansas it is scored at the field office.

Table 1. Jurisdictional Licensure Testing Practices

| Country | Age-based license testing or term | | | | | | Phys. report to DMV (7) | No ren. tests in general (8) | Driver record can trigger a test (9) | Ren. vision & knowl. tests (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Knowledge (1) | Road (2) | Vision (3) | Medical exam/ report/cert. (4) | Basic lic. term (yrs.) (5) | License term shortened (6) | | | | |
| UNITED STATES | | | | | | | | | | |
| Alabama | | | | | 4 | | | 4 | | |
| Alaska | | | | | | | | | | |
| Arizona | | | | | | | | | | |
| Arkansas | | | | | 4 | | | 4 | ? | |
| California | | | | | 4 | | M | | | 4 |
| Colorado | | | | | 5 | | | | | |
| Connecticut | | | | | 4 | | SA | 4 | | |
| Delaware | | | | | 5 | | M | | | |
| Dist of Columbia | 75 | 75 | | 70 | 4 | | | | | |
| Florida | | | | | 6 | | SA | | | |
| Georgia | | | | | | | M | | | |
| Hawaii | | | | | 4 | 65 | | | | 4 |
| Idaho | | | | | 4 | | | | | |
| Illinios | 69 | 69 | | | 4 | | SA | | | |
| Indiana | 75 | 75 | | | 4 | 75 | | | | |
| Iowa | | | | | 4 | 70 | | | | |
| Kansas | | | | | 4 | | | | | 4 |
| Kentucky | | | | | 4 | | | 4 | ? | |
| Louisiana | | | | | 4 | | | | | 4 |

## Table 1 (continued)

| Country | Age-based license testing or term | | | | | | Phys. report to DMV (7) | No ren. tests in general (8) | Driver record can trigger a test (9) | Ren. vision & knowl. tests (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Knowledge (1) | Road (2) | Vision (3) | Medical exam/ report/cert. (4) | Basic lic. term (yrs.) (5) | License term shortened (6) | | | | |
| Maine | | | 40 | | 4 | | | 4 | | |
| Maryland | | | | 70 (original) | 4 | | SA | | | |
| Massachusetts | | | | | 4 | | | | | |
| Michigan | | | | | 4 | | | | | 4 |
| Minnesota | | | | | 4 | | SA | | | |
| Mississippi | | | | | | | | 4 | Yes | |
| Missouri | | | | | 3 | | | | | |
| Montana | | | | | 4 | | | | | |
| Nebraska | | | | | 4 | | | | | |
| Nevada | | | | | 4 | | M | | | |
| New Hampshire | 75 | 75 | | | 4 | | | | | |
| New Jersey | | | | | | | M | 4(10% vision test) | | |
| New Mexico | | | | | 4 | 75 | | | | |
| New York | | | | | | | | | | |
| North Carolina | | | | | | | | | | |
| North Dakota | | | | | 4 | | SA | | | |
| Ohio | | | | | 4 | | SA | | | |
| Oklahoma | | | | | | | SA | 4 | | |
| Oregon | | | 50 | | 4 | | M | 4 | | |
| Pennsylvania | | | 45 (random) | 45 (random) | | | M | 4 | Yes | |
| Puerto Rico | | | | | | | | | | |
| Rhode Island | | | | | 5 | 68 | SA | | | |
| South Carolina | | | | | | | | | | |
| South Dakota | | | | | 4 | | | | | |
| Tennessee | | | | | 4 | | | 4 | | |
| Texas | | | | | 4 | | | | | |
| Utah | | | | | 10 | 65 | SA | | | 4 |
| Vermont | | | | | | | | 4 | | |
| Virginia | | | | | 5 | | | | | |
| Washington | | | | | 4 | | | | | |
| West Virginia | | | | | 4 | | | 4 | | |
| Wisconsin | | | | | 4 | | | | | |
| Wyoming | | | | | 4 | | | | | |
| <u>CANADA</u> | | | | | | | | | | |
| Alberta | 70 | 70 | 70 | 75 | | | SA | 4 | Yes | |
| British Columbia | | | | 75 | 5 | | SA | 4 | | |
| Manitoba | | | | 65 | 4 | | M | 4 | Yes | |
| New Brunswick | | | | | | | | 4 | | |
| Newfoundland | | | | 70 | | | | 4 | | |
| NW Territories | | | | | 5 | 70 | M | ? | | |
| Nova Scotia | | | | | | | SA | 4 | | |
| Ontario | 80 | 80 | 80 | | 3 | | M | | | |
| Prince Ed Island | | | | | 3 | | M | 4 | Yes | |
| Quebec | | | | 70 | 2 | | | | | |
| Saskatchewan | | | | | | | | 4 | | |
| Yukon Territory | | | | 70 | | | M | ? | | |

Legend: M = mandatory physician report of some types of patients to DMV
SA = statutorily authorized physician report to DMV under some circumstances

Most states require some periodic testing for renewal licensure, and of those administering some form of renewal test, most require vision screening. Six states administer both vision and knowledge tests, as shown in column 10 of Table 1. No jurisdiction administers driving tests to all renewal applicants.

Several jurisdictions are identified in Table 1 as having age-based knowledge, vision, or road testing; the age at which such testing begins is given in the table. In addition, some states, generally not those having age-based testing, shorten the license terms of drivers over a certain age. Physician report of patients with certain conditions is either mandated or authorized in most jurisdictions; the majority of those would be expected to be older people, who might then enter their jurisdiction's post-licensing control process.

Such jurisdictional practices have implications for the present project. Jurisdictions which customarily administer licensing tests to all renewal applicants, or to all applicants over a certain age, would probably have the least difficulty in incorporating new tests into their system. Those which do not administer renewal tests to drivers of any age would be expected to have much more difficulty in incorporating a testing system of any degree of complexity into their renewal process. In the case of cognitively impaired older drivers the most reliable source of identification is probably the physician rather than licensing tests but, as of the date of writing, California is the only state that mandates physician reporting of dementia. As Table 1 shows, numerous jurisdictions do not mandate or even statutorily authorize physician report of any medical condition. These potential impediments to any proposed identification/assessment system should be kept in mind.

*Review of screening test results for drivers 65+*

Printouts of test results and license restrictions for 1,501 license applicants with birth year prior to 1930 were collected from selected DMV field offices during a two-week period in November 1994. Almost all of these applicants were thus aged 65 or more, although those born in late November or December of 1929 had not quite reached their 65th birthday. Printouts had been requested from 27 of California's 176 offices, and all but 2 responded. As noted above, such printouts were available only for drivers whose applications were not completed on their first visit to the field office, usually because of test failure though sometimes for some other reason. Therefore the reader is again cautioned not to infer from the following what percentages of older drivers in general fail various tests.

Drivers not completing the application on their first visit included both original and renewal applicants for a California driver's license; 1,466 or 97.7% were renewals—that is, their expiring license was a California one. (Individuals who have been licensed in another state and are applying for their first California license are considered original applicants, although they are not novice drivers.) Applicants could hold, or be applying for, licenses of any class, but it was expected that in this age range very few would drive heavy commercial vehicles, and this proved to be the case. In fact, four drivers applied for commercial licenses at the surveyed application; three of these had previously held commercial licenses. Of the drivers applying for private passenger vehicle licenses, five had previously been commercial heavy-vehicle operators.

Drivers under age 70 were underrepresented in the sample. Probably the chief factor accounting for this was the renewal-by-mail (RBM) program in California which, as mentioned above, allows many drivers under 70 to renew their licenses by mail. The criteria for RBM eligibility are not stringent, though they are voluminous. In addition to the age requirement, RBM-eligible drivers now (and in 1994) cannot have the driving privilege on probation—including medical probation—and for the 2 years preceding license expiration cannot have certain medical impairment codes (e.g., for vision loss) on their driving records, cannot have been involved in two or more accidents, cannot have more than one point on the driving record indicating a traffic violation or responsible accident, cannot have failed either to appear in court or to forfeit bail in connection with a traffic citation, cannot have been suspended administratively for driving under the influence of alcohol or drugs, and cannot have refused a chemical test of intoxication when requested to complete one by a law enforcement officer. In the 3 years prior to license expiration, the driver cannot have been involved in as many as three accidents, responsible or not. Those drivers under 70 who are not eligible for RBM thus tend either to have worse driving records than the average or some driving-related physical or mental impairment that has come to the attention of the department.

As noted, applicants renewing their licenses in a field office must pass tests of driving-related knowledge and high-contrast static visual acuity (Snellen chart). Applicants for original California licenses who previously were licensed in another jurisdiction take the same tests. Original applicants who have not previously been licensed, and applicants seeking to upgrade from a private passenger vehicle license to a heavy-vehicle license, take a road test in addition to knowledge and vision tests. In addition, as part of the in-person application process, selected renewal applicants may be asked to take a road test if their observable behavior raises doubts about their competence to drive. Such drivers, who may show confusion, tremor, unsteady balance, etc., are more likely than not to be elderly.

Table 2 lists reasons for an incomplete application and the number (percentage) of documents reviewed which showed each reason type.

Table 2

Reasons for Incomplete Application

| Reason | Number | (%) |
| --- | --- | --- |
| Test failure—test type not specified | 607 | (40) |
| Knowledge test failure | 400 | (27) |
| Photo needed | 174 | (12) |
| Vision test failure and referral to vision specialist | 84 | (6) |
| Three-time test failure (usually knowledge test) | 60 | (4) |
| Message number needed | 56 | (4) |
| Drive test failure | 48 | (3) |
| Drive test mandatory | 35 | (2) |
| Verification of social security number required | 21 | (1) |
| Verification of birthdate required | 7 | (<1) |
| Driver Safety referral | 5 | (<1) |
| Other | 4 | (<1) |
| Total | 1,501 | (100) |

In this sample, reasons indicating poor performance on tests, or other evidence of disability, accounted for over 80% of the cases. Some of the reasons in the table above are self-explanatory. Use of the code for unspecified “test results” is discouraged if the specific test is known, but the code may often be used simply because it fits a wide variety of cases. “Photo needed” implies that all licensing tests have been passed, and the application is ready to be completed as soon as the photo is taken or the photo document printed. A “vision referral” code, appearing in the table as “vision test failure and referral to vision specialist” requires the applicant to obtain a Report of Vision Examination (DL-62) filled out by that specialist. Results of the DMV vision test are also entered on the DL-62, which is to be returned to DMV with the specialist’s notations. Retesting and perhaps a road test follows. A “three-time test failure” has taken some kind of test (usually the knowledge test) three times without being able to pass it. Such a person must apply again, paying another fee, and will not be licensed until he or she has passed a road test after first passing the test failed three times. “Message number needed” conveys technical information irrelevant to our concerns here. A “mandatory drive test” is a legally required road test, given not only when the applicant has never been licensed or wants to change to a higher class of license, but also, e.g., whenever a recommendation is made to issue, extend, or end a limited-term (less than 4-year) license, or whenever any restriction (except corrective lens) due to a physical condition is imposed or removed. (There is also a code for “discretionary drive test,” which applies to cases in which the licensing technician determines that such a test should be given because of marginal knowledge of driving laws or observable disability. No such codes appeared in this sample, implying that discretionary road tests are rarely required.) A Driver Safety referral (from the field office to Driver Safety) is given in cases where there may be some physical or mental disorder that could make driving unsafe and should be investigated further—by getting a medical evaluation of the driver, for instance, and perhaps by a later reexamination. It is possible that some of these notations represent discretionary road tests, but there were only 5 Driver Safety referrals in all in this sample, less than 1% of the 1,501 contacts.

Some drivers fail (different versions of) the knowledge test several times, despite having an opportunity to review the material in the Driver Handbook between tests, and Table 3 shows the number and percentage of successive knowledge test failures by age group. In the present sample, the proportion of applicants passing the knowledge test tended to decrease with advancing age, although the relationship was not monotonic. Within the sample as a whole, 52.6% failed it on their first attempt. This failure rate is higher than that for the population as a whole, and higher than that for young original applicants. But again it should be kept in mind that this was a sample of older drivers who had to return to the office precisely because their application could not be completed in one visit (sometimes more than one), most often due to test failure.

Table 3

Number (%) of Successive Knowledge Test Failures by Age

| | Number of failures | | | | |
|---|---|---|---|---|---|
| Age | 0 | 1 | 2 | 3 | Total |
| Under 70 | 73 (59.4) | 36 (29.3) | 12 (9.8) | 2 (1.6) | 123 (100) |
| 70-74 | 229 (44.5) | 189 (36.7) | 80 (15.5) | 17 (3.3) | 515 (100) |
| 75-79 | 232 (53.3) | 132 (30.3) | 55 (12.6) | 16 (3.7) | 435 (100) |
| 80-84 | 128 (42.0) | 108 (35.4) | 51 (16.7) | 18 (5.9) | 305 (100) |
| 85 & up | 50 (40.6) | 44 (35.8) | 26 (21.1) | 3 (2.4) | 123 (100) |
| Total | 712 (47.4) | 509 (33.9) | 224 (14.9) | 56 (3.7) | 1,501 (100) |

As indicated above, applicants must eventually pass the knowledge test but are allowed to take it as many as three times on one application, which is good for a year. In the table, those who had already failed the knowledge test once appear in the column headed "1" if they passed the test on their second attempt in November 1994; if they again failed on this second attempt they appear in that headed "2." Applicants who have failed three times become "three-time test failures," described above. It can be seen that the relationship between age and test failure is not monotonic, although in general an older person in this sample was more likely to fail than a younger one.

A record is kept of the number of knowledge test failures and each test version failed, because a different version must be given on each attempt. For vision no sequential record is kept. As noted, if a driver fails to reach the 20/40 acuity screening level, he or she is given a DL-62 form to be filled out by a vision specialist and returned to the department; this form calls not only for acuity but also for visual field extent, diagnosis, prognosis, and other information. Drivers may or may not undergo corrective efforts by the vision specialist; in either case they must retake the DMV test. If they pass they can be licensed, assuming satisfactory performance on other tests; if not, they are typically given a road test to determine whether they can compensate for their impaired vision and qualify for a restricted license. If their vision condition is progressive the license term may also be shortened (a limited-term license) or they may be required to come back in a year or less for retesting (a "calendar reexamination"). The number (%) and age of applicants failing the vision test follows in Table 4.

Table 4

Number (%) of Vision Test Failures by Age

| Age | Fail | Pass | Total |
|---|---|---|---|
| Under 70 | 9 (7.3) | 114 (92.7) | 123 (100) |
| 70-74 | 21 (4.1) | 494 (95.9) | 515 (100) |
| 75-79 | 43 (9.9) | 392 (90.1) | 435 (100) |
| 80-84 | 50 (16.4) | 255 (83.6) | 305 (100) |
| 85 & up | 25 (20.3) | 98 (79.7) | 123 (100) |
| Total | 148 (9.9) | 1,353 (90.1) | 1,501 (100) |

Although a majority of applicants in each age group (over 90% in the three youngest age groups) passed the vision test, the percentage passing dropped fairly regularly after age 74. The under-70s are aberrant in that they performed less well on the vision test than did those aged 70-74. As noted above, sufficiently poor vision can make drivers ineligible for mail renewal; it is also possible that poor vision among the under-70s contributed to crashes and violations that led to the same result.

It is not rare at any age to fail the vision screen and receive a referral to a vision specialist, but drivers aged 65 or more constitute 62.5% of vision referrals, according to an unpublished tabulation by Michael Gebers (personal communication, 1997) based on 1992 data representing a random sample of the entire driving population. Of drivers aged 65-69, approximately one percent received vision referrals; in the age groups 70-74, 75-79, and 80 or more the corresponding rates were 1.97%, 3.64%, and 8.71%, respectively.

Table 5 shows, by age group, the number and percentage of applicants required to take a road test, and the number and percentage who failed, *relative to the number taking it* (conditional failure rates). Unconditional failure rates (number failing/total number in age group), which—ignoring the aberrant youngest category—were monotonic, are shown in the last column. Still ignoring those under 70, the likelihood of being asked to take a road test increased regularly with age but the likelihood of failure given that a test was taken was not monotonic, though highest for those aged 75 or more.

Table 5

Conditional and Unconditional Road Test Failure Rates by Age

| Age | Took road test | Conditional failure no. (rate) | Total no. | Unconditional failure rate |
|---|---|---|---|---|
| Under 70 | 8 (6.5%) | 6 (75.0%) | 123 | 4.9% |
| 70-74 | 22 (4.3%) | 14 (63.6%) | 515 | 2.7% |
| 75-79 | 29 (6.7%) | 25 (86.2%) | 435 | 5.7% |
| 80-84 | 33 (10.8%) | 26 (78.8%) | 305 | 8.5% |
| 85 & up | 17 (13.8%) | 14 (82.4%) | 123 | 11.3% |
| Total | 109 (7.3%) | 85 (78.0%) | 1,501 | 5.7% |

Limited-term licensees are tabulated in Table 6, which shows that in this sample term limitation was (still ignoring the aberrant under-70 category) employed proportionately more often as driver age increased. A limited-term license is issued when a driver is judged to be still licensable, but has a progressive or unstable condition (frequently a vision condition) which requires, in the opinion of the examiner, that he or she be retested in less than four years. Road testing is required if a recommendation has been made to issue, extend, or end a limited-term license. The license is issued for one or two years; if more frequent monitoring is necessary a requirement for calendar reexamination is imposed rather than a limited license term.

Table 6

Number (%) with Limited-Term Licenses by Age

| Age | Number (percent) | License term | Total |
|---|---|---|---|
| Under 70 | 3 (2.4) | 2 years | 123 (100) |
| 70-74 | 5 (1.0) | three 2 years, two 1 year | 515 (100) |
| 75-79 | 6 (1.4) | 2 years | 435 (100) |
| 80-84 | 9 (3.0) | seven 2 years, two 1 year | 305 (100) |
| 85 & up | 6 (4.9) | five 2 years, one 1 year | 123 (100) |
| Total | 29 (1.9) | | 1,501 (100) |

Table 6 shows that issuance of a limited-term license is infrequent in California. An unpublished tabulation by Michael Gebers (personal communication, 1997) shows that as of May, 1992, only one-third of one percent of drivers had limited license terms. Essentially all of these drove private passenger vehicles, and the great majority (85.6%) were 65 or more; two-thirds were 75 or more. Of the 29 people shown in Table 6 as receiving limited license terms, three were original applicants and the others renewals. One of the three original applicants never succeeded in being licensed with a limited term or otherwise, judging from a driving record printout obtained two years after his application. Almost all of these drivers were restricted to corrective lenses; some were restricted additionally to driving only in daylight or under customized circumstances; e.g., restriction to a particular area.

The numbers (percentages) by age group of drivers in this sample who had no restriction or only a corrective lens restriction (01) versus other restriction(s) appear in Table 7. Zero restrictions (shown by 448 or about 30% of these drivers) and restriction type 01 were combined because 01 is overwhelmingly the restriction most commonly used in California, for all ages.

It can be seen that over 98% of drivers in this sample, like the vast majority of those in the general driving population, had at most a corrective lens restriction. However, in this sample 29 people had other restrictions, either alone or (usually) in addition to 01 and perhaps others. Some had limited license terms, but it should be emphasized that the set of 29 people with restrictions other than 01 is not identical to the set of 29 people with limited-term licenses. Judging from these data, use of restrictions apart from 01 becomes relatively common only among drivers aged 85 or more.

Table 7

Number (%) with None or 01 Only vs. Other Restriction(s) by Age

| Age | None or 01 only | Other restriction(s) | Total |
|---|---|---|---|
| Under 70 | 120 (97.6) | 3 (2.4) | 123 (100) |
| 70-74 | 510 (99.0) | 5 (1.0) | 515 (100) |
| 75-79 | 433 (99.5) | 2 (0.5) | 435 (100) |
| 80-84 | 295 (96.7) | 10 (3.3) | 305 (100) |
| 85 & up | 114 (92.7) | 9 (7.3) | 123 (100) |
| Total | 1,472 (98.1) | 29 (1.9) | 1,501 (100) |

Two drivers in this sample had only restriction 50 (indicating customized restrictions, usually to specific areas or routes). All of the drivers having more than one restriction had 01 as one of these; there were 27 such people. Eighteen had only one restriction in addition to 01, with three having as their other restriction 06 (additional outside mirror), eight having 07 (daylight driving only), five having 50, one having 13 (area), and one having 48 (limited to vehicle without air brakes when driving commercially). Codes 13 and 50 can both indicate area restrictions, but DMV staff are directed in their code book to use restriction code 50 instead of 13 for this purpose. However, use of 13 had apparently not been totally discontinued when this sample was drawn.

Eight drivers had three restrictions—that is, two in addition to 01. Two of these were commercial heavy vehicle operators. One had restrictions 46 (must wear corrective lenses when driving commercially—seemingly redundant, given the 01 restriction) and 48 (limited to vehicles without air brakes when driving commercially). The other had restrictions 32 (must wear hearing aid when driving commercially) and 64 (when driving heavy vehicles, limited to those with an automatic transmission). Of the six triply restricted drivers licensed to drive only private passenger vehicles, one had restrictions 06 (additional outside mirror required) and 07 (daylight only); one had 09 (must drive vehicle with adequate signaling device) and 10 (limited to vehicle with automatic transmission); one had 06 and 50, and three 07 and 50. One driver had four restrictions, three in addition to 01; these were 06, 10, and 50.

Thus there were 13 drivers with restriction 13 or 50, commonly indicating limitation to a particular area or particular routes. Almost as prevalent in this sample was the 07 restriction which disallows driving at night; 12 drivers were limited in this way. The restriction is applicable to drivers with visual impairments that cannot be fully corrected, including those who can pass the vision test only with the aid of a bioptic telescopic lens. (Bioptic drivers also receive a restriction code of 44—restricted to use of bioptic lens; there were none in this sample.)

Another unpublished tabulation by Michael Gebers (personal communication, 1997) gives information on area and time-of-day (chiefly daylight driving only) restrictions for a 1992 random sample of the entire California driving population. These restrictions are imposed very uncommonly, on only .074% of the driving population, but again much more often on elderly drivers than on younger ones. Of those having an area and/or time-of-day restriction, 85.7% were aged 65 or more and 72.8% were aged 75 or more.

Graded licensing for impaired older drivers (Malfetti & Winter, 1990) involves use of suitable license restrictions in place of license withdrawal, given that an acceptable degree of safety can be achieved. What are the implications of the results of this test screen review for graded licensing? It is apparent that in California in 1994, at least, license restrictions were not often used to manage the risk of elderly drivers. Given the degraded vision and reduced information reception and information processing speeds characteristic of aging, as well as the fact that driving in darkness is a reduced-cue situation posing challenges to both visual and cognitive abilities, it would probably be wise to make greater use of the sunrise-to-sunset-only restriction. It might be assumed that this would demand vision testing of a type that is not done now, not to mention cognitive testing. But if drivers fail to pass the relatively unchallenging standard high-contrast static visual acuity test, it is reasonable to assume that their visual functioning is even worse in reduced illumination and headlight glare, even without evidence of impaired visual functioning that may come from the DL-62. In the absence of restrictions imposed by the licensing agency, only the fact that many elderly drivers already restrict themselves to daylight driving mitigates the risk that would otherwise be present.

While the 1,501 drivers whose test-result screen printouts were reviewed here were license applicants and not reexamination referrals (though several received referrals to a vision specialist and a few [see Table 2] were referred to Driver Safety as a result of their in-person application and/or test performance), a fully realized graded licensing program for medically impaired drivers of any age would be expected to make frequent use of restrictions, especially customized restrictions. The latter might limit driving to certain areas, certain routes, certain weather conditions, or to non-congested times of the day, in order to maximize safety while allowing the elderly driver to perform necessary errands. These restrictions, like daylight-driving-only, also limit the challenges to both vision and cognition, and have the potential to make a necessary degree of mobility possible for people with impairments beyond those associated with normal aging.

*Impaired drivers: Other means of identification*

At licensure, including license renewal by mail, drivers must answer health questions that ask whether they have or have had a "disease, disorder, disability, or addiction. . . including episodes of loss of consciousness or marked confusion or habitual use of any drug or medication" that could impair their ability to drive safely, and whether they have a vision disorder that cannot be corrected by lenses or surgery. An affirmative answer to one of these questions initiates an inquiry to determine whether the driver should be referred to Driver Safety for further exploration of the case. Affirmative answers are not common; for example, a 1979 collection of all application forms for original or renewal licenses on which a 'yes' answer appeared resulted, over a period of 6 1/2 months, in only 579 license applications showing an affirmative answer to the health question. (It should be added that no explicit question on vision disorders appeared on the application at that time.) The median age of this sample was 37.3 years; it was found that these self-reporting drivers had significantly worse prior crash-involvement records than had a randomly selected comparison sample having a median age of 37.8 years (Janke, 1980). This suggests that the application's medical impairment question does serve a beneficial traffic-safety purpose.

Apart from the license application process, drivers may be referred to DMV for reexamination by physicians, family, law enforcement, traffic courts, and other sources. Table 8 shows, for calendar year 1996, the numbers of drivers in various physical and mental impairment (P&M) categories who, not already under a P&M action by reason of their impairment, were dealt with through revocation, suspension, probation, or no action (from California Department of Motor Vehicles' Annual Suspension and Revocation reports). Data on imposition of license restrictions for persons in these impairment categories were not available.

Table 8

Disposition of Cases for P&M Drivers Not Under Preexisting P&M Action
(1996 Suspension and Revocation Report)

| P&M category | Action type | | | | Total # (%) |
|---|---|---|---|---|---|
| | Revocation # (%) | Suspension # (%) | Probation # (%) | No action # (%) | |
| General categories | | | | | |
| Mental condition | 77 (3) | 1,216 (41) | 200 (7) | 1,455 (49) | 2,948 (100) |
| Physical condition | 167 (2) | 4,598 (46) | 115 (1) | 5,096 (51) | 9,976 (100) |
| Lapse of conscious. | 111 (<1) | 11,732 (45) | 1,134 (4) | 13,101 (50) | 26,078 (100) |
| Drug addiction | 50 (4) | 541 (43) | 104 (8) | 551 (44) | 1,246 (100) |
| Lack of knowl./skill | 2,487 (28) | 2,225 (25) | 0 (0) | 4,115 (47) | 8,827 (100) |
| Alcoholism | 19 (2) | 281 (36) | 67 (9) | 413 (53) | 780 (100) |
| Specific categories | | | | | |
| Alzheimer's | 174 (16) | 616 (58) | 2 (<1) | 278 (26) | 1,070 (100) |
| Other/unkn. dement. | 454 (13) | 1,979 (58) | 5 (<1) | 993 (29) | 3,431 (100) |
| Cardiovascular | 13 (1) | 409 (42) | 14 (1) | 533 (55) | 969 (100) |
| Diabetes mellitus | 15 (<1) | 733 (35) | 112 (5) | 1,227 (59) | 2,087 (100) |
| Hearing loss | 0 (0) | 9 (53) | 0 (0) | 8 (47) | 17 (100) |
| Musculoskeletal | 3 (2) | 67 (38) | 4 (2) | 101 (58) | 175 (100) |
| Neurological | 15 (2) | 252 (40) | 7 (1) | 355 (56) | 629 (100) |
| Pulmonary | 2 (3) | 31 (42) | 2 (3) | 38 (52) | 73 (100) |
| Vision loss | 145 (8) | 656 (37) | 1 (<1) | 975 (55) | 1,777 (100) |
| Total for action type | 3,732 (6) | 25,345 (42) | 1,767 (3) | 29,239 (49) | 60,083 (100) |

Note: Volumes for specific P&M categories are independent of those for general P&M categories; there is no overlap.

Medically impaired drivers are also assigned "action reason codes" that appear on the driving record if an interview, reexamination, or hearing takes place. These codes denote either a general or a specific impairment category. There is no overlap between the two; a driver with Alzheimer's disease, e.g., might be assigned a code indicating either "mental condition" or "Alzheimer's disease" but not both. It can be seen that the largest P&M category has the general designation "Lapse of Consciousness." This may be in part for historical reasons. Since 1939, physicians have been required by law to report patients with (any) conditions causing lapses of consciousness that may recur; the requirement to report dementia was added almost 50 years later, in 1988 (Janke, 1993).

The most common dispositions of "P&M cases," as impairment cases become when referred to Driver Safety, are suspension for an indefinite period of time—until, perhaps, the condition is stabilized—and no action. The general category "Lack of Knowledge or Skill" is aberrant in that a substantial proportion of these drivers are revoked rather than suspended. Commonly the drivers in this category are people of advanced age with nonspecific or undiagnosed age-related impairments (including, and perhaps most commonly, beginning dementia) causing them either to be unable to pass the knowledge test on repeated attempts or to be reported by a police officer for some deviant form of behavior on the road. The driving privilege will then be revoked if it is judged that the individual is not likely to improve.

In such cases the licensing decision may now be delegated to the road-test examiner. This was decided in 1996, in conjunction with a change which, before it was implemented, Janke (1994; Part 4) described as follows:

> . . . *it can be expected that the development of this test, which will be called the Driver Performance Evaluation or DPE, will influence conduct of California's Special Drive Test (SDT), discussed below. It may even be that the DPE, augmented by condition-related modules, will serve as a substitute for the SDT.*

In 1996 this came to pass in offices (at present only those in southern California) where the DPE is administered. A modified version of the DPE (here called the MDPE) was used in San Jose and Novato; a restricted-area DPE, or ADPE, was also developed but only administered in San Jose.

When the licensing decision is delegated, the examiner has authority to order an immediate revocation of the driving privilege after any DPE test (although the referral form and score sheets are reviewed by Driver Safety to verify that the action was appropriate). The referral form now includes a licensing decision box which the Driver Safety hearing officer may check to indicate who is to make this determination. The decision is delegated to the examiner if the box is not marked, as well as in cases where, e.g., the driver was reported for lack of skill and has no (known) P&M impairment, or has only a slight, nonprogressive impairment that needs no further evaluation by the hearing officer. In general, if medical information must be considered in making the licensing decision, responsibility still rests with the hearing officer.

One would expect that older drivers would be more heavily impacted by the P&M program than younger ones. Table 9 shows, by age and P&M group, the numbers and percentages of drivers aged 50 or more having a P&M code on record. P&M

impairment group (e.g., vision) is indicated by the P&M code. These data, representing drivers of private passenger vehicles only, come from Michael Gebers' unpublished tabulation (personal communication, 1997), based on a random sample of licensed California drivers whose data were extracted in 1992. At that time only very general P&M categories were used—physical disorder, mental disorder, lack of knowledge or skill, and so forth. More recently the new codes indicating specific conditions such as Alzheimer's disease or diabetes mellitus came into use.

Table 9

P&M Group by Age of Driver (1992 Data)

| P&M group | Age | | | | | |
|---|---|---|---|---|---|---|
| | 50-59 | | 60-69 | | 70+ | |
| | *N* | % | *N* | % | *N* | % |
| None | 23,213 | 98.80 | 18,078 | 98.73 | 14,310 | 97.59 |
| Alcoholism | 88 | .37 | 48 | .26 | 27 | .18 |
| Drug addiction | 19 | .08 | 11 | .06 | 2 | .01 |
| Lack knowledge or skill | 5 | .02 | 8 | .04 | 91 | .62 |
| Lapse of conciousness | 95 | .40 | 74 | .40 | 75 | .51 |
| Mental condition | 18 | .08 | 17 | .09 | 15 | .10 |
| Physical condition | 58 | .25 | 75 | .41 | 143 | .98 |
| Total | 23,496 | 100.00 | 18,311 | 100.00 | 14,663 | 100.00 |

It will be noted that the vast majority of older drivers (as is even more true for younger ones) do not have P&M indicators on their records. This does not necessarily mean that they are free of possibly driving-related medical conditions; it simply means that their cases have not come, or been brought, to the attention of the department. The decline with increasing age in the categories *alcoholism* and *drug addiction*, and striking increase in the categories *lack of knowledge or skill* and *physical condition*, are notable as well. Drivers are most often placed in the *lack of knowledge or skill* category because they have been unable to pass the renewal knowledge test or because they have been reported to DMV by a law enforcement officer for some traffic offense that calls their competency to drive into question. Occurrences of both types may stem from cognitive impairment, an age-related disability of special interest in the present study.

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# PART 2
## First Study Site: San Jose

Tests which seemed to be promising candidates for first- and second-tier assessment batteries were administered at DMV's Santa Teresa field office, located in south San Jose. They had been chosen on the basis of an extensive review of the literature conducted for the present project (Janke, 1994), which included consideration of age-related medical impairments and existing tests of abilities related to driving. Subjects were two groups of experienced older drivers (age 55 or more initially; later age 65 or more). One of the two groups of study subjects consisted of 102 individuals meeting age and English literacy criteria who had been referred as part of normal DMV procedures to field office examiners for reexamination because of a medical condition, a series of licensing test failures, a flagrant driving error, or some other indicator of possible driving impairment. The group also included drivers who had been referred and had lost the driving privilege some time previously; now they were trying to regain it through passing a reexamination. All of these drivers constituted the referral group. The other group, used for comparison purposes, consisted of 33 paid volunteers, of similar age and also English-literate, who were recruited principally by means of signs posted at the study site and by word of mouth. This will be called the volunteer group.

## METHODS

Much of the following description of methodology appears in Janke and Eberhard (in press). Non-driving tests representing the first and second assessment tiers were administered by an advanced graduate student (the second author) trained in counseling psychology and having counseling experience. First-tier measures were considered to be those tests or observations which demanded no equipment beyond a PC. Specifically, they did not involve use of a driving simulator; those which did were considered to be in the second tier.

The driving tests (third-tier measures) were administered by two DMV special licensing examiners who had extensive training and experience in administering road tests to drivers with medical and aging-related impairments. These examiners were blinded to (i.e., kept unaware of) subjects' performance on the experimental nondriving tests, but they were not blinded to results of the standard vision screen and knowledge test, both of which are required for licensure in California. In the case of the referral group, a recommendation for continuation or termination of the driving privilege depended upon road test performance. In almost all cases (though some drivers showing extreme unsafety were summarily revoked by the examiner), hearing officers within DMV's Driver Safety Branch made the final licensing decision on the basis of examiner recommendation, medical information, and any other relevant information elicited from interviewing the driver. In the case of volunteers, performance on the road test had no effect on the driving privilege and no official record of it was kept. Road test examiners knew which subjects were referrals and which were volunteers; this was an unavoidable source of possible unconscious bias in their scoring of the test.

Testing began in the spring of 1995. In mid-September 1995, The Scientex Corporation of Kulpsville (then Lansdale) Pennsylvania, studying intersection negotiation problems of older drivers under a contract with NHTSA (Staplin, Gish, Decina, Lococo, & McKnight, in preparation), "joined the study" in the sense of sharing subjects and the two road tests described below. Their study dealt only with referral drivers, and after this point only two more volunteers were recruited, although several whose appointments had already been scheduled were tested. From mid-September on, subjects were administered both the DMV battery and the Scientex battery of nondriving tests.

*Nondriving tests*

Nondriving tests (other than those of the Scientex Corporation) included a modified Snellen chart (containing five lines of letters at the 20/40 size, California's visual acuity standard) viewed at a distance of 6m; Auto-Trails, a modified and automated version of Trails A of Reitan's (1955) Trail Making Test which had been developed by Dr. Frank Schieber of the University of South Dakota; Cue Recognition, a shortened version of perceptual-speed exercises developed by Doron Precision Systems, Inc. of Binghamton, New York; a driving knowledge (rules of the road) test; an experimental supplementary test of traffic sign knowledge and perception, and the Pelli-Robson test (Pelli, Robson, & Wilkins, 1988) of low-contrast acuity or, more generally, contrast sensitivity at one spatial frequency. (An Optec checkerboard visual acuity test was also given, but those data were not discriminatory and are not part of the present report.) The Scientex automated test battery (MultiCAD) included tests of static and dynamic acuity, static and dynamic contrast sensitivity, and more complex attention-related behaviors in a driving video. A manual test of neck flexibility, not part of MultiCAD, was also included in the Scientex battery.

To give a more detailed description of the tests:

(a) Auto-Trails presents 14 randomly arranged numbers on a computer monitor with touchscreen. These are displayed against the background of a traffic scene as observed by the driver through the windshield of a car. The subject's task is to touch the numbers in numerical order as rapidly and accurately as possible; timing is done by the computer. In the present study the score used was total time; very few subjects made errors. A paper-and-pencil version of the test has been published as a test of 'reaction time' in the American Association of Retired Persons' (AARP's) 1992 booklet, "Older Driver Skill Assessment and Resource Guide: Creating Mobility Choices."

(b) The three-part Cue Recognition test was administered by means of a non-interactive driving simulator system, Doron's L-300 Series Driver Analyzer. Earlier versions of the system have been successfully used in driving-related research on the performance of elderly and impaired individuals (e.g., Flint, Smith, & Rossi, 1988; Galski, Bruno, & Ehle, 1992). Before beginning the cue recognition segments of the test, a familiarization session accustomed subjects to the simulator and also gave the opportunity for testing choice reaction time (in braking to lights flashing in a certain configuration on the console). Scores on this exercise are referred to below as Doron reaction time (Doron RT). Cue Recognition proper consists of three parts here called Cue Recognition 1 (brake response), 2 (steering wheel response), and 3 (either response, depending upon the type of cue presented). The test displays car icons generally facing away from the subject and suddenly changing their positions on a wide projection screen. When the subject sees among these an "action cue"—an icon that faces forward or to the side—the task is to release the accelerator (otherwise held down per instructions) and within 5 seconds brake or turn the wheel in the appropriate direction, respectively. The proper braking or steering response must occur in order for the recognition response to "count," but what is actually timed is the recognition response—the release of the accelerator pedal at the appearance of the action cue. Thus the speed of the braking or steering response, so long as it is correct, is not a factor. At this study site scores for each trial were output automatically in terms of the distance (time-equivalent) that would have been traveled at 55 mph from action cue presentation to accelerator release. When there was no valid response on recognition trials, either because the subject did not respond (i.e., did not respond within the 5 seconds allowed) or because of another error (e.g., accelerator or steering wheel in the wrong position) it was decided to record their score for that trial as 404 (feet). This score represented a distance slightly greater than that traveled at 55 mph in 5 seconds (403.3 feet or 123 meters).

(c) In the 48-letter Pelli-Robson test (Pelli, Robson, & Wilkins, 1988) of high-luminance, low-contrast acuity (contrast sensitivity, in a broad sense) the contrast between letters and background decreases as one moves down and toward the right of a wall-mounted chart, which subjects viewed at a distance of 2 meters under normal room illumination. Letters (in groups of three) range from 90% contrast at the upper left of the chart to 0.5% contrast at the lower right. Standard Pelli-Robson scoring calls for a count of number correct, but in this case errors were counted, to conform with the scoring of the other tests. This test was found to be the most discriminating measure for crash prediction in a group of insurance policyholders aged 50 or more when it was used as part of a battery studied by the ITT Hartford Insurance Group (Brown, Greaney, Mitchel, & Lee, 1993).

(d) The knowledge test used here was a 12-item multiple-choice written test with four alternatives per item. Items were selected from versions of DMV's standard 18-item renewal knowledge test. Supplemental to it was a written traffic-sign test designed for the study. This had two parts. One presented pictures of traffic signs and asked, for each, whether it meant that the driver should perform a certain action, like "watch for hazards." The other presented several traffic sign shapes (e.g., the octagonal shape of a STOP sign) embedded in complex abstract drawings, and subjects were asked to indicate the number of sign shapes of a particular type hidden in the drawing. Such a test, called an "embedded figures test" or EFT, can be considered more generally a test of field dependence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962). EFTs have been found to be sensitive to cognitive impairment and, in some studies, to be related to accidents (e.g., Harano, 1963; Mihal & Barrett, 1976).

(e) While not a test, an observational measure was made by the second author of the number of observable "problems" or disabilities manifested by a subject during the testing process. A list of observable disabilities was communicated as part of the testing instructions before any test data were collected. The list included tremor, stiffness, weak grip, nonfunctional or missing limbs, impaired balance or use of a wheelchair or walker, and difficulty in understanding test instructions (recall that all subjects were English-literate).

(f) An overall avoidance measure was derived from a driving-habits survey previously used by Hennessy (1995), who found different forms of self-restriction to moderate the relationship between prior crash involvement and performance on vision tests. In nine questions subjects were asked whether they avoided specific driving situations (e.g., heavy traffic or unfamiliar areas); their answers could range on a four-point scale from "never" to "always." The overall measure, the sum of the numbers corresponding to their answers, is a function of both the number of situations avoided and the reported strength of avoidance.

Descriptions of tests (primarily from the automated Multiple Competency Assessment for Driving or MultiCAD) in the battery used by Scientex follow.

(a) Neck flexibility. In the only nonautomated test used by Scientex, subjects' neck rotation to left and right was measured manually on a graduated scale by the second author. The average of these two measurements was used here to define neck flexibility.

(b) Static high-contrast acuity. MultiCAD was used to measure subjects' ability to resolve fine detail on a stationary target under high-contrast conditions. Subjects were shown a driver's-eye view of travel along a suburban arterial, approaching and then stopping at an intersection featuring a readily visible traffic signal. The image of this signal then enlarged, filling the screen, and the subject was told (via recorded instructions) to press the appropriate button on a three-button response pad to indicate which of the three faces of the signal looked different from the other two. One of the signal faces contained a high-contrast test stimulus, a square-wave grating with vertical bars. The other two faces were of uniform luminance. Subjects' response times and accuracy of discrimination were recorded. Three levels of testing were conducted—using 20/40, 20/80, and 20/200 stimuli—and three replications of each measurement —i.e., three trials at each stimulus level—were given. First the subject was given three trials at the 20/200 level, then three trials at the 20/80 level, and finally three trials at the 20/40 level.

(c) Static contrast sensitivity. This test used MultiCAD to measure drivers' sensitivity to figure/ground brightness differences. Again, subjects were asked to depress the appropriate button of the three-button response pad to indicate which of the three signal faces contained a test pattern (i.e., was different from the other two, which contained no pattern). The test patterns were the same as those used in the static acuity test for 20/40 (equivalent to 15 cycles per degree) and 20/80 (equivalent to 7.5 cycles per degree); patterns at each spatial frequency level were presented at one of two contrast levels—20.6% ("higher") and 4.9% ("lower"). As with all of the MultiCAD visual function tests described here, three replications of each measurement were performed. The order of presentation was such that three trials involving the 20/80 stimulus at the higher contrast level were followed by three trials involving the 20/80 stimulus at the lower contrast level; then the same sequence was followed for the 20/40 stimulus, to give 12 trials in all.

(d) Dynamic high-contrast acuity. This was administered like the static acuity test, except that the target moved across the screen at a rate (12 degrees per second) corresponding to a speed of 25-40 mph, as when a driver tries to read a street sign while passing it at a moderate speed.

(e) Dynamic contrast sensitivity. This was administered like the static contrast sensitivity test except that, as in the dynamic acuity test, the target moved across the screen at a predetermined rate.

The MultiCAD measures used here were calculated in two different ways. In our early analyses we could use only "gross" overall measures, because we did not know how the various tests were presented and scored, and could not deduce stimulus characteristics from the MultiCAD printout. What we did have were response time measurements and an indicator of correctness or incorrectness for each response, so gross scores were defined as the average response time and number of errors made over all the trials for a specific visual function. (There were 9 static and 9 dynamic acuity trials in all, 12 static and 12 dynamic contrast sensitivity trials. The contrast sensitivity tests required more trials than the acuity tests because two stimulus features—size and contrast level—were being varied.)

Subjects were given 5 seconds in which to respond, so for purposes of making these gross measurements nonresponse errors were given a time score of 5.01. If a time score registered as zero and the answer was correct, the time was considered to be 0.01. If the time score was zero and the answer was incorrect, the score was not used in calculating average time. (This procedure was used for all four MultiCAD acuity and contrast sensitivity tests.)

Scientex later furnished us MultiCAD scores for the 82 referral subjects they are using in their analysis (Staplin et al., in preparation), and explained the basis upon which these were calculated. In the following these are referred to as "precise" MultiCAD measures, in contrast to the "gross" MultiCAD measures described above. For the precise measures corresponding to a particular visual function such as dynamic acuity measured at a particular stimulus level, response time is defined as the average time, considering correct responses only, over the three trials at a particular stimulus size—e.g., 20/80. There are three possible dynamic acuity scores corresponding to stimulus sizes of 20/40, 20/80, and 20/200. A binary correctness score is also expressed in terms of a particular stimulus size or level; if the subject correctly responded to 2 or more of the three dynamic acuity trials using the 20/80 stimulus, e.g., then the subject's overall response to that stimulus is considered correct. Otherwise it is considered incorrect. (In contrast, the gross time score for dynamic acuity is simply average time over the total nine dynamic acuity trials, regardless of stimulus level or response correctness. The gross error score is the total number of errors made in the nine trials.) Further test descriptions follow.

The following describes the MultiCAD driving video tests and their scoring:

(a) Angular motion sensitivity. This test measured subjects' ability to rapidly detect and respond (by means of braking) to changes in the relative motion of "their own" vs. other vehicles in a video of suburban driving scenes from a driver's perspective. The subject's vehicle followed a lead vehicle at varying distances along an arterial route with light traffic. Subjects were instructed to depress a brake assembly whenever the lead vehicle braked, or at any other time when it would be advisable in actual driving to brake.

(b) Functional field of view. This test, using the same video, measured subjects' ability to respond in a timely and appropriate manner to events occurring directly ahead in the travel path, while detecting unexpected critical events occurring in other areas of the visual field. A braking response to collision threats entering from the side (at two different angles of eccentricity) measured the functional field of view.

For purposes of making our "gross" driving video measures only an error frequency count was used to measure subjects' performance. This count applied to the combination of the two types of video tests, which we could not differentiate on the basis of information (frame numbers and error indicators) provided by the test result printouts. Similarly, we could not deduce response times from the frame numbers. Therefore the gross driving video error measure used here (as in interim analyses and in the Janke and Eberhard paper, in press) simply consists of the number of times the word "error" appeared on the printout of video test results.

Scientex' precise time measures for the driving video were brake reaction time in response to the slowing of a lead vehicle, both with and without brake lights on the lead vehicle (two separate measures), and brake reaction time in response to threats impinging from the periphery at either 15- or 30-degree angles of eccentricity. Incorrectness of video responses was indicated by the proportion of errors over trials involving a particular stimulus. For example, if the error proportion for braking in response to visible brake lights was .417, then on this proportion of trials in which the lead vehicle slowed and its brake lights were on and visible, the subject did not press the brake. There were 12 trials in which the lead vehicle's brake lights appeared; both the average time measure and the error proportion measure for this situation were based on those 12 trials. On three trials the lead vehicle slowed but no brake lights appeared; accordingly this situation's time and error measures were based on those three trials. On two trials a threat intruded from the periphery at a 15-degree angle (making the error proportion 0, .5, or 1), and on a single trial a threat intruded from the periphery at 30 degrees. Here the error proportion was either 0 or 1.

*Road tests*

Scientex and DMV used the same two road tests. For Scientex' purposes it was necessary to record in detail subjects' responses at intersections and the driving scene ahead to which they were responding, so after they joined the study in mid-September 1995 minicameras were mounted in subjects' vehicles to furnish video records of their trips. Those data are not a part of the present report.

The two road tests administered were a Modified Driving Performance Evaluation (MDPE), given on the first testing day in the neighborhood of the field office, and an Area Driving Performance Evaluation (ADPE) given by the same examiner, generally the next day, in the subject's home neighborhood. Scoring criteria and score sheets for the two tests appear in Appendix A. These tests, developed by an interdivisional DMV task force, are based on the Driving Performance Evaluation (DPE) which California DMV has adopted in southern California and plans to adopt statewide as its standard road testing instrument, both for novice drivers and for some experienced but functionally impaired drivers. The DPE itself is based on the test developed and validated for commercial tractor-trailer driving by Engel and

Townsend (1984); it was adapted to testing non-commercial drivers in California by another interdivisional DMV task force. Evaluation of the DPE, providing strong evidence of test validity, was reported by Hagge (1994) and by Romanowicz and Hagge (1995). Principally the test measures the constructs of visual search, speed control, and directional control. The MDPE used here omitted the DPE's freeway driving segment but included a destination-finding task—safely returning to the field office after being directed to drive a relatively short distance past it. (Subjects had been told prior to this "detour" that they would be expected to find their way back.) The "concentration errors" in Table 4 below—which may be thought of as confusion errors—are instances in which the subject did not appear to know how to begin returning to the office, did not understand what was to be done, or proceeded in the wrong direction without becoming aware of the mistake.

The ADPE included destination finding also, but in this case it was a matter of driving to familiar destinations and back, with both destinations and routes chosen by the subject. The ADPE also included an exercise in which the subject had to remember and follow a pair of instructions. The notation "multiple instr. errors" of Table 4 refers to this exercise.

As noted above, the road tests were conducted by two DMV examiners who had had extensive training in the effects of various impairments on driving and much experience in testing impaired older drivers, using the earlier and less reliable "Special Drive Test" (Janke, 1994; Hagge, 1995). Since the road test examiners were not familiar with the DPE, they underwent several days of training on the DPE-based MDPE and ADPE in order to learn how to administer and score them. Training was given by a professional instructor from the DMV's Training Branch.

Examiners had discretion as to whether to administer the second road test; if they judged a subject's performance on the MDPE to be unduly hazardous, they did not schedule an ADPE for that subject. They also had discretion to terminate the MDPE if the hazard was too extreme. Persons whose tests were thus terminated were given an unweighted error score of 40 for analytical purposes; their weighted error score depended on the number of "critical," including "hazardous," errors made during their abbreviated test. Critical and hazardous errors are defined below.

MDPEs were conducted along a fixed route. Test times ranged from half an hour to 45 minutes or (rarely) more. The examiner, sitting beside the driver, indicated on the score sheet when certain "structured" maneuvers at predesignated points on the route were performed unsatisfactorily (and in what way the performance was unsatisfactory—e.g., inadequate traffic check, poor lane position). The number of possible errors was thus fixed, with the exception of critical driving errors, which were recorded as they occurred. Insofar as possible the ADPE was scored like the MDPE, but because by definition area tests cannot be conducted on a fixed route, it lacks the potential reliability and standardization of the MDPE.

Errors defined as being "critical driving errors" appear at the lower left of the MDPE and ADPE score sheets in Appendix A. They are considered particularly serious and include such acts as striking an object, disobeying a traffic sign or signal, or driving at inappropriate speed. "Hazardous" errors, a subset of critical errors, were chosen for study purposes by the first author to include those involving dangerous—as judged by the examiner—maneuvers or necessitating examiner intervention. All critical errors, in a non-research situation, would have immediately caused the test to be terminated, but for study purposes they did not unless the examiner felt that safety considerations demanded such termination.

*Analytic methods*

The major data analytic programs used were SPSS-X CORRELATIONS, FREQUENCIES, CROSSTABS, FACTOR and T-TEST (Norusis/SPSS Inc., 1988a); SPSS-X REGRESSION (Norusis/SPSS Inc., 1988b), and SAS LOGISTIC (SAS Institute Inc., 1990).

In preliminary analyses, frequency tables and cross-tabulations as well as Pearson product-moment correlation matrices were produced. Since pairwise deletion was used in the correlation analyses, the numbers of cases entering into computation of particular correlation coefficients varied but this number was maximized for any particular pair of variables. Analyses were also conducted by means of t-tests to identify significant differences between the groups on particular variables. With a two-tailed significance level of .05 used for the set of comparisons, a Bonferroni-type correction was used to adjust the nominal alpha level in order not to inflate Type 1 error.

*Discrimination between groups*. A primary logistic regression was conducted to differentiate referrals from volunteers using first-tier measures. In addition, supplementary logistic regressions were run to determine what combination of tests, demographic and observational variables, or survey variables, selected separately from each of the three measurement tiers and a survey described in a separate section, would best differentiate volunteers from referrals, (presumably) cognitively impaired referrals from (presumably) cognitively unimpaired referrals, and volunteers from (presumably) cognitively impaired referrals. Although the correspondence was not perfect, referral status acted as a surrogate in this study for possible or likely driving impairment, while volunteer status acted as a surrogate for absence of impairment. The criteria for making a determination of presumptive cognitive impairment included a departmental "action reason code" indicating dementia, information from a physician's medical evaluation of the subject, or inability to understand test instructions, as observed by the second author. Meeting any of these criteria caused a subject to be placed in the cognitive impairment group. Of the 34 people so identified, 7 met only the last criterion; the other 27 were identified through action reason code and/or medical evaluation, possibly in addition to inability to understand the test instructions.

Considerations relevant to the primary analytic differentiation—that between referrals and volunteers, using first-tier measures—will be described first. One such consideration is that the degree of sensitivity and specificity required of a test battery to be used in a field office setting differs from that required in other applications. In medical applications, for example, where membership in a diagnostic category is to be predicted, high sensitivity is extremely important. If a condition is serious and treatment is available, it becomes critical for a test battery to identify correctly all or nearly all patients who have the condition. The emphasis in a field office environment is different. For one thing, the range of possible driving impairments is very broad and any battery feasible for field office use will probably be unable to correctly identify an extremely high proportion of differently and perhaps very subtly impaired drivers. Beyond this, high specificity in combination with "high-enough" sensitivity is arguably the most critical requirement. If too many people are wrongly identified as impaired drivers (false positive errors) and therefore subjected to additional tests, the testing process may become too expensive for the agency to support and may inconvenience and generate complaints from members of the public. It becomes perhaps wiser to allow some impaired elderly drivers to go unidentified by the screening tests (false negative errors), particularly since there are other sources of identification of such drivers and their degree of threat to society from crashes appears to be relatively low (Dulisse, 1997; also discussed in Part 1 of Janke, 1994). It is a matter of choice, but the level of predictive performance defined as being most acceptable here was thus accomplished by choosing a very high level of specificity and maximizing sensitivity for that level. Choice of a particular sensitivity-specificity tradeoff, it should be stressed, does not alter logistic regression coefficients, significance levels, or the odds ratios for particular variables. Rather it alters the accuracy of the classificatory equation in identifying the group to which each individual belongs. In this study the predictive performance of the model (detailed in Table 9 below) is merely illustrative and not generalizable to the wider population.

Following the three-tier assessment schema, the primary analysis for discriminating between referrals and volunteers included only first-tier measures. In this analysis a forward selection method was used to arrive at the logistic function, and the significance level for entry of a variable, after adjustment for those entering previously, was .05. Age and gender were forced into the model, as they were into all models discriminating volunteers from a referral group. This was done because, to anticipate presentation of the results, both the average age and gender composition of the referral and volunteer groups were different. In addition, an observed-problems score of 1 was assigned randomly to one of the volunteers in order to allow convergence of the model and obtain relatively nonspurious parameter estimates and calculable odds ratios for this variable. To once more anticipate presentation of results, the need for such a procedure arose because, in this sample, the only subjects noted by the second author to have any of a predetermined list of observable problems were in the referral group (comprising almost 30% of that group). Given this, the logistic model could not converge and the odds ratio for observed problems was shown as 999—the software's rendition of infinity, since the ratio's denominator was zero. Because the second author, who made the observations, was not blinded to group membership there is a possibility that some part of the association of group with observed problems was spurious. However she was well aware of the possibility for bias and guarded against it, so the finding may have been simply a reflection of reality. It is credible that medical referrals might have a much higher incidence of observable "problems" or symptoms than volunteers, who were selected in part on the basis of having good health.

Supplementary logistic regression analyses were also conducted using forward selection, although the significance level for entry of a variable was relaxed to .10 for these. All logistic regression analyses included only subjects who had scores on each variable in the set considered for entry (listwise deletion). Predictive performance data are not presented for models in the secondary analyses.

The variable "number of observed problems" was omitted from models that discriminated cognitively impaired referrals from either cognitively unimpaired referrals or volunteers, because one of those problems—inability to understand test instructions—was used as a criterion on the basis of which the cognitive impairment classification was made. Finally, precise MultiCAD measures were omitted from all models because their use would unduly have reduced the number of observations. Gross MultiCAD measures were used in supplementary analyses involving variables in the second tier of testing.

*Predicting road test score.* Multiple linear regression analyses using forward selection (entry significance level of .05) were conducted on data from referral subjects and from the total sample to predict the study criterion measure—weighted error score on the Modified Driving Performance Evaluation (MDPE). The measure is referred to below as MSCORE. Age and sex were included in the pool of variables competing for entry but were not forced to enter, because in this case there was interest in determining whether demographic variables were better than tests in predicting driving performance.

The unweighted error score on the MDPE (MTOTAL) was defined as the total number of errors made without regard to error severity, while MSCORE, weighted errors, gives greater weight to the more serious errors, those considered critical or hazardous. MSCORE was defined as MTOTAL plus twice the sum of "critical" and "hazardous" errors, defined above. Since hazardous errors are included in the set of critical errors, and critical errors in the set of total errors, this scheme essentially weighted hazardous errors by a factor of five and other critical errors by a factor of three. Weighting the more dangerous driving errors more heavily is consistent with the scoring method used by Dobbs (1997) who, in evaluating the driving ability of elderly dementia patients, found that errors defined as hazardous or potentially catastrophic were made almost exclusively by dementia patients or control subjects showing frank indications of a cognitively impairing condition.

*Determining road test interrater reliability*. During a 2-month period (January-March, 1996), on 20 MDPEs and 20 ADPEs both examiners rode in the car and scored the driver, one riding in the front seat and one in the back. The purpose of this dual scoring was to assess, at least crudely, the interrater reliability of the road tests. Almost all of the drivers on these tests were study subjects, but a small number were DMV staff or acquaintances; no driver whose test had to be terminated was included. The front-seat rater was the "official" examiner, and filled out an official report on performance in the case of referral subjects. Examiners alternated their front-seat vs. back-seat position from one driver to another, but drivers had the same front-seat examiner on both the MDPE and the ADPE. The back-seat rater did not communicate with the driver at any point, and the two raters did not communicate with one another on the test, but scored it independently.

The ADPE posed a particular problem for reliability assessment within the DPE framework of structured, scored maneuvers and others which are not scored. Parts of the route were chosen by the driver, as he or she drove to familiar locations; the rest of the route, as well as the particular maneuvers to be scored, was chosen by the front-seat examiner. Since he did not convey information to the back-seat examiner, the latter did not necessarily choose the same maneuvers to score. However it was reasoned that under operational conditions, given this type of relatively free-form test on an unstructured route and using a single examiner, variability among examiners in what they choose to score is simply a inescapable source of variance that must be taken into account in determining the test's reliability. To avoid the problem by, e.g., having the front-seat examiner signal when he intended to score a particular maneuver, would have yielded misleading results.

## RESULTS

### *Missing data*

Numerous data elements were missing, for many reasons—Scientex' late entry into the project and availability of precise MultiCAD measures for 82 referral subjects only, a requirement to return the Auto-Trails equipment before data collection was completed, a decision to abandon the traffic sign test, which proved to be very time-consuming and did not relate to other study variables, and equipment malfunctions. To convey the extent of the missing-data problem and the resulting effective sample sizes, Table 1 shows the number of valid cases available for each variable, by subject group.

It is notable that for the precise MultiCAD scores there were fewer valid cases for time scores than for correctness scores, and fewer valid cases for time scores involving more difficult discriminations. No doubt this is because, in calculating response time, only correct responses (out of three trials at a particular stimulus level for vision measures, and sometimes less than this for driving video measures) were used by Scientex. If a task was sufficiently difficult it was possible to have no correct responses, so the corresponding time score was missing.

Table 1

Number of Valid Cases by Variable and Group

| Variable | Number of cases | | | | |
|---|---|---|---|---|---|
| | Total group (135) | Referrals vs. volunteers | | Referrals (cog. impaired [CI] vs. unimpaired [CU]) | |
| | | Referral (102) | Vol. (33) | CI (34) | CU (68) |
| **Nondriving Measures Excluding MultiCAD** | | | | | |
| Auto-Trails time | 100 | 69 | 31 | 22 | 47 |
| Observed problems | 135 | 102 | 33 | 34 | 68 |
| Snellen failure | 133 | 100 | 33 | 34 | 66 |
| Pelli-Robson errors | 131 | 98 | 33 | 33 | 65 |
| Doron avg. reaction time | 117 | 90 | 27 | 31 | 59 |
| Doron total errors | 121 | 91 | 30 | 31 | 60 |
| Cue Recog. 1 avg. distance (time) | 124 | 92 | 32 | 32 | 60 |
| Cue Recog. 2 avg. distance (time) | 123 | 91 | 32 | 31 | 60 |
| Cue Recog. 3 avg. distance (time) | 123 | 91 | 32 | 31 | 60 |
| Knowledge test errors | 128 | 95 | 33 | 33 | 62 |
| Sign test errors | 101 | 70 | 31 | 24 | 46 |
| Neck flexibility (Scientex) | 97 | 80 | 17 | 25 | 55 |
| **Road Test Measures** | | | | | |
| ADPE unweighted errors | 111 | 78 | 33 | 20 | 58 |
| ADPE multiple instr. errors | 103 | 71 | 32 | 19 | 52 |
| ADPE failure | 112 | 79 | 33 | 21 | 58 |
| ADPE hazardous errors | 111 | 78 | 33 | 20 | 58 |
| ADPE critical errors | 111 | 78 | 33 | 20 | 58 |
| ADPE weighted errors | 111 | 78 | 33 | 20 | 58 |
| MDPE unweighted errors | 132 | 99 | 33 | 32 | 67 |
| MDPE concentration errors | 120 | 87 | 33 | 23 | 64 |
| MDPE failure | 132 | 99 | 33 | 32 | 67 |
| MDPE hazardous errors | 132 | 99 | 33 | 32 | 67 |
| MDPE critical errors | 132 | 99 | 33 | 32 | 67 |
| MDPE weighted errors | 132 | 99 | 33 | 32 | 67 |

Table 1 (continued)

| Variable | Number of cases | | | | |
|---|---|---|---|---|---|
| | Total group (135) | Referrals vs. volunteers | | Referrals (cog. impaired [CI] vs. unimpaired [CU]) | |
| | | Referral (102) | Vol. (33) | CI (34) | CU (68) |
| **Gross MultiCAD Measures** | | | | | |
| Static acuity time | 96 | 79 | 17 | 26 | 53 |
| Static contrast sens. time | 96 | 79 | 17 | 26 | 53 |
| Dynamic acuity time | 96 | 79 | 17 | 26 | 53 |
| Dynamic contrast sens. time | 94 | 77 | 17 | 26 | 51 |
| Static acuity errors | 96 | 79 | 17 | 26 | 53 |
| Static contrast sens. errors | 96 | 79 | 17 | 26 | 53 |
| Dynamic acuity errors | 96 | 79 | 17 | 26 | 53 |
| Dynamic contrast sens. errors | 96 | 79 | 17 | 26 | 53 |
| Video errors | 97 | 79 | 18 | 26 | 53 |
| **Precise MultiCAD Measures** | | | | | |
| Static acuity 20/40, correct | 80 | 80 | 0 | 26 | 54 |
| Static acuity 20/80, correct | 80 | 80 | 0 | 26 | 54 |
| Static acuity 20/200, correct | 80 | 80 | 0 | 26 | 55 |
| Static acuity 20/40, time | 74 | 74 | 0 | 24 | 50 |
| Static acuity 20/80, time | 77 | 77 | 0 | 25 | 52 |
| Static acuity 20/200, time | 77 | 77 | 0 | 24 | 53 |
| Dynamic acuity 20/40, correct | 79 | 79 | 0 | 26 | 53 |
| Dynamic acuity 20/80, correct | 79 | 79 | 0 | 26 | 53 |
| Dynamic acuity 20/200, correct | 79 | 79 | 0 | 26 | 53 |
| Dynamic acuity 20/40, time | 79 | 79 | 0 | 22 | 48 |
| Dynamic acuity 20/80, time | 75 | 75 | 0 | 23 | 52 |
| Dynamic acuity 20/200, time | 78 | 78 | 0 | 25 | 53 |
| Static c.s. 20/40 hi, correct | 79 | 79 | 0 | 26 | 53 |
| Static c.s. 20/40 lo, correct | 79 | 79 | 0 | 26 | 53 |
| Static c.s. 20/80 hi, correct | 80 | 80 | 0 | 26 | 54 |
| Static c.s. 20/80 lo, correct | 79 | 79 | 0 | 26 | 53 |
| Static c.s. 20/40 hi, time | 68 | 68 | 0 | 24 | 44 |
| Static c.s. 20/40 lo, time | 40 | 40 | 0 | 11 | 29 |
| Static c.s. 20/80 hi, time | 76 | 76 | 0 | 25 | 51 |
| Static c.s. 20/80 lo, time | 63 | 63 | 0 | 20 | 43 |
| Dynamic c.s. 20/40 hi, correct | 77 | 77 | 0 | 26 | 51 |
| Dynamic c.s. 20/40 lo, correct | 76 | 76 | 0 | 26 | 50 |
| Dynamic c.s. 20/80 hi, correct | 79 | 79 | 0 | 26 | 53 |
| Dynamic c.s. 20/80 lo, correct | 77 | 77 | 0 | 26 | 51 |
| Dynamic c.s. 20/40 hi, time | 51 | 51 | 0 | 15 | 36 |
| Dynamic c.s. 20/40 lo, time | 46 | 46 | 0 | 18 | 28 |
| Dynamic c.s. 20/80 hi, time | 64 | 64 | 0 | 19 | 45 |
| Dynamic c.s. 20/80 lo, time | 54 | 54 | 0 | 14 | 40 |
| Brake, lights, time | 79 | 79 | 0 | 25 | 54 |
| Brake, lights, error | 80 | 80 | 0 | 26 | 54 |

Table 1 (continued)

| Variable | Number of cases | | | | |
|---|---|---|---|---|---|
| | Total group (135) | Referrals vs. volunteers | | Referrals (cog. impaired [CI] vs. unimpaired [CU]) | |
| | | Referral (102) | Vol. (33) | CI (34) | CU (68) |
| Brake, no lights, time | 75 | 75 | 0 | 24 | 51 |
| Brake, no lights, error | 80 | 80 | 0 | 26 | 54 |
| Threat at 15 degrees, time | 63 | 63 | 0 | 19 | 44 |
| Threat at 15 degrees, error | 72 | 72 | 0 | 25 | 47 |
| Threat at 30 degrees, time | 49 | 49 | 0 | 17 | 32 |
| Threat at 30 degrees, error | 73 | 73 | 0 | 26 | 47 |

The number of missing observations, particularly for Auto-Trails, the traffic sign test, the ADPE (which drivers judged to be dangerous were not allowed to take), the gross and precise MultiCAD measures, and to a lesser extent the Doron measures, constitute a study limitation that became especially apparent in statistical procedures using listwise deletion and diminishes the generality of findings.

*Demographics and performance: Referrals versus volunteers*

The referral and volunteer groups showed notable differences in average age and gender. Table 2 shows the age range, average age, and percent male for volunteers and referrals. The referral group was considerably older than the volunteer group and almost two-thirds were men, while men comprised less than half of the volunteers. These imbalances can be considered artifacts of the subject selection method. It would have been preferable, given a sufficient number of potential comparison subjects, to match them to referrals, at least on age. However, the number of volunteers was so small that any loss of subjects due to matching constraints was deemed unacceptable.

Table 2

Age and Gender of Study Subjects

| | Referrals ($N$ = 102) | Volunteers ($N$ = 33) |
|---|---|---|
| Age range | 60-91 | 56-85 |
| Average age | 76.2 | 68.5 |
| Percent male | 64.7 | 45.5 |

Given the imbalance in age, it was not surprising that nearly all of the tests administered—nondriving and road tests alike—discriminated between the referral and volunteer groups, with the referral group performing consistently more poorly on the average. On the driving habits survey, which was of course not a test, referrals reported more avoidance behavior. Table 3 presents product-moment correlation coefficients showing that the strength of the linear relationship between age and the various original (before Scientex) nondriving test or survey measures tends to be almost as great as (in the case of overall avoidance and Cue Recognition 2 score even greater than) the strength of the corresponding relationship between subject group and those measures. Using a Bonferroni-type correction to adjust for the enhanced probability of finding one or more spuriously significant results by chance when a family of comparisons is made, almost all nondriving measures were linearly related to both age and group at the .05 significance level. Reflecting the conservatism of the Bonferroni adjustment procedure (which should be kept in mind throughout this section), most of the measures not showing significance when this adjustment was made did reach nominal significance ($p < .05$). Number of observed problems, Doron reaction time (distance), and knowledge errors had nominally significant positive correlations with age, their significance levels ranging from .026 to .031. Auto-Trails time and Snellen failure had nominally significant positive correlations—$p = .015$ and .020 respectively—with gender, while overall avoidance had a nominally significant negative correlation ($p = .025$). Finally, knowledge errors and traffic sign errors had nominally significant positive correlations with group, their probability levels being .008 and .023, respectively.

Table 3

Correlations of Nondriving Measures with Age, Gender, Group

| | Age | Gender (0 = female, 1 = male) | Group (0 = volunteer, 1 = referral) |
|---|---|---|---|
| Auto-Trails time | .364* | .243 | .405* |
| No. of observed problems | .188 | -.028 | .272* |
| Snellen failure | .401* | .202 | .470* |
| Pelli-Robson errors | .436* | .109 | .484* |
| Doron measures | | | |
| Avg. reaction distance | .229 | -.065 | .162 |
| Total errors | .376* | -.022 | .402* |
| Cue Recognition 1 | .313* | -.109 | .363* |
| Cue Recognition 2 | .416* | .084 | .415* |
| Cue Recognition 3 | .508* | .066 | .541* |
| Overall avoidance | .423* | -.207 | .368* |
| Knowledge errors | .191 | -.063 | .234 |
| Traffic sign errors | .186 | -.141 | .227 |

*Nominal probability .004 or less; significant at .05 level using Bonferroni-type correction.

Table 4 shows correlations of the driving measures with age, gender, and group. Once more a Bonferroni-type correction was used. All measures excepting multiple instruction errors on the Area DPE and failure of the Modified DPE were significantly related to age. All measures excepting multiple instruction errors on the Area DPE were significantly related to group. None was related to gender. It is worth mentioning that, for those given both road tests (always by the same examiner), ADPE total unweighted and weighted errors were highly and significantly correlated with the corresponding MDPE measures, both correlations equaling .72.

Table 4

Correlations of Driving Measures with Age, Gender, Group

| | Age | Gender (0 = female, 1 = male) | Group (0 = volunteer, 1 = referral) |
|---|---|---|---|
| **Area DPE** | | | |
| Unweighted errors | .387* | .146 | .396* |
| Weighted errors | .400* | .186 | .414* |
| Test failure | .318* | .154 | .294* |
| Hazardous errors | .311* | .190 | .356* |
| Critical errors | .353* | .149 | .354* |
| Multiple instr. errors | .114 | .070 | .230 |
| **Modified DPE** | | | |
| Unweighted errors | .407* | -.118 | .441* |
| Weighted errors | .418* | -.108 | .462* |
| Test failure | .228 | .000 | .262* |
| Hazardous errors | .277* | -.010 | .359* |
| Critical errors | .352* | -.096 | .382* |
| Concentration errors | .268* | -.007 | .358* |

*Nominal probability .006 or less; significant at .05 level using Bonferroni-type correction.

Tables 5 and 6 display the group average scores for the referral and comparison groups on each of the original (before Scientex) nondriving and driving measures, respectively. Asterisked measures showed statistically significant differences at the .05 level or better between the groups, using conservative Bonferroni-type corrections as indicated in the table footnotes. Significant differences in favor of the volunteers were found on every nondriving measure except Doron reaction time (distance) and traffic sign errors. Every road test measure showed a significant difference between the groups, and again referrals performed more poorly.

Table 5

Group Average Scores, Nondriving Tests

| | Referrals | Volunteers |
|---|---|---|
| Auto-Trails time* | 24.26 | 16.91 |
| No. of observed problems* | 0.41 | 0.00 |
| Snellen failure (0 = pass, 1 = fail)* | 0.57 | 0.03 |
| Pelli-Robson errors* | 15.87 | 10.33 |
| Doron Measures | | |
| Reaction time (distance) | 323.78 | 292.66 |
| Total errors* | 5.02 | 1.13 |
| Cue Recognition 1 distance* | 180.73 | 110.31 |
| Cue Recognition 2 distance* | 205.72 | 126.10 |
| Cue Recognition 3 distance* | 245.51 | 140.16 |
| Overall avoidance* | 18.99 | 14.03 |
| Knowledge errors* | 2.70 | 1.58 |
| Traffic sign errors | 8.20 | 6.90 |

*Nominal probability .004 or less; significant at .05 level using Bonferroni-type correction.

Table 6

Group Average Scores, Driving Measures

| | Referrals | Volunteers |
|---|---|---|
| **Area DPE** | | |
| Unweighted errors* | 23.20 | 14.09 |
| Weighted errors* | 27.17 | 14.88 |
| Percent fail* | 53.16 | 21.21 |
| Hazardous errors* | 0.82 | 0.15 |
| Critical errors* | 1.26 | 0.24 |
| Multiple instruction errors* | 0.73 | 0.19 |
| **Modified DPE** | | |
| Unweighted errors* | 24.52 | 15.15 |
| Weighted errors* | 30.03 | 16.00 |
| Percent fail* | 57.58 | 27.27 |
| Hazardous errors* | 0.58 | 0.15 |
| Critical errors* | 1.75 | 0.27 |
| Concentration errors* | 0.56 | 0.15 |

*Nominal probability .006 or less; significant at .05 level using Bonferroni-type correction.

On the road tests, "failure" or unsatisfactory performance was defined by the examiner's global judgment. Judged test failure, like the other road test variables, showed significant between-group differences. However, when the point values for those judged as failing were examined, some unexplained scoring inconsistencies appeared in the case of volunteers. For example, 54% of the volunteers who had weighted error scores of 15-19 on the MDPE were judged to have failed, but of those with weighted error scores of 20-24, only 17% failed. This sort of reversal was not found for referrals; only 8% failed with a score of 15-19, 38% with a score of 20-24, 54% with a score of 25-29, and so on—the relationship was monotonic.

The referrals showed a much wider range of ability than the volunteers on all tests, some being markedly impaired and others demonstrating performance as good as that of volunteers. On road tests in particular, both groups contained drivers who performed extremely well, but it was also the case that the referral group contained a large percentage (almost 60% for the MDPE and over 40% for those taking the ADPE) of drivers who did worse than any volunteer.

*Distinguishing volunteers from referrals: Logistic regressions*

*First-tier measures*. Results of the primary analysis will be described first. The logistic regression model predicted the probability of being a referral as opposed to a volunteer. Variables in the candidate pool were considered "first-tier" measures. As stated above, first-tier tests are envisioned as preliminary screening measures taking little examiner time to administer and relatively inexpensive equipment. Their purpose would be to identify applicants with possible impairments which might affect their driving. Among the tests used in the present study, those seen as being of a type most suitable for the first tier were the Snellen high-contrast visual acuity chart, the Auto-Trails test, the Pelli-Robson contrast sensitivity (or low-contrast acuity) chart, the number of observed problems, the knowledge test, and the test of traffic-sign knowledge and perception. These tests require only relatively simple and affordable equipment, the PC needed for Auto-Trails being the most expensive item, and they involve little testing time. (The knowledge and traffic-sign tests sometimes take considerable examinee time, but in the form given here they never take much examiner time.) The purpose of the analyses described below was to isolate a subset of these tests that predicted subject group, and determine the goodness of prediction. A complicating factor was that use of a test that had proven promising in early results, Auto-Trails, would now greatly reduce the number of subjects available for the model. We had been asked to return the equipment for administering this test around the middle of 1996; the last subject to take Auto-Trails was tested on June 6. Still the Auto-Trails time measure had shown promise, so analyses were run that both included and excluded it.

It is as well to repeat at this point that, throughout presentation of the following results, it should be kept in mind that the specific values for error rates, sensitivity, specificity, and other statistics found for this sample would undoubtedly not hold for representative samples of the older driver population in California. The values presented may be interesting but should be considered only illustrative, since the composition of the sample (over 75% referrals) was undoubtedly different from that of any population occurring in nature. At least in California, and very likely elsewhere, only a small minority of drivers of any age are ever referred for reexamination. In addition to the numerical imbalance, differences in age and sex composition of the referral and volunteer groups also make the sample unrepresentative of older drivers in California.

For the first analysis, the pool of variables included age and sex (forced into the model), Auto-Trails, number of observed problems, Snellen failure, Pelli-Robson errors, and knowledge test errors. The traffic signs test was excluded; because testing time had become unduly long with the addition of the Scientex battery and scores on this particular test had been found unrelated to group or to driving performance, its use was terminated before project completion. Also average neck flexibility, though suitable for the first tier, was included with the other Scientex measures in second-tier logistic regressions to minimize loss of cases. The measure's simple correlation with subject group, -.06, was not significantly different from zero. Table 7 shows a summary of the forward selection procedure for the first analysis, with variables listed in the order of entry. Here and in all similar analyses presented below, the statistics given for each variable are for the final step, after adjustment had been made for other variables in the model. The designation "O.R." in this and following tables means "odds ratio."

Variables entering this model after adjustment for age and sex were Pelli-Robson errors and number of observed problems. (The odds ratio for observed problems would have been a meaningless 999—"infinity"—had not a score of 1 been assigned randomly to one of the comparison subjects as described in Methods. The significance level and odds ratio presented in Table 7 for that variable may now be considered to be conservative because of this random assignment of a "problem" to someone who actually showed none.)

Table 7

Logistic Regression: First-Tier Variables Discriminating Between Referrals and Volunteers; Age and Gender Forced ($N = 96$)

| Variable | Stand. param. est. | Chi-square | $p$ | O.R. |
|---|---|---|---|---|
| Age | 0.3098 | 2.5671 | .1091 | 1.070 |
| Gender | 0.1763 | 1.2373 | .2660 | 1.911 |
| Pelli-Robson errors | 0.9951 | 10.4339 | .0012 | 1.442 |
| No. of observed problems | 0.8156 | 3.4379 | .0637 | 7.435 |

*Note*: -2 Log L for intercept =120.777; -2 Log L for intercept and covariates = 73.001; chi-square for covariates = 47.776, $df = 4$, $p = .0001$.

Each additional error on the Pelli-Robson test increased the odds of being a referral by 44%, and each additional problem observed increased those odds by 644%. Gender was not significant at entry and remained nonsignificant. Age, highly significant at entry, was no longer significant after adjustment for other variables. Snellen failure, knowledge test errors, and Auto-Trails time did not enter the model.

At an acceptably high specificity (96.8%) the model's sensitivity was judged to be inadequate (47.7%); moreover, the number of observations was only 96 due to listwise deletion. Maximizing this number to the extent possible by eliminating Auto-Trails, which had not entered in any case, N was now 126. In this second model, after forcing age and sex, Snellen failure entered in addition to the two measures which had entered previously. Sensitivity for a high specificity of 97% was much improved, now being 64.5%. Only the knowledge test did not enter the model (the traffic signs test being again excluded from the variable pool). This model is illustrated in Tables 8 and 9.

Table 8 shows a summary of the forward selection procedure, together with final-step statistics for the test variables in the model, which are listed in their order of entry. Of variables in the candidate pool, the only one which did not enter was knowledge test errors.

Table 8

Logistic Regression: First-Tier Variables Discriminating Between
Referrals and Volunteers; Age and Gender Forced
(Auto-Trails Excluded from Pool; *N* = 126)

| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
|---|---|---|---|---|
| Age | 0.3429 | 3.0144 | .0825 | 1.080 |
| Gender | 0.1687 | 1.1849 | .2764 | 1.869 |
| Pelli-Robson errors | 0.7675 | 7.8454 | .0051 | 1.337 |
| Snellen failure | 0.5509 | 3.2776 | .0702 | 7.472 |
| No. of observed problems | 0.8649 | 3.3428 | .0675 | 7.688 |

*Note*: -2 Log L for intercept = 144.910; -2 Log L for intercept and covariates =78.584; chi-square for covariates = 66.326, $df = 5$, $p = .0001$.

The odds ratio of 1.34 for Pelli-Robson errors indicates that in this sample the odds of a person's being in the referral group increased by 34% with each additional error they made on the test, after adjustment for the other variables in the model. Again after adjustment, a person who failed the Snellen test was 7.5 times as likely to be a referral and each additional observed problem increased the odds of being a referral by 669%, although these measures failed to reach the .05 significance level after adjustment for other variables. Once more, gender lacked significance throughout and age was no longer significant after adjustment.

Table 9 shows the predictive performance of the model using observed problems, Pelli-Robson errors, and Snellen failure. Cut-points which might be used in deciding whether or not to refer an applicant for further testing are shown in the first column of the table. The *p*-value cut-points as used here represent the probability of being a referral; subjects are predicted to be members of the referral group if substituting their test scores into the logistic regression equation results in a *p* value equal to or greater than the probability indicated.

Table 9

Classification Cut-Points and Their Predictive Performance

| *p* (referral) | Percentages | | | | |
|---|---|---|---|---|---|
| | Correct classification | Sensitivity | Specificity | False positive number (Rate) | False negative number (Rate) |
| .04 | 73.8 | 100.0 | 0.0 | 33 (26.2) | 0 (0.0) |
| .06 | 75.4 | 100.0 | 6.1 | 31 (25.0) | 0 (0.0) |
| .08 | 75.4 | 98.9 | 9.1 | 30 (24.6) | 1 (25.0) |
| .10 | 75.4 | 98.9 | 9.1 | 30 (24.6) | 1 (25.0) |
| .12 | 75.4 | 97.8 | 12.1 | 29 (24.2) | 2 (33.3) |
| .14 | 75.4 | 97.8 | 12.1 | 29 (24.2) | 2 (33.3) |
| .16 | 76.2 | 97.8 | 15.2 | 28 (23.5) | 2 (28.6) |
| .18 | 76.2 | 97.8 | 15.2 | 28 (23.5) | 2 (28.6) |
| .20 | 75.4 | 96.8 | 15.2 | 28 (23.7) | 3 (37.5) |
| .22 | 76.2 | 95.7 | 21.2 | 26 (22.6) | 4 (36.4) |
| .24 | 77.0 | 95.7 | 24.2 | 25 (21.9) | 4 (33.3) |
| .26 | 77.0 | 95.7 | 24.2 | 25 (21.9) | 4 (33.3) |
| .28 | 78.6 | 95.7 | 30.3 | 23 (20.5) | 4 (28.6) |
| .30 | 81.0 | 95.7 | 39.4 | 20 (18.3) | 4 (23.5) |
| .32 | 81.7 | 94.6 | 45.5 | 18 (17.0) | 5 (25.0) |
| .34 | 84.1 | 94.6 | 54.5 | 15 (14.6) | 5 (21.7) |
| .36 | 84.1 | 93.5 | 57.6 | 14 (13.9) | 6 (24.0) |
| .38 | 84.1 | 93.5 | 57.6 | 14 (13.9) | 6 (24.0) |
| .40 | 84.1 | 91.4 | 63.6 | 12 (12.4) | 8 (27.6) |
| .42 | 83.3 | 90.3 | 63.6 | 12 (12.5) | 9 (30.0) |
| .44 | 83.3 | 90.3 | 63.6 | 12 (12.5) | 9 (30.0) |
| .46 | 84.1 | 90.3 | 66.7 | 11 (11.6) | 9 (29.0) |
| .48 | 83.3 | 89.2 | 66.7 | 11 (11.7) | 10 (31.3) |
| .50 | 82.5 | 88.2 | 66.7 | 11 (11.8) | 11 (33.3) |
| .52 | 83.3 | 88.2 | 69.7 | 10 (10.9) | 11 (32.4) |
| .54 | 83.3 | 88.2 | 69.7 | 10 (10.9) | 11 (32.4) |
| .56 | 84.9 | 88.2 | 75.8 | 8 (8.9) | 11 (30.6) |
| .58 | 84.9 | 88.2 | 75.8 | 8 (8.9) | 11 (30.6) |

Table 9 (continued)

| *p* (referral) | Percentages | | | | |
|---|---|---|---|---|---|
| | Correct classification | Sensitivity | Specificity | False positive number (Rate) | False negative number (Rate) |
| .60 | 84.1 | 86.0 | 78.8 | 7 (8.0) | 13 (33.3) |
| .62 | 83.3 | 84.9 | 78.8 | 7 (8.1) | 14 (35.0) |
| .64 | 83.3 | 84.9 | 78.8 | 7 (8.1) | 14 (39.0) |
| .66 | 84.1 | 84.9 | 81.8 | 6 (7.1) | 14 (34.1) |
| .68 | 82.5 | 82.8 | 81.8 | 6 (7.2) | 16 (37.2) |
| .70 | 82.5 | 81.7 | 84.8 | 5 (6.2) | 17 (37.8) |
| .72 | 82.5 | 80.6 | 87.9 | 4 (5.1) | 18 (38.3) |
| .74 | 81.0 | 78.5 | 87.9 | 4 (5.2) | 20 (40.8) |
| .76 | 80.2 | 77.4 | 87.9 | 4 (5.3) | 21 (42.0) |
| .78 | 80.2 | 77.4 | 87.9 | 4 (5.3) | 21 (42.0) |
| .80 | 80.2 | 77.4 | 87.9 | 4 (5.3) | 21 (42.0) |
| .82 | 77.8 | 74.2 | 87.9 | 4 (5.5) | 24 (45.3) |
| .84 | 74.6 | 69.9 | 87.9 | 4 (5.8) | 28 (49.1) |
| .86 | 74.6 | 69.9 | 87.9 | 4 (5.8) | 28 (49.1) |
| .88 | 74.6 | 68.8 | 90.9 | 3 (4.5) | 29 (49.2) |
| .90 | 72.2 | 65.6 | 90.9 | 3 (4.7) | 32 (51.6) |
| .92 | 72.2 | 64.5 | 93.9 | 2 (3.2) | 33 (51.6) |
| .94 | 73.0 | 64.5 | 97.0 | 1 (1.6) | 33 (50.8) |
| .96 | 66.7 | 55.9 | 97.0 | 1 (1.9) | 41 (56.2) |
| .98 | 58.7 | 45.2 | 97.0 | 1 (2.3) | 51 (61.4) |
| 1.00 | 26.2 | 0.0 | 100.0 | 0 (0.0) | 93 (73.8) |

As shown in Table 9, use of a cut-point of .94—considered to be the best under the circumstances for this sample—yielded sensitivity of 64.5% for 97.0% specificity. (The "best" cut-point might of course have been defined differently. When one considers the unbalanced nature of the sample perhaps the most neutral and statistically defensible position to take—though not the most operationally defensible one—is use of a probability level, here $p$ = .50, which equates the marginals and results in equal numbers of false positive and false negative errors. In this sample, Table 9 shows that when the numbers of false positive errors and false negative errors are equal at 11, sensitivity = 88.2% and specificity = 66.7%).

Because a potential drawback of the observed-problems measure if implemented by licensing agencies in general was possible bias and subjectivity, final logistic regressions forcing age and gender were run, one omitting from the variable pool both number of observed problems and Auto-Trails, and the other omitting only number of observed problems. Results of these analysis will not be shown in detail. In the first, representing 126 cases, the Pelli-Robson test and Snellen failure both entered the model and yielded a sensitivity of 54.8% at specificity 97% for these 126 subjects. Only the knowledge measure did not enter. Incremental prediction beyond that afforded by age and sex alone was highly significant; the chi-square value for the two vision measures, 28.83, was significant at the .0001 level for 2 degrees of freedom. In the second analysis, the number of cases was reduced to 96 because of the inclusion of Auto-Trails. Under these circumstances only the Pelli-Robson test entered, though the significance level for Auto-Trails, .0512, approached the .05 entry level. When the entry level was relaxed to .06 both the Pelli-Robson and Auto-Trails entered; the Snellen test and the knowledge test did not. Incremental prediction beyond that afforded by age and sex alone was again highly significant; the chi-square value for the two measures that entered the model, 24.341, was significant at the .0001 level for 2 degrees of freedom. Sensitivity was 52.8% at specificity 96.8%, about the same as in the previous analysis.

*Second- and third-tier measures: Supplementary analyses.* For these supplementary analyses, which were again forward-selection logistic regressions to distinguish referrals from volunteers on the basis of test results, the significance level for entry of a variable was relaxed to .10, as indicated above. Because of the demographic imbalance of the samples, age and sex were forced into the models prior to the entry of test variables.

In a preliminary analysis using second-tier (broadly speaking, simulation) measures, all Scientex variables were omitted in order to increase the number of complete cases. A second analysis was done using (first-tier) neck flexibility and gross but not precise MultiCAD measures, since the precise measures had more missing observations. In the third (road test) tier, ADPE scores were frequently missing because those who drove sufficiently poorly (i.e., dangerously) on the MDPE were not allowed to take the area test. Therefore, in place of ADPE error scores a binary variable was entered into the third-tier logistic regression which indicated whether or not the subject had been allowed to take the ADPE.

The preliminary second-tier analysis included only the five Doron measures in the test-variable pool. There were 114 subjects who had valid data for all five. Both Cue Recognition 3 and Cue Recognition 2 distances (time-equivalents) entered, in that order. The first had a final chi-square value of 10.38 ($p$ = .0013) with an odds ratio of 1.018; the second had a chi-square value of 3.11 ($p$ = .0779) with an odds ratio of 1.011. These odds ratios may seem only negligibly different from one, but the numerical values of odds ratios are a function of the measurement scale used. Here it was feet; if it had been meters, say, the odds ratios would have been larger. The values given here indicate that the odds of being in the referral group increased by 1.8% and 1.1% respectively for each additional foot of distance before the accelerator was released. At 55 mph, the standard speed value assumed by the two tests, an additional foot in “distance traveled” would amount to an additional 12 msec in response time. (Expressed in terms of 10-foot increments the additional time delay is 120 msec, slightly over 1/10 sec. The odds of being in the referral group increased by 28% and 24%, respectively, for each additional 120-msec recognition delay on modules Cue Recognition 2 and Cue Recognition 3.)

The other second-tier analysis included neck flexibility and gross MultiCAD measures in the pool as well as the Doron measures, reducing the number of subjects to 76. Results of this analysis appear in the upper part of Table 10. Variables are listed in order of entry.

Table 10

Logistic Regressions: Second-, and Third-Tier Variables Discriminating Between Referrals and Volunteers; Age and Gender Forced

| SECOND TIER (*N* = 76) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
| Age | -0.2828 | 0.388 | .5336 | 0.93 |
| Gender | 0.2742 | 0.944 | .3311 | 2.78 |
| Cue Recognition 3 | 1.0223 | 3.972 | .0463 | 1.02 |
| Dynamic contr. sens. errors | 1.5081 | 5.082 | .0242 | 2.90 |
| Cue Recognition 2 | 1.1729 | 3.143 | .0762 | 1.02 |

Note: -2 Log L for intercept = 62.847; -2 Log L for intercept + covariates = 25.109; chi-square for covariates = 37.739, *df* = 5, *p* = .0001.

| THIRD TIER (*N* = 132) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
| Age | 0.4242 | 5.586 | .0181 | 1.10 |
| Gender | 0.3558 | 5.980 | .0145 | 3.73 |
| MSCORE (wted. errors) | 0.9434 | 9.736 | .0018 | 1.14 |
| Concentration errors | 0.6154 | 4.496 | .0340 | 3.53 |

Note: -2 Log L for intercept = 148.456; -2 Log L for intercept + covariates = 89.790; chi-square for covariates = 58.667, *df* = 4, *p* = .0001.

Cue Recognition 2 and 3, as well as the gross MultiCAD measure of dynamic contrast sensitivity errors, entered. Interpretation of odds ratios for the Cue Recognition tests has been described. The number of dynamic contrast sensitivity errors could assume integer values of 0 through 12; in this sample each additional error on that test increased the odds of being in the referral group by almost 200%. After adjustment for all other variables in the model, the chi-square values for age and sex were not significant; as before, gender (but not age) lacked significance even at entry. Test variables which did not enter included total Doron errors, Cue Recognition 1, average reaction time on Doron familiarization trials, neck flexibility, and the following gross MultiCAD measures: static acuity time and errors, dynamic acuity time and errors, static contrast sensitivity time and errors, dynamic contrast sensitivity time, and driving video errors.

In the third-tier (road test) analyses, where the pool of variables included MDPE weighted errors (MSCORE), concentration errors, unweighted errors and test failure, as well as the "no ADPE" indicator, only the first two of these variables entered, in the order given above. Results of the analysis appear in the lower part of Table 10. MSCORE could assume integral values ranging from 0 to approximately 60; the actual range of scores in this sample was 7 to 58. The odds of being a referral subject increased by approximately 14% with each additional error point on this scale. Concentration errors could assume integral values of 0 through 2, and the measure's odds ratio indicates that each additional such error increased the odds of being in the referral group by slightly more than 250%. Unlike results in the second-tier analysis, age and sex were significant and remained so even after MSCORE and concentration errors entered the model. Each additional year of age increased the odds of being in the referral group by 10%, and being male increased those odds by 273%. Variables in the candidate pool which did not enter included MDPE failure, unweighted MDPE errors, and the no-ADPE indicator.

*All-tier analyses*. In global logistic regressions to predict subject group (referral vs. volunteer), the results of which will not be presented in detail, test measures which had entered the preceding first-tier, second-tier, and third-tier models were all put into the pool and allowed to compete with one another for entry. The purpose of this exercise was to determine which variable might prove to be the best predictor, and what the general level of predictability might be. One model included the gross MultiCAD measure of dynamic contrast sensitivity errors, which had entered the second-tier model. With it, complete data were available for 84 subjects. A second model excluded this measure from the pool, increasing the number of cases to 121.

In the first of these analyses, after age and sex had been forced into the model four other variables entered—Pelli-Robson errors, Cue Recognition 3 distance (time-equivalent), dynamic contrast sensitivity errors, and MSCORE. The maximum correct classification rate using this model was 92.9%, yielding sensitivity of 92.6% and specificity of 93.8%. The strongest predictor was MSCORE, the road test measure itself; it entered immediately after age and sex with a chi-square at the .0001 significance level. Variables which failed to enter were Snellen failure, number of observed problems, Cue Recognition 2, and MDPE concentration errors.

In the second analysis, after forcing age and gender four variables again entered, two of them—Cue Recognition 3 and MSCORE—having also entered the preceding model. The other two were Snellen failure and concentration errors. Prediction was not so good as before, as would be expected considering the increased sample size; the highest correct classification rate attained was 86.0%, and at that value sensitivity was 85.4% and specificity 87.5%. The most powerful predictor in this analysis, with an entry significance level of .0001, was Cue Recognition 3. MSCORE had an entry significance level of .0008. Pelli-Robson errors, number of observed problems, and Cue Recognition 2 did not enter the model.

*Predicting road test performance*

*Simple correlations with MSCORE.* Table 11 shows, for referrals, simple Pearson product-moment correlations between each Doron or MultiCAD (possible second-tier) measure and MSCORE, weighted road test errors, as well as their nominal probability levels. (The correlation for neck flexibility was -.0613, not significant.) The Ns involved in these correlations ranged from 36 to 79. Using a Bonferroni-type correction, asterisked correlations (nominal probability level .003 or less) would be significant experimentwise at the .05 level.

Significant correlations were found for all Doron measures except reaction time (distance) on the orientation exercise, and for that measure the correlation was almost significant. Significant correlations were also found for the gross MultiCAD measures of static acuity time, dynamic acuity time, and number of driving video errors. Among precise MultiCAD variables, the static acuity time measure at 20/80 and the static contrast sensitivity time measure at 20/80, using the higher contrast level, showed significant correlations; the correlation for static acuity time at 20/40 just missed significance. Several other measures showed correlations at a nominal significance level of around .01 or less, indicating promise. Note that accuracy for the gross MultiCAD visual function measures was in terms of errors (which had positive correlations with MSCORE), while for the precise ones it was in terms of correctness (showing negative correlations with MSCORE). For both the gross and precise MultiCAD visual function measures, response time was much more closely related to MSCORE than was response accuracy within the referral group. The reverse was true for driving video measures.

Table 11

Doron Measures, Gross and Precise Scientex Measures:
Correlations with MSCORE for Referrals

| Measure | *r* with MSCORE | Nominal *p* |
|---|---|---|
| **DORON MEASURES** | | |
| Doron total errors | .4382* | .000 |
| Average RT (Doron orientation exercise) | .3297 | .005 |
| Cue Recognition 1 average distance | .4777* | .000 |
| Cue Recognition 2 average distance | .4645* | .000 |
| Cue Recognition 3 average distance | .3584* | .002 |
| **GROSS SCIENTEX MEASURES** | | |
| Gross static acuity time | .3519* | .002 |

Table 11 (continued)

| Measure | *r* with MSCORE | Nominal *p* |
|---|---|---|
| Gross static contrast sensitivity (CS) time | .1866 | .104 |
| Gross dynamic acuity time | .3346* | .003 |
| Gross dynamic CS time | .1153 | .325 |
| Number of errors, static acuity trials | .0983 | .395 |
| Number of errors, static CS trials | .1337 | .246 |
| Number of errors, dynamic acuity trials | .2346 | .040 |
| Number of errors, dynamic CS trials | .2420 | .034 |
| Number of errors indicated for video | .3462* | .002 |
| **PRECISE SCIENTEX MEASURES** | | |
| Static acuity @ 20/40, correctness | .0855 | .457 |
| Static acuity @ 20/80, correctness | -.0799 | .487 |
| Static acuity @ 20/200, correctness | -.0048 | .966 |
| Static acuity time @ 20/40, correct trials only | .3395 | .004 |
| Static acuity time @ 20/80, correct trials only | .4230* | .000 |
| Static acuity time @ 20/200, correct trials only | .1970 | .090 |
| Dynamic acuity @ 20/40, correctness | -.1418 | .219 |
| Dynamic acuity @ 20/80, correctness | -.1211 | .294 |
| Dynamic acuity @ 20/200, correctness | -.2283 | .046 |
| Dynamic acuity time @ 20/40, correct trials only | .3092 | .010 |
| Dynamic acuity time @ 20/80, correct trials only | .3256 | .005 |
| Dynamic acuity time @ 20/200, correct trials only | .3297 | .004 |
| Static CS @ 20/40, higher contrast, correctness | .0519 | .654 |
| Static CS @ 20/40, lower contrast, correctness | -.2477 | .030 |
| Static CS @ 20/80, higher contrast, correctness | -.0582 | .613 |
| Static CS @ 20/80, lower contrast, correctness | -.1513 | .189 |
| Static CS time @ 20/40, higher contrast, correct trials only | .1666 | .181 |
| Static CS time @ 20/40, lower contrast, correct trials only | .1926 | .240 |
| Static CS time @ 20/80, higher contrast, correct trials only | .3884* | .001 |
| Static CS time @ 20/80, lower contrast, correct trials only | .0747 | .561 |
| Dynamic CS @ 20/40, higher contrast, correctness | -.0705 | .548 |
| Dynamic CS @ 20/40, lower contrast, correctness | .0643 | .586 |
| Dynamic CS @ 20/80, higher contrast, correctness | -.2575 | .024 |
| Dynamic CS @ 20/80, lower contrast, correctness | -.2030 | .081 |
| Dynamic CS time @ 20/40, higher contrast, correct trials only | .0401 | .782 |
| Dynamic CS time @ 20/40, lower contrast, correct trials only | -.2059 | .180 |
| Dynamic CS time @ 20/80, higher contrast, correct trials only | .2466 | .049 |
| Dynamic CS time @ 20/80, lower contrast, correct trials only | -.0947 | .500 |
| Mean brake time w/visible brake lights, correct only (12 trials) | .0861 | .457 |
| Proportion error, trials w/visible brake lights | .2801 | .013 |
| Mean brake time, no visible brake lights, correct only (3 trials) | -.0238 | .841 |
| Proportion error on trials w/no brake lights | .1994 | .080 |
| Mean time to correct *R*, threat @ 15 degrees, correct only (2 trials) | .1891 | .144 |
| Proportion error on trials w/threat @ 15 degrees | .2430 | .043 |
| Mean time to correct *R*, threat @ 30 degrees, correct only (1 trial) | .1181 | .429 |
| Proportion error on trial w/threat @ 30 degrees (1 or 0) | .1675 | .163 |

* Nominal probability .003 or less; significant at .05 level using Bonferroni-type correction.

Table 12 gives information for combined referrals and volunteers similar to that in Table 11, except that the precise MultiCAD measures, which were not available for volunteers, are omitted. The *N*s involved in the correlations now ranged from 92 to 123 and, for comparability with Table 11, the same nominal probability level of .003 or less was regarded as significant. Significant correlations are again asterisked.

Table 12

Doron Measures and Gross MultiCAD Measures: Correlations with MSCORE for Referrals plus Volunteers

| Measure | *r* with MSCORE | Nominal *p* |
|---|---|---|
| **DORON MEASURES** | | |
| Doron total errors | .5294* | .000 |
| Average RT (Doron orientation exercise) | .3672* | .000 |
| Cue Recognition 1 average distance | .4819* | .000 |
| Cue Recognition 2 average distance | .6068* | .000 |
| Cue Recognition 3 average distance | .5207* | .000 |
| **GROSS MULTICAD MEASURES** | | |
| Gross static acuity time | .4898* | .000 |
| Gross static contrast sensitivity (CS) time | .3987* | .000 |
| Gross dynamic acuity time | .4794* | .000 |
| Gross dynamic CS time | .1821 | .082 |
| Number of errors, static acuity trials | .2395 | .020 |
| Number of errors, static CS trials | .3112* | .002 |
| Number of errors, dynamic acuity trials | .3518* | .001 |
| Number of errors, dynamic CS trials | .4229* | .000 |
| Number of errors indicated for video | .4495* | .000 |

* Nominal probability .003 or less; significant at .05 level using Bonferroni-type correction.

In this more heterogeneous sample, in which volunteers as a group performed better than referrals on every test, all of the Doron measures and most of the gross MultiCAD measures correlated significantly with MSCORE. The only two which did not were dynamic contrast sensitivity time and static acuity errors. It can be seen that the correlations of MSCORE with the Doron measures tended to be stronger than with the gross MultiCAD measures, and that the distinction between

MultiCAD time and accuracy measures on the visual function tasks which was notable within the referral group is no longer apparent.

For comparison purposes, correlation coefficients expressing the relationship between MSCORE and each of the non-simulator, or possible first-tier, measures are shown in Table 13, together with their nominal probabilities. These are given both for referrals and volunteers combined (with *N*s ranging from 96 to 132) and for referrals only (with *N*s ranging from 67 to 99). In a three-tier assessment scheme, first-tier measures would be used to predict possible impairment within a group of unselected drivers, but some might also help to predict road test score within a group of drivers already determined to be impaired.

Table 13

Possible First-Tier Measures, Correlations with MSCORE

| Measure | *r* with MSCORE | Nominal *p* |
|---|---|---|
| **Combined Referrals and Volunteers (total *N* = 135)** | | |
| Age | .4182* | .000 |
| Overall avoidance | .4394* | .000 |
| Snellen failure | .3553* | .000 |
| Auto-Trails time | .4523* | .000 |
| Pelli-Robson errors | .4009* | .000 |
| Knowledge test errors | .3847* | .000 |
| Sign test errors | .2026 | .044 |
| Number of observed problems | .3944* | .000 |
| Probable cognitive impairment | .3919* | .000 |
| Neck flexibility | -.0573 | .579 |
| **Referrals Only (total *N* = 102)** | | |
| Age | .3228* | .001 |
| Overall avoidance | .3573* | .001 |
| Snellen failure | .1846 | .070 |
| Auto-Trails time | .3748* | .002 |
| Pelli-Robson errors | .2069 | .044 |
| Knowledge test errors | .3316* | .001 |
| Sign test errors | .1046 | .396 |
| Number of observed problems | .3185* | .001 |
| Probable cognitive impairment | .2919* | .003 |
| Neck flexibility | -.0613 | .591 |

*Nominal probability .006 or less; significant at .05 level using Bonferroni-type correction.

Using a Bonferroni-type correction, correlations with a nominal probability level of .006 or less can be considered significant experimentwise at the .05 level. These are asterisked in the table. All measures with the exception of the traffic-signs test were significantly correlated with MSCORE within the complete study group. Within the group of referrals, significant correlations were found for age (preferably not to be used as a measure), overall avoidance level (subject to inaccurate or misleading reporting), Auto-Trails time, knowledge test errors, number of observed problems (subject to bias, and therefore preferably to be used only in preliminary screening), and the indicator of presumptive cognitive impairment described in Methods.

*Multiple regression analyses*. Linear multiple regression analyses were conducted to predict the weighted-error criterion measure MSCORE for referrals only, and for the total group. Because in an operational testing system only those drivers with presumptive impairment would be required to take a road test, results obtained in predicting referrals' road test performance (the primary analysis) will be described first, and in greater detail than are those for the total group (the secondary analysis).

For referrals, the forward selection method was used to predict MSCORE, using an entry significance level of .05. The variables included in the pool of potential predictors were those identified as significant predictors in Janke and Eberhard (in press), plus the precise MultiCAD measures that were similar to them in measuring aspects of the same visual function. Thus the pool of variables included Cue Recognition 2 score (critical icon facing to the side, steering response), Auto-Trails time, gross dynamic contrast sensitivity errors, gross static acuity response time (all from Janke & Eberhard), and additionally precise static acuity time using the 20/80 stimulus and precise dynamic contrast sensitivity correctness scores for both higher and lower contrast using the 20/80 stimulus. The particular stimulus levels chosen for the precise MultiCAD measures were selected on the basis of the measures' simple correlations with MSCORE as shown in Table 11.

Results of the regression are shown in Table 14. Three measures—gross static acuity response time, gross dynamic contrast sensitivity errors, and dynamic contrast sensitivity correctness at 20/80 and the higher contrast level—did not enter. Variables entering the equation were precise MultiCAD static acuity time using the 20/80 stimulus, Cue Recognition 2 distance (time-equivalent), Auto-Trails time, and the precise MultiCAD dynamic contrast sensitivity correctness score for lower contrast using the 20/80 stimulus. As indicated above, the direction of the correctness score for dynamic contrast sensitivity at 20/80 is opposite to that of the other variables in the equation, which represented response time (or time-equivalent). Not surprisingly, increased dynamic contrast sensitivity errors and slower response times on other perceptual/attentional tests were associated with increased and more serious errors on the MDPE. It is noteworthy that although both gross and precise MultiCAD measures were in the variable pool, only precise ones entered the prediction equation. Multiple *R* was .77 and $R^2$ adjusted for shrinkage was .54.

Table 14

Multiple Regression: Prediction of MSCORE, Referrals Only (*N* = 41)

| Variable | *B* | SE(*B*) | Beta | (Part corr)$^2$ | *t* | *p* |
|---|---|---|---|---|---|---|
| Precise static acuity time, 20/80 | 4.0786 | 1.6944 | .2906 | .0659 | 2.407 | .0213 |
| Cue Recog. 2 distance | .0618 | .0154 | .4497 | .1838 | 4.019 | .0003 |
| Auto-Trails time | .3563 | .1635 | .2523 | .0540 | 2.179 | .0359 |
| Dyn. contrast sens. correctness, lower contrast, 20/80 | -5.4605 | 2.6513 | -.2264 | .0483 | -2.060 | .0467 |
| *R* = .768, adj. $R^2$ = .545, *F* = 12.97, sig. (*F*) = .0000 | | | | | | |

The goodness of prediction can be attributed in large part to a small case-to-variable ratio and considerable capitalization on chance. Lacking the possibility of cross-validating these results, the adjusted $R^2$ statistic overestimates the true predictive power of the model.

Table 15 shows multiple regression results for referrals and volunteers combined. Again, the variables chosen to be in the pool from which selection was made were those described as being predictive in the Janke and Eberhard report (in press), a set similar to that used in the analysis for referrals only, but one which did not include precise MultiCAD measures. The variable pool included Cue Recognition 2 score (critical icon facing to the side, steering response), Auto-Trails time, and gross MultiCAD static acuity response time, static acuity errors, and dynamic contrast sensitivity errors. All except the last entered the prediction equation.

Table 15

Multiple Regression: Prediction of MSCORE, All Subjects (*N* = 59)

| Variable | *B* | SE(*B*) | Beta | (Part corr)$^2$ | *t* | *p* |
|---|---|---|---|---|---|---|
| Cue Recog. 2 dist. | .0483 | .0133 | .3521 | .0862 | 3.629 | .0006 |
| Auto-Trails time | .4864 | .1314 | .3233 | .0897 | 3.702 | .0005 |
| Gross static acuity time | 8.3278 | 2.1573 | .5636 | .0976 | 3.860 | .0003 |
| Gross static acuity errors | -2.0702 | .8048 | -.3318 | .0433 | -2.573 | .0129 |
| *R* = .803, adj. $R^2$ = .620, *F* = 24.67, sig. (*F*) = .0000 | | | | | | |

Here the goodness of prediction, indicated by an adjusted $R^2$ of .62, is due in part not only to the factors mentioned above but also, in all likelihood, to the fact that the combination of volunteers and referrals formed not only a more heterogeneous sample, but in fact one that was highly contrasted. Much shrinkage of $R$ would be expected on cross-validation of the model, so again adjusted $R^2$ overestimates its predictive power.

It may be noted that two variables in the equation, Cue Recognition 2 and Auto-Trails, were also significant in the referrals-only equation. Two more, the gross MultiCAD measures, did not enter that equation but show very significant beta weights in Table 15, with gross static acuity time adding the greatest amount of unique variance, as shown by its squared part correlation of almost .10. Also a suppressor effect emerged, as shown by the negative weight given to gross static acuity errors. Apparently the static acuity time score (correlating .49 with MSCORE, nominal probability level .000) contained variance uncorrelated with MSCORE which was shared by the static acuity error score (correlating .24 with MSCORE, nominal probability level .020). This variance may have stemmed from factors specific to the MultiCAD task and not generalizing to driving performance. Entry of static acuity errors into the equation evidently suppressed the irrelevant (to the criterion) variance in the static acuity time measure, doubling its weight and multiplying its unique contribution to the predictive equation by a factor of 1.74—as inferred from the squared part correlation for this variable, which increased from .0557 to .0976.

*Cognitively impaired drivers*

On the basis of action reason code, information on the medical evaluation form, or seeming inability to comprehend test instructions (all subjects being able to speak and read English), 34 referral drivers were identified as being probably cognitively impaired, at least to some degree. No volunteer met any of these criteria. Fourteen referrals placed in the cognitive impairment category had reason codes on their driving records indicating dementia (presumably mild); the rest had nonspecific reason codes indicating such things as lack of knowledge or skill, physical impairment, or mental impairment. Seven were placed in the category only because they did not understand test instructions. There is certainly a possibility of miscategorization, but it is likely that at least some of the drivers not identified in departmental records as dementing were in an early, perhaps unrecognized, stage of dementia. The subgroup's performance on nondriving and road tests was compared with that of referral subjects whose medical evaluations and behavior showed no evidence of cognitive disorder. For cognitively unimpaired referral subjects the most prevalent impairment was visual; 48% had information on record indicating visual disability (perhaps combined with other disabilities, most commonly cardiovascular disease, diabetes, and/or cerebrovascular disease). In contrast, records indicated that only 24% of the presumably cognitively impaired referrals also had visual disability.

*Differentiating cognitively impaired and cognitively unimpaired referrals: Univariate tests.* Table 16 shows average scores on the nondriving tests for cognitively impaired and cognitively unimpaired referrals, using gross measures to represent the MultiCAD tests. Tables 17 and 18 give similar information for precise MultiCAD measures and road test measures, respectively. In Table 16, asterisked measures show significant experimentwise differences between the groups at the $p = .05$ level using a Bonferroni-type correction; i.e., nominal significance levels for individual comparisons of .003 or less.

Table 16

Average Nondriving Scores, Cognitively Impaired vs. Unimpaired Referrals

| Measure | Cognitively impaired ($n$ = 34) | Cognitively unimpaired ($n$ = 68) |
|---|---|---|
| Auto-Trails time | 27.38 | 22.80 |
| Number of observed problems* | 0.85 | 0.19 |
| Snellen failure (0 = pass, 1 = fail) | 0.62 | 0.54 |
| Pelli-Robson errors | 16.64 | 15.48 |
| Doron measures | | |
| Reaction time (distance)* | 380.48 | 293.98 |
| Total errors* | 7.77 | 3.60 |
| Cue Recognition 1 distance* | 222.47 | 158.47 |
| Cue Recognition 2 distance* | 246.92 | 184.44 |
| Cue Recognition 3 distance* | 284.52 | 225.35 |
| Overall avoidance | 19.54 | 18.71 |
| Knowledge errors | 3.76 | 2.14 |
| Traffic sign errors | 8.67 | 7.96 |
| Gross MultiCAD Measures | ($n$ = 26) | ($n$ = 56) |
| Static acuity time | 2.12 | 1.71 |
| Contrast sensitivity time | 2.86 | 2.71 |
| Dynamic acuity time | 1.49 | 1.33 |
| Dynamic contrast sens. time | 1.80 | 1.67 |
| Static acuity errors | 1.81 | 1.42 |
| Contrast sensitivity errors | 4.62 | 4.00 |
| Dynamic acuity errors | 2.15 | 1.21 |
| Dyn. contrast sens. errors | 7.81 | 6.47 |
| Driving video errors* | 7.50 | 3.36 |
| Avg. neck flexibility (degrees) | 68.60 | 71.18 |

Note: Impaired: average age 76.4, 68% male. Unimpaired: average age 76.1, 63% male.
*Nominal significance level .003 or less; significant at .05 level using Bonferroni-type correction.

The significant differences shown in Table 16 are nearly all on Doron tests, where performance of cognitively impaired subjects was consistently inferior. (They also had more observed problems, although without doubt this was partly due to the fact that inability to understand test instructions was one of the predetermined list of "problems.") On Scientex measures a significant difference in favor of the unimpaired group appeared only on total errors for the driving video, the only test which elicited responses to naturalistic driving situations containing a number of distractors. The lack of other significant differences was undoubtedly in part due to small sample sizes, but perhaps more importantly attributable to the fact that most of the MultiCAD measures had a substantial visual, as well as perceptual and psychomotor speed, component; as indicated, cognitively unimpaired referrals commonly had vision problems. However, it is notable that on every measure, even those not showing significant differences, cognitively impaired subjects performed directionally more poorly.

Table 17 presents averages for the two cognitive status groups on the precise MultiCAD measures. Though altogether there were 36 comparisons it was considered that only 16 independent ones were involved, making the nominal significance level necessary for reaching experimentwise significance of .05 approximately .003. Only one variable reached or even approached this level, proportion of error trials for braking to a lead vehicle's visible brake lights.

Table 17

Average Scores on Precise MultiCAD Measures,
Cognitively Impaired vs. Unimpaired Referrals

| Measure<br>Stimulus level | Cognitively impaired<br>(*n* = 26) | Cognitively unimpaired<br>(*n* = 56) |
|---|---|---|
| Static acuity, accuracy (0 vs 1) | | |
| 20/40 | .923 | .870 |
| 20/80 | .808 | .926 |
| 20/200 | .731 | .815 |
| Static acuity, response time | | |
| 20/40 | 1.940 | 1.681 |
| 20/80 | 1.838 | 1.490 |
| 20/200 | 1.529 | 1.409 |
| Dynamic acuity, accuracy (0 vs 1) | | |
| 20/40 | .577 | .736 |
| 20/80 | .885 | .981 |
| 20/200 | .885 | .981 |

Table 17 (continued)

| Measure<br>Stimulus level | Cognitively impaired<br>(*n* = 26) | Cognitively unimpaired<br>(*n* = 56) |
|---|---|---|
| Dynamic acuity, response time | | |
| 20/40 | 1.665 | 1.398 |
| 20/80 | 1.319 | 1.141 |
| 20/200 | 1.541 | 1.349 |
| Static contrast sens., higher cont., accur. (0 vs 1) | | |
| 20/40 | .731 | .660 |
| 20/80 | .885 | .907 |
| Static contrast sens., lower cont., accur. (0 vs 1) | | |
| 20/40 | .192 | .340 |
| 20/80 | .577 | .736 |
| Static contrast sens., higher contrast, *R* time | | |
| 20/40 | 2.300 | 2.160 |
| 20/80 | 2.053 | 1.666 |
| Static contrast sens., lower contrast, *R* time | | |
| 20/40 | 3.425 | 3.122 |
| 20/80 | 2.402 | 2.283 |
| Dyn. contrast sens., higher cont., accur. (0 vs 1) | | |
| 20/40 | .231 | .451 |
| 20/80 | .500 | .774 |
| Dyn. contrast sens., lower cont., accur. (0 vs 1) | | |
| 20/40 | .115 | .200 |
| 20/80 | .385 | .431 |
| Dyn. contrast sens., higher contrast, *R* time | | |
| 20/40 | 1.639 | 1.588 |
| 20/80 | 1.402 | 1.372 |
| Dyn. contrast sens., lower contrast, *R* time | | |
| 20/40 | 1.497 | 2.037 |
| 20/80 | 1.329 | 1.577 |
| Driving video, proportion error | | |
| follow and brake, brake lights* | .473 | .210 |
| follow and brake, no lights | .332 | .265 |
| brake to threat, 15 deg. | .340 | .160 |
| brake to threat, 30 deg. | .346 | .298 |
| Driving video, *R* time | | |
| follow and brake, brake lights | 1.538 | 1.363 |
| follow and brake, no lights | 5.096 | 4.524 |
| brake to threat, 15 deg. | 2.111 | 2.027 |
| brake to threat, 30 deg. | 1.871 | 1.493 |

*Note*: On measures scoring accuracy as 0 vs. 1, subjects correct on at least 2 of the 3 trials at each stimulus level were scored 1; otherwise they were scored 0. Response times are measured in seconds.
*Nominal probability .001; significant at .05 level using Bonferroni-type correction.

As before, even though only one measure significantly differentiated the groups when the conservative Bonferroni adjustment was used, cognitively impaired subjects were directionally inferior on almost every measure, whether of speed or of accuracy. The significant contribution of the driving video "follow and brake" error measure shown in Table 17 is consistent with that shown in Table 16 for the gross measure of overall video errors. This consistency is not surprising because the precise error measure would in fact constitute the greater part of the gross measure—it was based on 12 trials requiring braking to visible brake lights in the driving video, while other precise driving video scores were based on many fewer than 12 trials. These latter measures were response time and proportion error in braking when the lead vehicle showed no brake lights (3 trials) and braking to peripheral threats impinging from two different angles (2 trials and 1 trial for the different eccentricities). Since so few trials were involved, the latter measures may have lacked reliability and thus have been less likely as individual measures to reach significance. Additionally the points made above in presenting results for the gross MultiCAD measures would apply here as well.

It may be of interest that, within the cognitively impaired group, accuracy means on the static acuity task are in reverse order from what might be expected. That is, since getting 2 out of 3 trials correct was coded 1 and less than this coded 0, one would expect scores to increase in magnitude as stimulus level went from 20/40 to 20/200, while in fact the reverse was true. This can be interpreted as a practice effect, and will be discussed at greater length in the Discussion section.

Table 18 shows differences on the road test measures between cognitively impaired and cognitively unimpaired referral drivers.

Using a Bonferroni-type correction for multiple comparisons and considering the interrelated nature of many of the road test variables, a nominal significance level of .008 or less was required for experimentwise significance at the .05 level. No significant difference was found between cognitively impaired and cognitively unimpaired referrals on any of the six ADPE measures. Even the nominal significance levels were greater than .05 for all comparisons, the one showing the lowest nominal probability involving multiple instruction errors ($p$ = .063). Statistical power to find a difference was not great, since only 21 cognitively impaired subjects (vs. 58 unimpaired) took the ADPE. Nevertheless, consistently with the trend for nondriving measures, the cognitively impaired group showed directionally worse performance (higher score) on every driving measure. This was so even though the cognitively impaired drivers who were allowed to take the ADPE were among the best of their group; in many cases it was judged by the examiner on the basis of their MDPE performance too dangerous to allow these drivers to attempt the area test.

Table 18

Average Driving Scores, Cognitively Impaired vs. Unimpaired Referrals

| | Cognitively impaired ($n$ = 34) | Cognitively unimpaired ($n$ = 68) |
|---|---|---|
| Area DPE | *(n = 21)* | *(n = 58)* |
| Unweighted errors | 24.55 | 22.72 |
| Weighted errors | 28.68 | 26.66 |
| Percent fail | 66.67 | 48.28 |
| Hazardous errors | 1.00 | 0.76 |
| Critical errors | 1.40 | 1.21 |
| Multiple instruction errors | 1.32 | 0.52 |
| Modified DPE | *(n = 32)* | *(n = 67)* |
| Unweighted errors | 28.25 | 22.73 |
| Weighted errors* | 35.62 | 27.36 |
| Percent fail | 68.75 | 52.24 |
| Hazardous errors | 1.41 | 0.82 |
| Critical errors | 2.28 | 1.49 |
| Concentration errors | 0.78 | 0.48 |

Note: Impaired: average age 75.6, 64% male. Unimpaired: average age 75.6, 63% male.

* Nominal significance level .008 or less; significant at .05 level using Bonferroni-type correction.

With the exception of one subject whose test was terminated in the parking lot because of hazard, the MDPE was given to all the referrals in both cognitive status groups. Cognitively impaired subjects again showed directionally poorer performance than the cognitively unimpaired on each MDPE measure. All comparisons excepting that for test failure ($p$ = .115) had nominal probabilities less than .05, although the only one reaching significance under the Bonferroni constraint was that for MSCORE, which had a nominal probability of .008. In comparisons involving the other measures, nominal probabilities ranged from a nearly significant .009 (concentration errors) to .048 (critical errors).

*Differentiating cognitively impaired and cognitively unimpaired referrals: Logistic regressions*. Cognitively impaired and cognitively unimpaired referrals were also differentiated by means of test results through forward selection logistic regression analyses. (It has been stated in Methods that logistic regressions using, separately, first-tier, second-tier, third-tier, and survey measures were conducted to differentiate these two cognitive status groups and, additionally, to distinguish between cognitively impaired referrals and volunteers. Differentiations based on survey measures are presented in a separate section.) The pool of first-tier measures (again excluding neck flexibility) included Auto-Trails time, observed problems, Snellen failure, and Pelli-Robson errors. The pool of second-tier measures included neck flexibility (Scientex' first-tier measure), gross MultiCAD scores, and Doron scores. The pool of third-tier measures consisted of MDPE concentration errors, MDPE failure, total MDPE unweighted errors, MSCORE, and the no-ADPE indicator. The groups did not differ in average age or sex composition, so these were included in the candidate variable pools but not forced to enter the models. What was being predicted in these analyses was the probability that a subject was a cognitively impaired as opposed to a cognitively unimpaired referral.

Results for first-, second-, and third-tier measures appear in Table 19.

Table 19

Logistic Regressions: First-, Second-, and Third-Tier Variables Discriminating Between Cognitively Impaired and Cognitively Unimpaired Referrals

| FIRST TIER ($N = 65$) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
| Knowledge test errors | 0.3710 | 5.229 | .0222 | 1.35 |

| SECOND TIER ($N = 65$) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
| Total Doron errors | 0.5369 | 5.796 | .0161 | 1.24 |
| Gross driving video errors | 0.4272 | 3.971 | .0463 | 1.20 |

Table 19 (continued)

| THIRD TIER ($N$ = 99) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-square | $p$ | O.R. |
| Concentration errors | 0.5885 | 14.837 | .0001 | 3.12 |
| Gender | 0.2570 | 2.903 | .0884 | 2.66 |

*Notes*: 1st tier: -2 Log L for intercept = 81.792; -2 Log L for intercept and covariates = 75.800; chi-square for covariates = 5.992, $df$ =1, $p$ =.0144.

2nd tier: -2 Log L for intercept =84.473; -2 Log L for intercept and covariates = 62.644; chi-square for covariates =21.829, $df$ = 2, $p$ =.0001.

3rd tier: -2 Log L for intercept = 124.598; -2 Log L for intercept and covariates =105.281; chi-square for covariates = 19.317, $df$ =2, $p$ = .0001.

In the first tier the only variable entering the equation was knowledge test errors. Each additional error (out of 12 possible) increased the odds of being in the cognitively impaired group by 35%. If number of observed problems had been allowed to enter, prediction would have improved; in a previous analysis it was the only first-tier measure to enter the equation and showed an odds ratio of 7.576. But the measure was excluded because, as noted above, its odds ratio would be expected to be spuriously high since lack of understanding of test instructions was both an observed problem and a criterion for cognitive impairment. Variables included in the candidate pool which did not enter the model were age, sex, Auto-Trails time, Snellen failure, and Pelli-Robson errors.

In the regression using second-tier measures, shown in the same table, each additional Doron error, either on the reaction time exercise or on the three Cue Recognition modules, increased the odds of being cognitively impaired by 24%. Each additional gross MultiCAD driving video error (i.e., each additional word ERROR appearing on the printout) increased these odds by 20%. Numerous variables failed to enter—age, sex, average distance (time-equivalent) scores on the three Cue Recognition exercises, Doron reaction time, neck flexibility, and all of the gross MultiCAD visual function measures.

The only test variable entering the regression equation using third-tier variables was the number of MDPE concentration errors; its odds ratio indicates that each such error (two was maximum) increased the odds of belonging to the impaired group by 212%. Gender also entered the model, its odds ratio of 2.66 indicating that, after adjustment for number of concentration errors, men were more than twice as likely as women to be in the cognitively impaired referral group. Variables failing to enter the model included age, MDPE failure, MDPE unweighted and weighted errors, and the no-ADPE indicator.

*Differentiating cognitively impaired referrals and volunteers: Logistic regressions.* In these analyses, as in those discriminating between referrals and volunteers, age and sex were forced into the models, and for the same reason—cognitively impaired referrals and volunteers differed on these variables due to the very different ways in which they entered the study, resulting in demographically unbalanced samples. In the first-tier analysis, number of observed problems was again not included in the variable pool, for the reason given above. However, Auto-Trails was included. Results of the regressions for first-, second-, and third-tier measures appear in Table 20, with variables listed in their order of entry.

Table 20

Logistic Regressions: First-, Second-, and Third-Tier Variables Discriminating Between Cognitively Impaired Referrals and Volunteers: Age and Gender Forced

| FIRST TIER (*N* = 52) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
| Age | 0.0528 | 0.023 | .8804 | 1.01 |
| Gender | 1.1043 | 4.352 | .0370 | 55.42 |
| Pelli-Robson errors | 1.5505 | 6.864 | .0088 | 1.95 |
| Knowledge test errors | 0.6041 | 3.873 | .0491 | 1.58 |
| Auto-Trails time | 0.7354 | 3.182 | .0745 | 1.16 |

| SECOND TIER (*N* = 56) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
| Age | 0.5607 | 1.936 | .1641 | 1.14 |
| Gender | 1.0485 | 5.523 | .0188 | 46.12 |
| Cue Recognition 2 distance | 1.0773 | 1.807 | .1788 | 1.02 |
| Total Doron errors | 2.0762 | 3.567 | .0589 | 2.03 |

| THIRD TIER (*N* = 65) | | | | |
|---|---|---|---|---|
| Variable | Stand. param. est. | Chi-Square | *p* | O.R. |
| Age | 0.4711 | 1.914 | .1665 | 1.12 |
| Gender | 1.1786 | 5.289 | .0218 | 72.50 |
| MSCORE (weighted errors) | 1.5512 | 8.535 | .0035 | 1.21 |
| Concentration errors | 1.6585 | 7.309 | .0069 | 19.54 |

*Notes*: 1st tier: -2 Log L for intercept = 70.152; -2 Log L for intercept and covariates = 23.568; chi-square for covariates = 46.584, df = 5, p =.0001.
2nd tier: -2 Log L for intercept = 77.347; -2 Log L for intercept and covariates = 24.240; chi-square for covariates = 53.106, df = 4, p =.0001.
3rd tier: -2 Log L for intercept = 90.094; -2 Log L for intercept and covariates = 25.880; chi-square for covariates = 64.213, df = 4, p =.0001.

The only test variable available for entry into the first-tier model which did not enter was Snellen failure. The odds ratio for Pelli-Robson errors indicates that each additional error on that test increased the odds of being a cognitively impaired referral subject by 95%. In place of the omitted number of observed problems both knowledge test errors and Auto-Trails time entered, the former's odds ratio of 1.58 indicating that each additional error increased the odds of being a cognitively impaired referral by 58%, and the latter's odds ratio of 1.16 indicating that each added second of time to complete the task increased those odds by 16%. Age was far from significant after adjustment for other variables in the model; gender was not only significant but had an odds ratio of 55. This inordinately high odds ratio is apparently an artifactual result of very small cell sizes in some gender comparisons. The odds ratio for gender increased greatly after Auto-Trails entered the model, and there was evidence for an interaction between cognitive status and gender with respect to Auto-Trails time. Cross-tabulation showed that within the volunteer group 18 women and 13 men had scores of 24 seconds or less while no woman, and two men, had scores of 25 or more. Within the cognitively impaired referral group, two women and seven men had scores of 24 or less; four women and nine men had scores greater than 24. Thus within the cognitively impaired group the men were fairly evenly balanced between "adequate" and "inadequate" performance on Auto-Trails, while twice as many of the women showed inadequate performance. This interactive pattern, combined with the small sample sizes, no doubt tended to produce very unstable estimates of parameters involving gender effects.

In the second tier, a drastic reduction of $N$ led to empty cells when MultiCAD scores were included in the pool, with complete separation of sample points and odds ratios of 999 (i.e., infinity) when such a variable entered. It was decided therefore to exclude MultiCAD variables. Inclusion of Scientex' neck flexibility measure reduced $N$ to 35 and the variable did not enter the model, so in the analysis shown in Table 20 it was excluded as well, leaving only Doron measures. The first and third Cue Recognition modules did not enter this model; neither did choice reaction time (in braking to a particular configuration of lights on the console) on the Doron familiarization exercise.

Cue Recognition 2 entered immediately after age and sex and showed a significance level of .0009, but after adjustment its effect was not significant, as shown by the final $p$ value in the table. Total Doron errors (over the reaction time task and all three Cue Recognition modules) entered and remained significant ($p < .10$) after adjustment. Its odds ratio indicates that each additional error increased the odds of being a cognitively impaired referral by approximately 100%. Age was not significant after adjustment, but once more sex was, its odds ratio indicating that men were 46 times more likely to be in the cognitively impaired referral group (as opposed to the volunteer group) than women were. This value again is probably inflated due to small cell $N$s together with an interaction between cognitive status and gender with respect to Doron errors. Cross-tabulation showed that within the volunteer group 16 women and 14 men made 5 or fewer Doron errors, while one woman and no man made more than 5. But within the cognitively impaired group there was a marked gender imbalance on the Doron error measure—men were evenly (11 and 11) split between making 5 or fewer and 6 or more errors, while almost all (8) women in the group made 6 or more errors and only one made 5 or fewer. This may account for the increased influence of gender after Doron errors entered the model.

Concerning third-tier measures, it will be recalled that MSCORE and concentration errors discriminated between the referral group as a whole and the volunteer group (shown in Table 10). In Table 10 the odds ratios of these variables were shown as 1.14 and 3.53 respectively; here the influence of MSCORE remained about the same but that of concentration errors greatly increased. In the third-tier model age was not significant after adjustment; MDPE failure, MDPE unweighted errors, and the no-ADPE indicator did not enter.

The odds ratio for concentration errors in Table 20 indicates that each additional such error increased the odds of being a cognitively impaired referral subject by 1854%. Once again there is evidence for an interaction effect involving gender. This latter variable showed a greatly enhanced odds ratio of 72.5, indicating that after adjustment for other variables in the model men were 72.5 times more likely than women to be in the cognitively impaired group. In this analysis, 5 women and 13 men in the cognitively impaired group were represented in the model. Of the 5 cognitively impaired women, none had zero concentration errors. Of the 18 cognitively impaired men, 5 or 28% had no such errors. In the volunteer group, however, very similar percentages of women and men had zero concentration errors—15 of the 19 women represented and 15 of the 18 men. This interaction with respect to concentration errors between cognitive status and sex may account for the increased influence of the concentration error measure when adjusted for gender.

To forestall drawing premature conclusions about gender effects, the reader should remember that the volunteer sample does not represent any underlying population of general significance. In particular, its imbalance in gender composition probably reflects only the vagaries of study recruitment, which was in part by word of mouth. Since volunteers and referrals did differ in average age and sex, these demographic "nuisance" variables were forced into all logistic models predicting group membership. Thus the large odds ratios for gender in models predicting cognitively impaired referral vs. volunteer status should not be used to support a conclusion that men are more likely to be cognitively impaired than women. Even if the odds ratio were not inflated, such a conclusion would have no generality and would simply indicate that, because of the happenstance of group self-selection, if one bet on a woman to be a volunteer rather than a member of the cognitively impaired referral group, one would be correct more often than not. Within the referral group, however, some tentative hypotheses involving gender can be formulated. The interactions described above suggest that the small number of women in the cognitively impaired referral group may have been more impaired cognitively than were the men in that group. It is possible that women who are cognitively impaired are not reported to DMV as early in the course of their disease as men are.

*Road test reliability*

It will be recalled that two road test examiners participated in this study. On the 20 reliability trials for each road test, with one examiner in the front seat and one in the back, the interrater reliability was statistically significant but not high. Table 21 shows the results.

The pass/fail or satisfactory/unsatisfactory judgment was somewhat subjective, and the greater agreement for the ADPE than for the MDPE may have been due in part to examiners' forming congruent global impressions regarding a subject's general competence to drive after almost two hours, on two different days, of observing that subject's performance on the road.

Table 21

Road Test Interrater Reliability: Front-Seat Rater versus Back-Seat Rater

| | MDPE (20 tests) | ADPE (20 tests) |
|---|---|---|
| Correlation between numbers of errors (*r*) | .542 | .512 |
| Correlation between satisfactory vs. unsatisfactory judgments (Ø) | .600 | .809 |

*Driving information survey results*

After taking all nondriving tests, subjects at the San Jose site (and later at the Novato site, described in Part 3) were asked to complete a survey asking for information on their quantitative exposure (hours, days, and miles of driving in a normal week), whether or not they had been licensed in any state for 5 years, their qualitative exposure (principal reason for driving, most- and least-used types of roadways), driving habits (smoking, wearing corrective lenses), and ratings of their strength of avoidance of certain types of driving situations and their general health. A follow-up question asked whether guide signs were adequate when driving in unfamiliar areas. With the exception of this question and an added avoidance question asking to what degree the respondent avoided driving on unfamiliar routes, the questionnaire was essentially the same as the Driving Habits Survey used by Hennessy (1995) in his study evaluating vision tests.

Two questions relating to unfamiliar routes did not appear on Hennessy's survey. They were added after the questionnaire had been printed, and so were appended to the Traffic Sign Knowledge and Perception test. At the Novato site all the questions appeared on a single survey form, shown in Appendix B.

*Referrals and volunteers: Exposure tabulations.* Tables 22 and 23 below show the distribution of answers to the quantitative and qualitative exposure questions, respectively, on the survey for referrals and volunteers. In Table 22 are summarized subjects' estimates of driving quantity in terms of days, miles, and hours per week. Answers are tabulated for the 102 referral subjects and 33 volunteer comparison subjects who comprised the total sample.

Table 22

Referrals and Volunteers: Amount of Exposure (Averages)

| | Referrals (*N* = 102) | Volunteers (*N* = 33) |
|---|---|---|
| Days per week | 4.9 (*n* = 95) | 5.9 (*n* = 31) |
| Miles per week | 32.6 (*n* = 102) | 45.9 (*n* = 33) |
| Hours per week | 5.0 (*n* = 101) | 4.3 (*n* = 33) |

Of the total number responding to the first survey question, three referral subjects and one volunteer (3% of the total sample) indicated that in most weeks they did not drive. The estimates shown in the table for number of days of driving per week are based on information from the 97% of subjects who did. Of those respondents, 59% of referrals and 84% of volunteers reported driving 5 or more days per week.

Almost equal percentages of the groups, 18 referrals (18%) and 7 volunteers (21%) were high-mileage drivers, reportedly driving over 150 miles in a normal week. But there were proportionately more low-mileage drivers among the referrals than among the volunteers; 24 of the former group (24%) and 3 of the latter (9%) reportedly drove less than 21 miles per week.

Table 23 shows response distributions for qualitative aspects of exposure—the most frequent reason for driving and the most frequently used roadway type. These would be expected to determine in part the demand characteristics of the driving task—the amount of traffic congestion at the time of driving, for example. The most commonly reported reason for driving, in both groups, was running errands. Roadway type tended to differ primarily in that proportionately twice as many volunteers as referrals reported freeways as the type of roadway on which they most commonly drove (although the difference did not show statistical significance in a chi-square test). This question (#6) was probably not worded in the most appropriate manner; in answering it, some subjects may have been thinking of the time they spent on various roadway types rather than how often they used them. Strictly speaking, frequency of use would be expected to be greatest for streets around the subjects' homes—most likely "residential streets"—since any trip beginning and ending at home would necessarily involve those streets.

Table 23

Referrals and Volunteers: Most Frequent Type of Exposure (%)

| | Referrals ($N$ = 102) | Volunteers ($N$ = 33) |
|---|---|---|
| Reason for driving | ($n$ = 99) | ($n$ = 32) |
| to/from work | 13.1 | 9.4 |
| recreation | 5.1 | 3.1 |
| on job | 3.0 | 0.0 |
| errands | 75.8 | 81.3 |
| out-of-town trips | 1.0 | 3.1 |
| none apply | 2.0 | 3.1 |
| Roadway type | ($n$ = 98) | ($n$ = 32) |
| residential streets | 64.3 | 43.8 |
| nonresid. city streets | 20.4 | 31.3 |
| freeways | 11.2 | 25.0 |
| county roads | 3.1 | 0.0 |
| none apply | 1.0 | 0.0 |

*Referrals vs. volunteers: Logistic regressions.* Table 24 shows the results of a forward-selection logistic regression run to identify the survey variables which best differentiated referrals and volunteers. The procedure modeled the probability that a subject was a referral. Qualitative exposure questions relating to reason for driving and roadway type were excluded from this analysis because the answers were not on an ordinal scale, but all other survey questions, including those relating to quantitative exposure, were included. As in preceding analyses contrasting referrals and volunteers, age and sex were forced into the model before other measures were allowed to enter. The significance level used for entry remained .10.

Five measures from the survey (in addition to age and sex) distinguished between the volunteer and referral groups. Table 24 shows those measures, the standardized parameters corresponding to them, their final chi-square values with significance levels, and odds ratios. Measures are listed in order of entry.

Table 24

Logistic Regressions: Demographic and Survey Variables Discriminating Between Referrals and Volunteers: Age and Gender Forced (*N* = 113)

| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
|---|---|---|---|---|
| Age | 0.618 | 10.59 | .0011 | 1.14 |
| Gender | 0.406 | 5.46 | .0194 | 4.38 |
| Avoid night driving | 0.528 | 5.10 | .0240 | 2.36 |
| Avoid freeway | 0.334 | 2.25 | .1334 | 1.74 |
| Smoke while driving | 0.360 | 3.08 | .0792 | 8.61 |
| Not lic. contsly., prior 5 yrs. | 0.428 | 3.94 | .0470 | 11.25 |
| Health | 0.299 | 3.23 | .0723 | 2.51 |

*Note*: -2 Log L for intercept = 136.496; -2 Log L for intercept and covariates = 84.312; chi-square for covariates = 52.184, *df* = 7, *p* = .0001.

One survey variable ("not licensed more than 5 years," question #4) had been meant to get at driving experience. But to forestall possible confusion it is referred to in tables and figures as "not licensed continuously, prior 5 years" because it appeared from results that this latter wording conveys better the meaning of the question as respondents generally interpreted it. This point is discussed further below. The question was scored on only a 2-point scale, with 1 indicating that the person had been licensed (in some state) for more than 5 years and 2 indicating that they had not. The health question was scored on a scale ranging from 1 (excellent) to 4 (poor); the questions on avoidance of night driving, avoidance of freeway driving, and smoking while driving were also scored on a 4-point scale (1 = never to 4 = always).

The variable "not licensed more than 5 years" or "not licensed continuously, prior 5 years" requires clarification and some interpretation. Seventeen referrals, as opposed to one volunteer, indicated that they had not been licensed for more than 5 years, and a higher percentage of cognitively impaired than of unimpaired referrals gave this response. It thus seems likely that such an answer characterizes, in addition to the few persons in the sample who might lack driving experience, those under a preexisting license action because of disability at the time of their reexamination who were seeking to regain their licenses. Such persons, even though experienced, would legitimately have answered the licensure question in the negative because the question had two possible interpretations: "Have you ever been licensed for more than 5 years?" vs. "As of now, have you been licensed for more than 5 years?" Such people were in all likelihood more numerous in this sample than were novice drivers.

Figure 1 shows the distribution of survey responses for referrals and volunteers on the five survey questions that discriminated between the groups.  To avoid a double negative, the licensure item is worded in the positive direction.

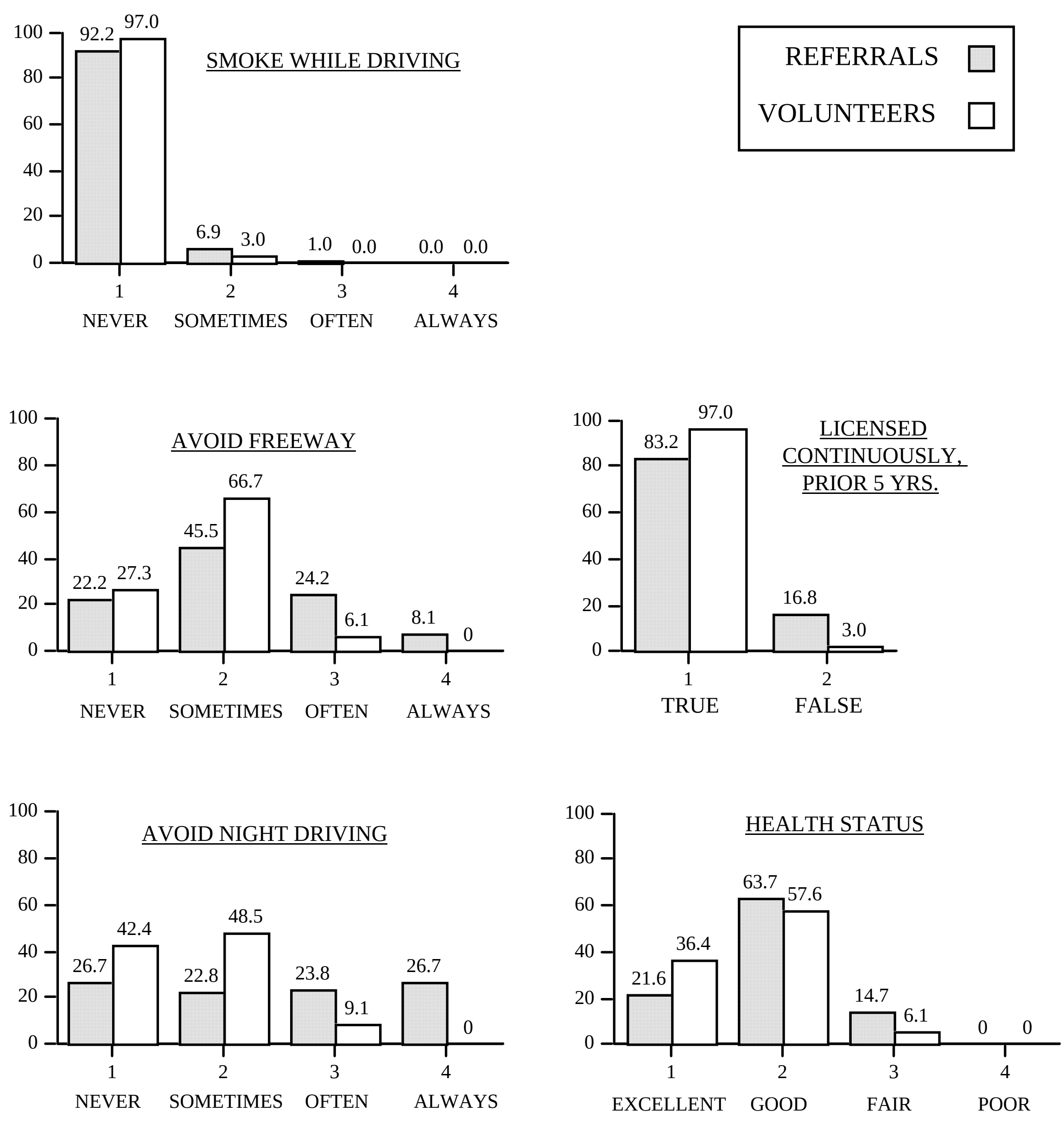


Figure 1 .  Response percentages for survey questions differentiating referrals ($N$ = 80) from volunteers ($N$ = 33).

As noted, the logistic procedure modeled the probability that a subject was a referral. After adjustment for age, sex, and the other variables entering the model, subjects reporting 5 or fewer years of licensure (in any state) were 11 times as likely to be referrals as volunteers. Subjects were also more likely to be referrals if they reported worse health (each additional point on the health scale increasing the odds of being a referral by 150%), if they more strongly avoided driving at night (an increase of 136%), and if they more often smoked while driving (an increase of 760%). Avoidance of freeway driving entered the model but was not significant after adjustment for other variables. The great majority in both groups reportedly never smoked while driving, as shown in Figure 1.

*Cognitively impaired referrals vs. other referrals and volunteers: Exposure tabulations.* Table 25 summarizes quantitative exposure information for the two cognitive status groups within the referral group, the 34 subjects identified as probably being cognitively impaired to some degree, and the 68 subjects not so identified. (Criteria used in making this determination are stated above.)

Table 25

Cognitively Impaired and Other Referrals: Amount of Exposure (Averages)

| | Cognitively impaired referrals (*N* = 34) | Other referrals (*N* = 68) |
|---|---|---|
| Days per week | 4.8 (*n* = 31) | 5.0 (*n* = 64) |
| Miles per week | 24.0 (*n* = 34) | 36.8 (*n* = 68) |
| Hours per week | 4.0 (*n* = 34) | 5.7 (*n* = 67) |

Two respondents in the cognitively impaired subgroup, and one in the cognitively unimpaired subgroup of referral drivers, indicated that in most weeks they did not drive. These were omitted from the calculation of average days per week, but included as zero scores in calculating average mileage and average hours. Cognitively impaired drivers showed some tendency to report fewer miles and hours of driving than did the cognitively unimpaired, but the differences were not significant. In both groups roughly one quarter of the subjects reported driving at most 20 miles in a normal week, but even in the cognitively impaired group there were a few subjects (4 out of 34, or 12%) who reportedly drove over 150 miles.

Similarly, the primary reasons for driving did not differ between the two cognitive status groups, as shown by Table 26. An overwhelming majority (91%) of cognitively impaired referrals gave "errands" as their primary type of driving;

errands were also named by almost 70% of cognitively unimpaired referrals. The next most commonly reported type of driving (the only other type reported by the cognitively impaired) was "to and from work."

Table 26

Cognitively Impaired and Other Referrals: Most Frequent Type of Exposure (%)

| | Cognitively impaired referrals ($N$ = 34) | Other referrals ($N$ = 68) |
|---|---|---|
| Reason for driving | $n$ = 32 | $n$ = 67 |
| to/from work | 9.4 | 14.9 |
| recreation | 0.0 | 7.5 |
| on job | 0.0 | 4.5 |
| errands | 90.6 | 68.7 |
| out-of-town trips | 0.0 | 1.5 |
| none apply | 0.0 | 3.0 |
| Roadway type | $n$ = 34 | $n$ = 64 |
| residential streets | 70.6 | 60.9 |
| nonresidential city | 11.8 | 25.0 |
| freeways | 14.7 | 9.4 |
| county roads | 2.9 | 3.1 |
| none apply | 0.0 | 1.6 |

There was no significant difference, again, for roadway type. It may be of interest to note that although neither group did a great deal of driving on freeways, cognitively impaired subjects apparently drove no less on them than did the cognitively unimpaired. Over 60% of each group named residential streets as their primarily used roadway type.

*Cognitively impaired vs. unimpaired referrals: Logistic regression.* A forward-selection logistic regression like the one described above were conducted to determine which survey variables differentiated cognitively impaired from cognitively unimpaired referrals. For this purpose age and sex were included in the candidate variable pool but not forced, because the two groups of referrals did not differ on these demographic measures. Results of this analysis appear in Table 27.

Table 27

Logistic Regressions: Survey Variables Discriminating Between Cognitively Impaired and Cognitively Unimpaired Referrals
($N$ = 80)

| Variable | Stand. Param. Est. | Chi-Square | $p$ | O.R. |
|---|---|---|---|---|
| Wear lenses when driving | -0.212 | 2.780 | .096 | 0.701 |

*Note*: -2 Log $L$ for intercept = 100.893; -2 Log $L$ for intercept and covariates = 98.125; chi-square for covariate = 2.768, $df$ = 1, $p$ = .0961.

The logistic regression procedure modeled the probability of a referral subject's being cognitively impaired. In distinguishing the two subsets of referral subjects, only the corrective lens question on the survey was significant. That question, "Do you wear glasses or contact lenses when you drive?" was scored on a 4-point scale like the avoidance questions, with 1 = never and 4 = always. Its odds ratio of 0.701 indicated that a person reportedly wearing lenses less often had an increased likelihood of being cognitively impaired. In part, this may simply reflect the fact that those referral subjects who did not come to the attention of the department because of cognitive impairment commonly came to its attention on account of their poor vision. In any case the corrective lens variable did not add particularly meaningfully to prediction. As shown by information in the table note, the reduction in -2 log likelihood (or, essentially, in residual error) due to inclusion of the covariate was small.

Figure 2 shows the distribution of responses among referrals to the corrective lens question, by cognitive status.

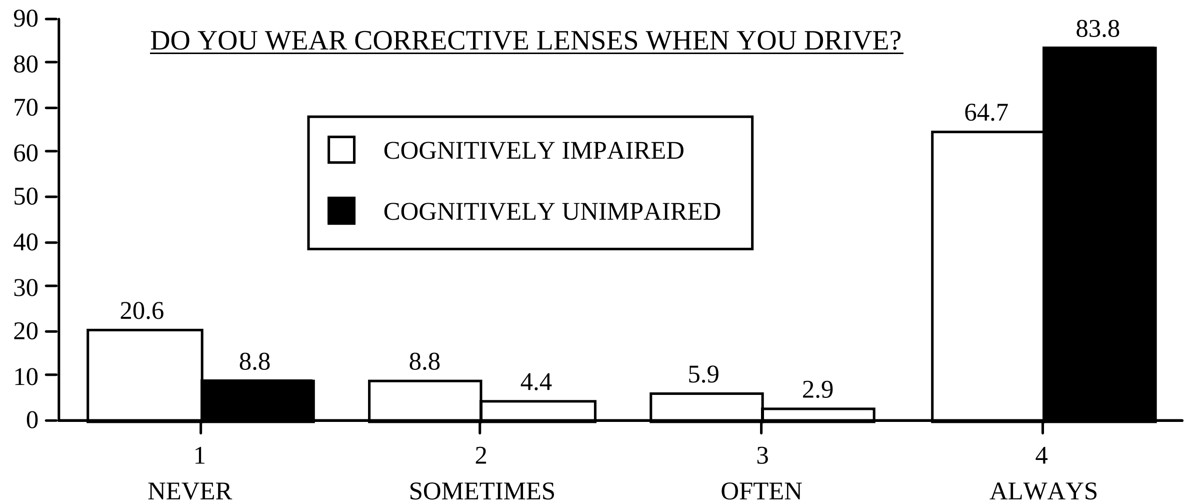


Figure 2 . Response percentages for corrective lens questions differentiating cognitively impaired ( *N* = 26) from cognitively unimpaired ( *N* = 54) referrals.

*Cognitively impaired referrals vs. volunteers: Logistic regression.* A second differentiation was between volunteers and cognitively impaired referrals by means of their survey responses. The regression again modeled the probability of a subject's being a cognitively impaired referral, and age and sex were forced into the model before other measures were allowed to enter, for the reason given above. Table 28 shows results of this logistic regression; variables are shown in order of entry.

Table 28

Logistic Regressions: Demographic and Survey Variables Discriminating Between Cognitively Impaired Referrals and Volunteers: Age and Gender Forced
($N$ = 59)

| Variable | Stand. param. est. | Chi-square | *p* | O.R. |
|---|---|---|---|---|
| Age | 0.691 | 7.57 | .0059 | 1.17 |
| Gender | 0.528 | 5.22 | .0223 | 6.73 |
| Avoid night driving | 0.628 | 6.12 | .0134 | 2.99 |
| Not licensed continuously, prior 5 yrs. | 0.415 | 3.01 | .0826 | 11.82 |

Note: -2 Log *L* for intercept = 80.959; -2 Log *L* for intercept and covariates = 49.199; chi-square = 31.760, *df* = 4, *p* = .0001.

The first survey variable entering the model was avoidance of night driving, measured on a 4-point scale ranging from never avoid (1) to always avoid (4). Each additional degree of avoidance on that scale increased the odds of a respondent's being a cognitively impaired referral as opposed to a volunteer by almost 200%. The licensure or driving experience question, measured on a 2-point scale, was the last to enter. Respondents who reported not being licensed more than 5 years (or not licensed continuously over the past 5 years) were almost 12 times more likely than those reporting licensure for a longer period to be cognitively impaired referrals. The ambiguity of this question has been pointed out above; as concluded there, this may simply indicate that more referrals than volunteers had had their driving privilege withdrawn at a prior date and were now seeking to regain it. Of course no volunteers were suspended or revoked at the time of testing; if they were they could not have entered the study. After adjustment for other variables in the model, males were almost 7 times more likely to be in the cognitively-impaired referral group, and each additional year of age increased the odds by 17%.

Figure 3 shows the distribution of responses to the two survey questions differentiating cognitively impaired referrals and volunteers. Again the licensure item is stated positively.

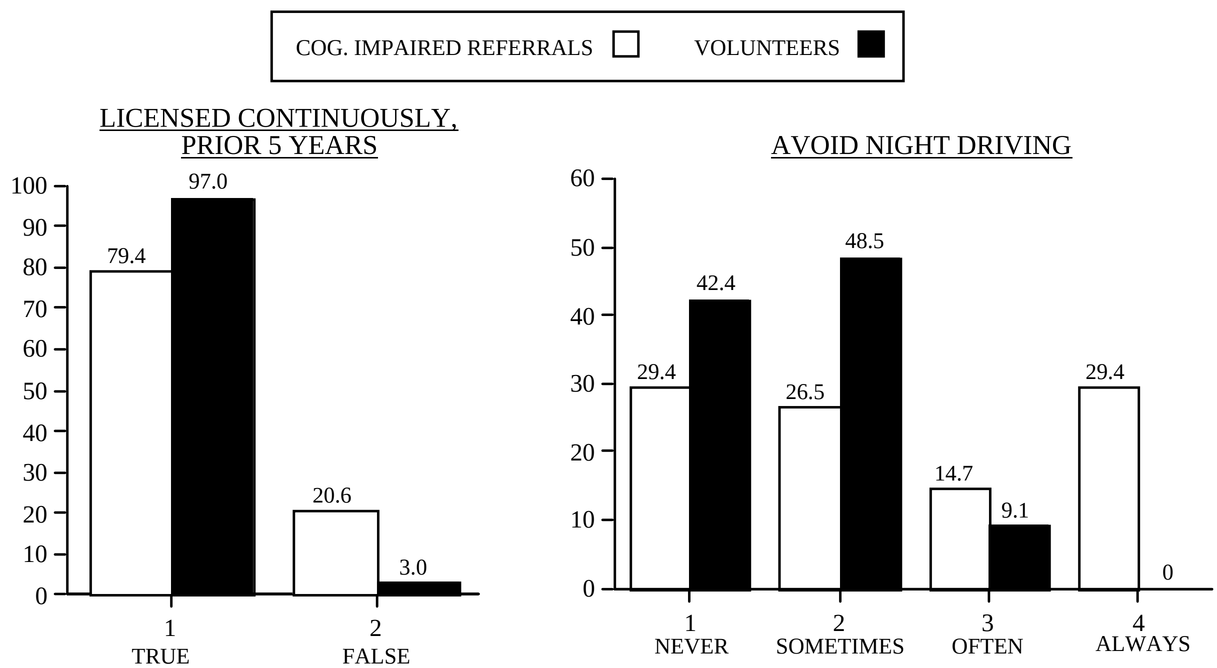


Figure 3. Response percentages for survey questions differentiating cognitively impaired referrals ($N$ = 26) from volunteers ($N$ = 33).

As the figure shows, cognitively impaired referrals avoided driving at night more than volunteers did; this is understandable because they were older on the average, and is consistent with adequate judgment in this respect despite mild cognitive impairment—again on the average, since 10 members of the group reportedly never avoided night driving.

*Factor analysis: Measurement dimensions*

An exploratory factor analysis was conducted on the combined scores of referrals and volunteers, so as to be able to describe more concisely the patterns of interrelationships among observed variables—tests, survey measures, and classification variables—when they were considered simultaneously. It was hoped that these patterns might suggest underlying measurement dimensions possibly tapped by a variety of superficially different response measures.

Because of the richness of that data set it had also been hoped to conduct the analysis on the referral group data using both gross and precise MultiCAD measures in addition to the other test, survey, and classificatory variables. This was found not to be possible. If all variables were put into the variable pool, when listwise deletion was used only a handful of cases remained; pairwise deletion led to negative eigenvalues and a matrix which was not positive definite, and the mean-substitution method did not seem applicable. This last was true because, given Scientex' scoring method, a possible reason for missing values on the precise MultiCAD time measures was lack of any correct response in the three trials for a specific visual function at a specific stimulus level. Therefore referrals and volunteers were combined and the only MultiCAD measures used were gross ones. Even so, the number of complete cases (30) was small enough to make the results below only suggestive at best.

Oblique (oblimin) rotation was used, because some correlation among factors was anticipated. The first three factors accounted for about 45% of the total variance; description and interpretation is limited to these because of the extremely small sample size and small variance percentages of factors following the third. Speculative interpretation appears in this section rather than being deferred to the Discussion section, because it was judged that this would make the reader's task easier. This interpretation was based on inspection of the structure matrix, which contains correlations between factors and variables that, under oblique rotation, are somewhat inflated (Tabachnick & Fidell, 1983). In this particular case the inflation is judged probably to be modest because the factors are not highly correlated. Table 29 shows eigenvalues for all 14 factors, with the variance percentage attributable to each. Communalities of the variables are not shown but they were quite high, ranging from .69 for avoidance of freeway driving to .95 for Pelli-Robson errors. (The communality of overall avoidance would have been even higher than this, but this variable was eliminated to avoid spuriously high part-whole correlations.) Of the 46 variables in the analysis, 2 had communalities below .80 (multiple instruction errors on the ADPE in addition to the previously mentioned avoidance of freeway driving). On the other hand, 19 variables had communalities above .90.

Table 29

Factor Eigenvalues and Percentages of Variance

| Factor | Eigenvalue | Percentage of variance | Cumulative percentage |
|---|---|---|---|
| 1 | 10.76 | 23.9 | 23.9 |
| 2 | 5.47 | 12.2 | 36.1 |
| 3 | 3.75 | 8.3 | 44.4 |
| 4 | 3.13 | 7.0 | 51.4 |
| 5 | 3.01 | 6.7 | 58.0 |
| 6 | 2.35 | 5.2 | 63.3 |
| 7 | 2.24 | 5.0 | 68.2 |
| 8 | 1.62 | 3.6 | 71.8 |
| 9 | 1.52 | 3.4 | 75.2 |
| 10 | 1.26 | 2.8 | 78.0 |
| 11 | 1.23 | 2.7 | 80.8 |
| 12 | 1.14 | 2.5 | 83.3 |
| 13 | 1.05 | 2.3 | 85.6 |
| 14 | 1.02 | 2.3 | 87.9 |

For the first eight factors, the percentage of variance accounted for by each and variable loadings whose absolute value equals .30 or more are shown in Table 30.

## Table 30

### Factor Analysis: Structure Matrix of Variable Loadings on First Eight Factors

| Variable | Variance Percentage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 23.9% | 12.2% | 8.3% | 7.0% | 6.7% | 5.2% | 5.0 | 3.6% |
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 | Factor 8 |
| Cue Recog. 2 dist. | .87 | | | | | | | |
| Cue Recog. 3 dist. | .76 | | | | | | | |
| Total Doron errors | .67 | .31 | | | .55 | | | |
| Auto-Trails time | .60 | | | | | | | |
| Avoid parallel park | .55 | | | | | | | |
| Dyn. acuity time | .54 | | | | | | .36 | |
| Cue Recog. 1 dist. | .49 | .35 | | | .35 | -.47 | .34 | |
| Avoid sunrise/sunset | | .77 | | | -.34 | | | |
| Concentration errors | | .77 | | | | | | |
| Avoid night driving | | .71 | -.38 | | | | | |
| Avoid rain/fog | | .54 | | | | | | -.40 |
| Days/week driving | | -.48 | .45 | | -.44 | -.40 | | |
| Knowledge errors | | | .85 | | | | | |
| Miles/week driving | | | .80 | | | | | |
| Hrs./week driving | | | .59 | | | -.34 | | .35 |
| Dyn. cont. sens. time | | | | .91 | | | | |
| Poorness of health | | | | | -.88 | | | |
| Doron RT | .38 | | | | .74 | | | |
| Not lic. continuously prior 5 years | .33 | | | -.35 | .56 | | .52 | |
| Snellen failure | .42 | | | | | -.69 | | |
| Avoid driving alone | | .57 | | | | -.59 | | |
| Mult. instr. errors | | | | | | | .76 | |
| Info. from signs OK | | | | | | -.32 | -.66 | |
| Smoke while driv. | | | | | | | | .90 |
| No. of observ. probs. | | | | | | | | .87 |
| Avoid heavy traffic | | .46 | | | | | | |
| Avoid unfamil. rtes. | .33 | | | .50 | | | | |
| Age | | | | .41 | | | | |
| Static acuity errors | | | .42 | | | | -.41 | |
| Static acuity time | .56 | | | | | | | |
| ADPE wted. errors | .56 | | | | | | .46 | |
| Driv. video errors | .30 | | .31 | | | .35 | | .33 |
| MSCORE | .60 | | | | | | | |
| Avoid freeway driv. | | .38 | | | | | | |
| Sex | | | .39 | -.44 | | | | |
| Static cont. sens. err. | | | | | | -.30 | | |
| Stat. cont. sens. time | .46 | | | | .32 | | | |
| Pelli-Robson errors | .63 | | | | | | | |
| Cognitive impairmt. | .45 | | | | | .41 | | |
| Dyn. acuity errors | .47 | | | -.43 | .43 | | | |

Tentative interpretations of the first three factors follow, although the reader should be warned that they are extremely speculative. Factor 1 may be considered primarily a driving disability factor with the disabilities appearing to be in several domains—visual, psychomotor, and cognitive. The test variables loading strongly on it (.70 or more), in the direction of poor performance, were Cue Recognition 2 and Cue Recognition 3 average time-equivalent scores. Test variables showing moderate loadings (.50-.69), in the direction of poorer performance, were total Doron errors, Auto-Trails time, gross MultiCAD dynamic acuity time, gross MultiCAD static acuity time, ADPE weighted errors, MDPE weighted errors (MSCORE), and Pelli-Robson errors. One survey variable, avoidance of parallel parking, also loaded moderately on Factor 1, in the direction of greater avoidance. It is especially noteworthy that the criterion measure MSCORE loaded .60 on this factor, the direction indicating poorer performance on the road test. In fact only on Factor 1 did MSCORE show a loading of .30 or more. Variables loading relatively weakly on the factor (below .50), and their directionality, were greater avoidance of unfamiliar routes, poorer performance on Cue Recognition 1, Snellen failure, longer choice reaction time on the Doron orientation task, licensure for 5 years or less (or probably more accurately, lack of continuous licensure over the prior 5 years), more errors on the MultiCAD driving video, greater MultiCAD static contrast sensitivity response time, more MultiCAD dynamic acuity errors, and presumed cognitive impairment as defined above.

Factor 2 appears to combine elements of avoidance and visuospatial if not more general cognitive impairment. The variables loading most strongly on it were avoidance of driving at sunrise or sunset and of driving at night, and concentration errors. Avoidance of driving in rain or fog and driving alone showed moderate loadings. Variables loading relatively weakly included (increased) total Doron errors, slower or invalid responses on Cue Recognition 1, driving fewer days per week, avoidance of heavy traffic, and avoidance of freeway driving. Since cognitive impairment per se did not load on the factor, the cause of the concentration errors may have been more a "poor sense of direction" than a more general cognitive deficiency, but the loadings for avoidance of driving alone, total Doron errors, and Cue Recognition 1 suggest a very mild degree of cognitive impairment for which subjects perhaps tried to compensate through various forms of exposure restriction.

Factor 3 is defined by increased errors on the knowledge test and increased driving, miles per week loading very strongly and positively but hours and days per week loading, though less strongly, in a positive direction as well. It is thus intriguing in that it seems to combine possible cognitive impairment (or ignorance, or lack of verbal facility) with no reduction of driving in general or driving at night, the latter of which showed a relatively weak loading of .39. Other variables loading relatively weakly (less than .50) on the factor, and their directionality, were increased errors on both the MultiCAD static acuity test and driving video, and male gender.

*Test acceptance*

In considering what tests are appropriate to administer in a licensing agency, it is important to select those that are acceptable to the public and seen by them as having potential value in identifying "bad drivers." Therefore, after each administration of Auto-Trails, Doron Cue Recognition, the Pelli-Robson test, or the Traffic Sign Knowledge/Recognition test to the first 39 referral and first 31 volunteer subjects at San Jose, the second author asked them the following questions:

1. Were the instructions easy to understand?
2. Do you think that this test would help DMV predict which people might have trouble driving?
3. Do you think it would be *fair* to give drivers this kind of test to see if they should get restrictions on their license?

Finally she asked whether they had any other comments about the test.

Answer categories for each of the three structured questions were (1) definitely no, (2) probably no, (3) probably yes, and (4) definitely yes. These answer codes were written on the test sheet, along with any comments the subject made. If a subject refused to answer a question or could not form an opinion, that response was not considered in making the following tabulations and the indicated sample N is reduced accordingly.

It was of course possible that referrals and volunteers might answer these questions differently because of their differing perspectives. Referrals' driving privileges were in jeopardy, and this could have influenced them either to praise DMV's selection of tests in hope of making a favorable impression or, on the other hand, to express a negative opinion of DMV testing in general. Therefore results are presented separately for the two groups. However, it was found that their results were not greatly discrepant. The highest ratings in terms of face validity issues—perceived utility of the tests for predicting driving problems and fairness of the tests when used to make licensing or restriction decisions—were given to Auto-Trails, Cue Recognition, and the Pelli-Robson; lower ratings were given to the traffic sign test and there was more variability in those ratings.

Table 31 shows sample sizes, average ratings, and the standard deviation of ratings for referral subjects.

Table 31

*N*s, Means, and Standard Deviations of Test Ratings, Referrals

| | *n* | $\bar{X}$ | s |
|---|---|---|---|
| Question 1: Were instructions easy to understand? | | | |
| Auto-Trails | 39 | 3.95 | .22 |
| Doron Cue Recognition | 38 | 3.66 | .63 |
| Pelli-Robson Low-Contrast Acuity | 38 | 3.95 | .23 |
| Traffic Sign Knowledge/Perception | 31 | 3.16 | 1.16 |
| Question 2: Would test help predict “trouble driving”? | | | |
| Auto-Trails | 37 | 3.49 | .61 |
| Doron Cue Recognition | 36 | 3.72 | .57 |
| Pelli-Robson Low-Contrast Acuity | 36 | 3.67 | .59 |
| Traffic Sign Knowledge/Perception | 28 | 3.29 | .98 |
| Question 3: Would it be fair to give test to determine license restrictions? | | | |
| Auto-Trails | 38 | 3.79 | .41 |
| Doron Cue Recognition | 36 | 3.64 | .64 |
| Pelli-Robson Low-Contrast Acuity | 36 | 3.75 | .44 |
| Traffic Sign Knowledge/Perception | 28 | 3.54 | .79 |

Table 32 gives the same information for volunteers.

Table 32

*N*s, Means, and Standard Deviations of Test Ratings, Volunteers

| | *n* | $\bar{X}$ | s |
|---|---|---|---|
| Question 1: Were instructions easy to understand? | | | |
| Auto-Trails | 31 | 3.97 | .18 |
| Doron Cue Recognition | 30 | 3.83 | .46 |
| Pelli-Robson Low-Contrast Acuity | 31 | 4.00 | .00 |
| Traffic Sign Knowledge/Perception | 30 | 3.47 | 1.04 |
| Question 2: Would test help predict “trouble driving”? | | | |
| Auto-Trails | 31 | 3.48 | .63 |
| Doron Cue Recognition | 30 | 3.77 | .43 |
| Pelli-Robson Low-Contrast Acuity | 27 | 3.74 | .45 |
| Traffic Sign Knowledge/Perception | 28 | 3.11 | 1.13 |

Table 32 (continued)

| | $n$ | $\overline{X}$ | s |
|---|---|---|---|
| Question 3: Would it be fair to give test to determine license restrictions? | | | |
| Auto-Trails | 31 | 3.42 | .76 |
| Doron Cue Recognition | 30 | 3.73 | .64 |
| Pelli-Robson Low-Contrast Acuity | 28 | 3.68 | .52 |
| Traffic Sign Knowledge/Perception | 29 | 3.21 | 1.18 |

Overall, ratings of and comments about the tests were generally favorable, with the exception of the traffic sign test—especially its perception exercises, in which the task was to determine the number of traffic sign shapes of a particular kind when these shapes were embedded in abstract figures. Referral subjects commented that some questions on this test could be interpreted in two ways that the perception questions were hard to understand and confusing, and even that those questions were unfair. Regarding the other (knowledge) aspect of the test, referrals said that people should be familiar with the signs on the roads, and that this test was a good step in the right direction, although it needed improvement. One person felt that the test would probably help in testing immigrants. Volunteers held views similar to those of referrals, pointing out that the perception questions were "kind of tricky and confusing" and that the directions should indicate that there was no distortion in the embedded shapes. In a back-handed compliment, one person said that, overall, the test was "better than the other junk the DMV gives."

To illustrate the mostly favorable tone of comments elicited by the other tests, some referral subjects' comments on Auto-Trails were as follows: good, especially for beginning drivers . . . difficult if you wear bifocals . . . these tests are good because they make you safer . . . good test for reaction time . . . interesting and helpful . . . excellent; this test is great for older people to test reaction time . . . the more tests the better; there are many people who should not have licenses . . . if people can't see, they will have trouble driving . . . I don't see much value [in this], but the DMV should give as many tests as they can . . . people need to scan the road quickly to be good drivers . . . this is important for vision; it makes me wise up when I drive.

The volunteers' comments on Auto-Trails included the following: easy; great to test speed and ability . . . helps people focus and use eye-hand coordination; would be good to use with a battery of tests . . . probably better than most; should use a larger screen for larger eye scan . . . rear view mirror gets in the way . . . [meant] for a good purpose, [but] would be confusing for a lot of people . . . fabulous, would teach you to concentrate . . . I liked it; it could help . . . not fair for older people, OK for younger ones.

Subjects were very favorably inclined toward the Cue Recognition exercises, which they interpreted as testing for slow reflexes, giving the exercises face validity for them. With respect to improving the test as a whole, several pointed out that it was hard to distinguish between icons (primarily between front-facing and rear-facing ones in the first and third modules, as noted above) and that the test was not realistic enough ("easier if there were pictures of real cars and real traffic situations"). One volunteer complained that "the screen is much closer than in real driving situations." After the three-part test was over, one referral subject remarked that "it's nice that the DMV would take this much time to test people."

The test eliciting the least negative comment was the Pelli-Robson. It was generally seen as a straightforward test of vision and "one of your better ones." Some subjects explicitly mentioned that driving in fog or darkness is difficult, and that the test is important for that reason, although one referral subject said that there was no need for it because "the other vision test [Snellen] is enough." (On the other hand, a volunteer felt that the Pelli-Robson is more helpful than the Snellen.) Two volunteers, confronted by the (almost invisible) last line on the chart, said that if it were that foggy they would stay home.

The general impression gained here is that although subjects sometimes found the tests confusing, they were not really aversive. The respondents believed that testing older people is a good idea (no one mentioned the possibility of age discrimination), and they encouraged DMV to improve its licensing tests and give more of them. In all likelihood negative responses to the traffic sign test, especially its "hidden figures" segment, were based on the particular test format used rather than on any belief that drivers should not be expected to perceive, and understand the meaning of, traffic signs.

## DISCUSSION

Broadly speaking, the two major goals of the present study were, first, to identify tests which would distinguish between impaired and unimpaired drivers (here operationalized as referrals and volunteers) and second, to identify tests which would predict the road test score of referrals (or the entire sample). Since it was additionally possible to separate referrals into a presumably cognitively impaired and presumably cognitively unimpaired group, differentiating between these groups and the volunteers by means of test scores became a point of interest, and other secondary topics such as survey responses were explored as well.

McKnight and Lange (1997) similarly differentiated by means of non-driving tests between a group of drivers referred for reexamination (in this case because of driving problems/errors rather than disease) and a group of volunteers. Their study used National Public Services Research Institute's (NPSRI's) Automated Psychophysical Test (APT) battery, described by Janke (1994, Part 3). The battery they administered, to 261 drivers aged 62 or more, consisted of 22 visual, attentional, perceptual, cognitive, and psychomotor tests. All ability measurements differentiated between the groups in terms of correlations, tests defined as cognitive showing the strongest association with subject group. APT cognitive measures tapped information processing (digit matching, figure matching, and identification of the pattern missing from a series), short-term memory (digit matching and figure matching), and delayed short-term memory (digit matching). While these measures had the greatest predictive value, McKnight and Lange noted that age-related deficit appears to pervade all aspects of ability to some extent. This statement, of course, applies to the (referral) group as a whole, not necessarily to each individual in it. And since the controls (volunteers) were selected to be approximately the same age as the driving-impaired subjects, it should perhaps be explicitly noted that the deficits, though related to age, were not an effect of age per se—if we define age as depending simply upon the passage of time. (It may be recalled that Hochschild [1990; cited in Janke, 1994] distinguished between biological and chronological age, emphasizing that aging is not only a function of the passage of time but also of many other factors, including such lifestyle factors as smoking and consumption of fats.) In any case, the APT tests have been shown to differentiate between groups having different levels of age-related impairment, and the authors stated their intention later to disclose the relationship between test scores and specific driving errors.

*Differentiating groups*

Univariate tests showed that performance on almost every measure used in this study, driving and non-driving, differed significantly between referrals and volunteers. In the logistic regression analysis whose results are presented in Tables 8 and 9, it was possible to differentiate volunteers from referrals with high specificity (judged the more important consideration in this case) and good sensitivity, using as predictors errors on the Pelli-Robson test, Snellen failure, and number of observed problems. These three measures demand little in the way of equipment or examiner time. The Snellen test of high-contrast visual acuity has been a part of DMV's licensure testing procedure for many years, and certainly it cannot be questioned that adequate acuity is necessary for competent driving. Contrast sensitivity is a particularly promising measure; it has been found to be related to crash experience, both by Decina and Staplin (1993), who found a significant relationship for elderly drivers between prior mileage-adjusted crash involvement and visual performance including contrast sensitivity, and by Hennessy (1995), who found that low-contrast acuity had crash-predictive value not only for drivers aged 70 or more but also for younger people wearing contact lenses. This suggests that the Pelli-Robson test may have value in routine licensure screening regardless of the age of the applicant.

In elderly people, Hennessy noted, low-contrast acuity loss may be due to cataracts, glaucoma, or retinal disease—age-related disorders differentially impacting contrast sensitivity and visual acuity in such a way that, in their early stages, low-contrast acuity is likely to be impaired but high-contrast acuity, as tested with the Snellen chart, is not. Passing only a high-contrast visual acuity test like the Snellen for licensure may leave impaired drivers with a false sense of security and a lack of any indication that their visual functioning may be inadequate in critical driving situations.

Regarding observational measures, California DMV policy presently authorizes field office staff to refer individuals with observable physical or mental impairments for road testing, but this is rarely done. However, successful operational programs along these lines, such as the one used by Florida's Department of Highway Safety and Motor Vehicles, are possible. Florida's program is described in relative detail by Janke and Eberhard (in press). Sufficient training in making objective observations of predetermined driving-relevant characteristics is obviously a necessity; given this, licensing agency staff may be able to make consistent and unbiased judgments with respect to well-defined symptoms of possible impairment shown by license applicants. In the present study, the second author's observations of "problems" exhibited by subjects formed a strong predictor of potential impairment (here, membership in the referral group) and a significant correlate of driving performance within both the group of referrals (Table 11) and the total sample (Table 12). However, since there is a possibility of bias and the method at a minimum requires intensive training of the staff members who will make the observations, some jurisdictions may prefer not to use it. It has been shown in different subsets of the total sample that use of the Snellen and Pelli-Robson tests alone, or use of the Pelli-Robson with Auto-Trails, have predictive value. The latter combination involves a computer, but on the other hand taps cognitive abilities to a greater extent than the first one.

Secondary logistic regression analyses identified measures from each assessment tier which, after adjustment for age and sex when necessary, distinguished between referrals and volunteers, cognitively impaired and cognitively unimpaired referrals, and cognitively impaired referrals and volunteers. Second-tier measures proving useful in distinguishing referrals from volunteers (necessarily excluding precise MultiCAD measures) were Cue Recognition 2 and 3 distance/time-equivalents and gross MultiCAD dynamic contrast sensitivity errors. Third-tier measures were the number of concentration errors made in the destination-finding task of the MDPE and the weighted error score on the MDPE, our criterion measure MSCORE.

All-tier logistic regressions were conducted to determine the order of primacy of predictors from all tiers combined in predicting whether a person had a likely impairment for driving or not (in this case, was a referral or a volunteer). It has been described above that one analysis used the gross measure of MultiCAD dynamic contrast sensitivity errors, while the second analysis omitted this measure from the pool in order to increase the number of cases. First-, second-, and third-tier measures entered both models, and it is of special interest to point out that in the model containing the greater number of cases the most powerful predictor of group membership, even beyond the road test MSCORE measure itself, was Cue Recognition 3. In its present form Cue Recognition 3 is not suitable for use in screening (as opposed to intensive testing), but if it could be converted to a personal computer-joystick format and abbreviated so that the complete Cue Recognition 1 and 2 modules did not have to be administered first in order for testees to learn the third-module task, it might have considerable potential for this purpose.

In addition to separating presumably impaired drivers (referrals) from presumably unimpaired drivers (volunteers), there was interest in the type of impairment involved. Perhaps the major impairment of interest in this project, as originally conceived, was dementia—at least, cognitive impairment to some degree. Thirty-four referrals were identified here as having probable cognitive impairment. Test results for these subjects, contrasted with those for cognitively unimpaired referrals, are shown in Tables 16 and 17 (nondriving tests) and Table 18 (road tests). With the exception of some precise MultiCAD measures shown in Table 17, the cognitively impaired group was directionally worse than the unimpaired one on all nondriving speed and error measures. They reported more avoidance on the Driving Information Survey, and their neck flexibility was directionally less. Using a Bonferroni-type correction, significant univariate differences were found for number of observed problems, all Doron measures, and MultiCAD driving video errors. On the precise MultiCAD measures, cognitively impaired subjects were directionally inferior on all but static acuity accuracy at 20/40, static contrast sensitivity accuracy at 20/40 for the higher contrast level, and dynamic contrast sensitivity response time at both 20/40 and 20/80 for the lower contrast level. Using a Bonferroni-type correction, only the measure of braking to a lead vehicle showing visible brake lights differentiated the groups significantly. On the road tests, significant (experimentwise $p < .05$) or marginally significant differences were found only for MSCORE (nominal $p = .008$) and concentration errors (nominal $p = .009$), but all of the other driving measures, without exception, showed a directional difference in favor of the cognitively unimpaired.

Logistic regressions conducted to differentiate cognitive status groups among the referrals showed that knowledge test errors, total Doron errors over all modules, the gross measure of MultiCAD driving video errors, and concentration errors on the MDPE were significant discriminators (Table 19). It is notable that in these analyses no significant differences appeared on nondriving tests which had a major emphasis on visual functioning, which of course was impaired for many referral drivers whose cognitive functioning was normal.

In contrasting cognitively impaired referrals and volunteers (Table 20) the picture was a little cloudier because cognitively impaired referrals often had some visual (or other) impairment as well, while volunteers were relatively free of any type of impairment. In addition the number of cases was reduced for these comparisons, leading, in the presence of interactions involving gender, to inflated odds ratios for that variable. These interactions have been described above in Results; they suggest that the women in the cognitively impaired group, though fewer in number, were more impaired than the men. It can be speculated that men are more likely to be reported for dementia, and at an earlier stage in the process, than women are.

After adjustment for age and gender, knowledge test errors, Pelli-Robson errors, and Auto-Trails time discriminated between the cognitively impaired and volunteer groups, as did (in the second tier) total Doron errors. Cue Recognition 2 entered and was highly significant at entry, but became insignificant after adjustment. On the third tier, MSCORE and concentration errors were significant predictors. The tests discriminating between cognitively impaired referrals and volunteers were, for the most part, tests with a substantial cognitive component. Of the tests listed above, only the Pelli-Robson can be said with some confidence to be a test more closely related to sensory/perceptual functioning than to higher-level abilities.

It was not surprising that concentration (confusion) errors also differentiated cognitively impaired referrals both from cognitively unimpaired referrals and from volunteers. But its effect in making the latter discrimination appears to be spuriously powerful, judging from the high odds ratio. This may be in part because of very small cell Ns and in part because of the interaction, pointed out in Results, between cognitive status and gender with respect to the commission of concentration errors. In any case concentration errors were highly significant, and the utility of this variable strongly suggests that a standardized road test given to older drivers who are experienced but possibly impaired should contain a task, like the destination task used here, that demands more in terms of cognitive abilities than simply following an examiner's direct instructions. As examples apart from the MDPE destination task and the ADPE multiple-instructions task used in this study, road test exercises used in the dementia study described by Dobbs (1997) involved planning (e.g., making a maneuver that required a preparatory lane change), memory (e.g., "turn left after you have gone two blocks"), and problem solving in finding a destination (Drive*Able* Testing Ltd., 1997).

A small but interesting point in Table 17, comparing scores for the two referral cognitive status groups on precise MultiCAD measures, is the apparently diminishing accuracy of cognitively impaired subjects on the static acuity task from the 20/40 stimulus (the most difficult) to the 20/200 stimulus (the easiest). This may be a result of chance, but it seems more likely that it was due to the order of administration of the MultiCAD tests. Following an initial hardware checkout, which would have familiarized subjects to some extent, static acuity was the first vision exercise; the first three trials of that exercise used the 20/200 stimulus. Three trials followed using the 20/80 stimulus, and finally there were three trials using the 20/40 stimulus. Thus subjects had their first opportunities to learn the procedure during familiarization/hardware checkout and on the static acuity task with a 20/200 stimulus. It seems reasonable to hypothesize that the cognitively unimpaired subjects learned their task faster than the impaired ones did, and if the test is primarily meant to assess visual abilities this suggests that the familiarization phase should be lengthened and perhaps that the order of stimulus levels within tasks should be counterbalanced. Alternatively, when norms are established for these tests, inferred rate of learning or accommodating to the first task might be used as an indicator of cognitive status.

In addition to differentiating groups by test performance, there was interest in differentiating them by means of their responses to the Driving Information Survey. As before, logistic regressions were run to differentiate the referral group from the volunteers, cognitively impaired referrals from those not cognitively impaired, and cognitively impaired referrals from volunteers. These results, presented in Tables 24, 27, and 28, will be very briefly recapitulated and discussed.

After adjustment for age and sex, reported licensure for less than 5 years (or noncontinuous licensure over the past 5 years), health status, smoking while driving, and avoidance of night driving all differentiated referrals and volunteers. Directionality was such that referrals more often smoked while driving (though few in either group did so), were more likely not to have been licensed continuously over the past 5 years, were more likely to avoid freeway and night driving, and had poorer health. Objective health of the volunteers would be expected to be better than that of referrals, and it is of some interest that self-reported health was also in this expected direction. Greater avoidance would be expected of less competent drivers (or drivers whose licenses have been suspended). This reduces exposure to the risk of traffic tickets or crashes, and consistently with this, Table 22 showed that referrals reported driving directionally less than volunteers in terms of days, hours, and miles per week.

The only survey variable discriminating between cognitively impaired and cognitively unimpaired referrals was wearing corrective lenses while driving. The latter group more often did this, and the suggestion has been offered that this was possibly due to the much greater prevalence of vision problems among members of the group, vision problems that not infrequently led to the referral for reexamination. Despite possible judgmental impairment, there was no evidence that cognitively impaired referrals showed fewer specific avoidance behaviors than the unimpaired, and Table 25 shows directional differences suggesting that they may have driven less.

Noncontinuous licensure over the prior 5 years and avoidance of night driving discriminated between cognitively impaired referrals and volunteers after adjustment for age and sex, both of which were significant. Besides being much more likely not to have been licensed continuously over the past 5 years, cognitively impaired referrals more often avoided night driving. These differences were also found in comparing volunteers with the referral group as a whole; a difference on self-perceived health status was not found and would not be expected because a person in apparently robust physical health can have mild cognitive impairment.

*Predicting road test score*

Prediction of road test score, especially within a relatively homogeneous group—homogeneous in that almost all of its elderly members had some driving-related impairment—is much more difficult than distinguishing group membership. Prediction of road test error score among referral subjects in the present study was statistically significant and at least moderate in degree (Table 14), although it has been emphasized that considerable capitalization on chance occurred and replication or cross-validation would yield less impressive results. In predicting weighted road test errors of referral drivers, two precise MultiCAD measures were significant—the static acuity time score, using a 20/80 stimulus, and the dynamic contrast sensitivity correctness score, using a 20/80 stimulus and the lower contrast level (again suggesting the utility of a contrast sensitivity test in evaluating driving fitness). The roughly similar gross MultiCAD measures of dynamic contrast sensitivity errors and static acuity time did not enter when the precise measures were available; although gross scores may suggest the severity of a visual defect, precise scores are more useful in pinpointing its degree. The predictive value of the precise scores would probably have been even greater had time scores not been missing for visual functions/stimulus combinations eliciting no correct responses in three trials, had those scores been based on more than three trials, or had an artificial score indicating the longest time possible been assigned in these cases.

Inspection of the simple correlations in Table 11 suggests that, among the MultiCAD precise visual function measures, response time scores were more highly correlated with road test performance than were correctness indicators. On the driving video (which used proportions of incorrect trials, rather than binary correctness indicators), the reverse appeared true. It may be relevant that McKnight and Lange (1997), administering their APT battery to elderly referral and volunteer subjects, found that for primarily cognitive tasks (as the Scientex driving video arguably was) higher correlations with subject group were found for error measures than for time measures. They expressed the view that the time required to respond to their visual acuity and cognitive measures, including a cognitively-demanding perceptual exercise, seems not to be particularly related to the abilities being measured.

In predicting road test weighted error score for referrals and volunteers combined, a highly contrasted group (Table 15), it was necessary to use gross MultiCAD measures in place of the precise ones. Cue Recognition 2 and Auto-Trails were again significant predictors, combined with the gross MultiCAD static acuity time and error measures. As one might expect, adjusted $R^2$ was higher than before, equaling .620. Further study of these tests or tests of similar functions is obviously necessary, but the results obtained here are promising. The ultimate objective, of course, is to produce a battery that will predict with acceptable accuracy how well individual drivers are likely to perform on a road test, in order to form the basis for a decision to require, or not require, passing such a test in order to be licensed.

For best prediction of road test performance, tests demanding some degree of psychomotor speed and accuracy may be necessary, since these abilities are highly relevant to real-world driving. The Cue Recognition and MultiCAD tests, as well as Auto-Trails, are such tests. With respect to the last of these, it should be noted that Part 3 describes results using another derivative of Reitan's (1955) Trail Making Test—in that case one based on Trails B rather than Trails A, from which Auto-Trails was derived. Both Trails A and Trails B have been used successfully in a licensing agency setting to predict prior crash frequency (Stutts, Stewart, & Martell, 1996); the latter, a more difficult test, performing better than the former.

The good predictive results found here for road test performance suggest that the road test itself was psychometrically sound. The criterion road test examination was the MDPE, based on a test, the Driving Performance Evaluation or DPE, found to be reliable and valid (Hagge, 1994; Romanowicz & Hagge, 1995). The DPE is so largely because of its objective scoring criteria and its focus on abilities that tend to discriminate between good and inadequate drivers—for example, the kind of ongoing observational behavior that leads to constant awareness of the changing traffic situation. The finding of only moderate interrater reliability for the slightly modified version of the test used in this study (Table 21) is probably largely due to the short time available for training the two examiners, who were completely unfamiliar with the DPE. Some unreliability in scoring the MDPE may also have been due to the rear-seat examiner's not being able to observe the driver's behavior as fully as the front-seat examiner could. These reliability trials were given after Scientex joined the study, and the rear-seat examiner had to share the space with their equipment needed for making videos of the driver. Even so, the relative success found here within a sample of older and often impaired drivers in predicting MDPE scores from nondriving test data indicates that this modified version, like the original, has value. And the fact that the interrater reliability was modest only increases the meaningfulness of predictors identified as being statistically significant, since unreliability attenuates validity and their effectiveness would have been enhanced given a more reliable test.

The ADPE could not be standardized to the same extent as the MDPE. An area test intrinsically depends not only on conformance with objective written procedures but to a much greater extent than the MDPE on the judgment of the individual giving it—since that person (except for the destination trips) chooses the routes and determines which maneuvers to score. This lack of standardization was mitigated somewhat by keeping the scoring criteria for various maneuvers the same as in the MDPE; Tables 6 and 18 indicate that the ADPE measures did significantly differentiate referrals and volunteers and tended consistently to differentiate cognitively impaired and cognitively unimpaired referrals. Despite its relative lack of standardization, it is necessary for a licensing agency to have an area road test in its armamentarium, if the agency is contemplating an area restriction for a driver and wants to determine whether the driver can perform safely within this limited area. It should be the case, however—which it rarely is, due to time constraints—that driving examiners are thoroughly familiar with the area in which they are examining the applicant.

Much more work remains to be done and in fact is currently being done by other investigators, using larger samples and different tests. Even in the present pilot study the requirement for a broader variety of tests was met to a degree, when the study moved to a second site in Novato. Work at this second site is described in Part 3, which will present a discussion in which implications of the findings at both sites are explored.

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## PART 3
## Second Study Site: Novato

A test battery different from that used in San Jose was piloted at the Buck Center for Research in Aging (BCRA) in the affluent community of Novato, Marin County. BCRA is a non-profit research organization which has been engaged since 1989 in longitudinal studies of a community-dwelling cohort of older people. The health status and functioning of this cohort, which was designed so as to oversample the oldest age groups, was described by Reed, Satariano, Gildengorin, McMahon, Fleshman, and Schneider (1995). Staff at BCRA have a special interest in driving and in the possibility of rehabilitating aging drivers whose road safety is impaired. From January through April 1997 BCRA researchers and other professional staff, aided by volunteers from the community who administered most of the tests, collected survey and nondriving test data for 101 licensed drivers. Each driver was also given a road test by the project driving instructor, the owner/operator of a driving school in San Francisco.

All drivers who served as subjects were aged 70 or more; they were members of the preexisting study cohort who had agreed to participate in this study. An attempt was made to recruit three equally sized groups of such drivers, one group with cognitive impairment, another with Parkinson's disease or stroke residuals but no cognitive impairment, and a third group of healthy controls. The data used to identify potential members of these groups for recruitment purposes were based on their most recent followup examination, in 1993-1995. This plan was found not to be feasible. The conditions of some potential subjects had changed since their last examination and some—roughly 20% in the two impaired groups and 6% in the intact group—had stopped driving. Others (generally in the impaired group) declined to participate because of illness, either theirs or their spouse's; still others (generally in the intact group) because they had no time due to other commitments. The final sample of 101 licensed drivers included only 2 with Parkinson's disease, 3 who had suffered a stroke, and 1 with MMSE score less than 24. (According to Braekhus, Laake, and Engedal [1992], a cutoff value of 23 or less on the MMSE is commonly used to indicate cognitive impairment.)

## METHODS

Although some subjects were given the road test before the nondriving tests in order to accommodate the schedule of the driving instructor, the latter tests will be described first. The entire nondriving testing process took about an hour.

*Nondriving tests*

*Balance and gross mobility*. Subjects were required, first, to perform a “tandem stand” (standing with the heel of one foot touching the toe of the other, both feet pointing straight ahead) for 10 seconds. Then their mobility was tested; in this exercise they walked back and forth along a 10-foot path for a 60-second test period. Both of these tests were scored in terms of pass vs. fail.

*Mini-Mental Status Evaluation (MMSE).* Results of this test (described in Part 3 of Janke [1994], the project literature review) were interpreted and scored by the neuroepidemiologist, Catherine West, M.D., Dr.P.H., who was responsible for the conduct of the study at BCRA and is principal investigator on other studies involving their elderly cohort. The MMSE contains 20 separate items and yields a maximum score of 30. Sixteen of the questions, in particular the nonverbal ones, are scored right vs. wrong, but the rest—immediate recall, short-term memory, backward spelling or alternatively subtraction by 7s starting at 100, and following a three-step command—are scored on 3- or 5-point ordinal scales. Possible errors can occur in six general cognitive domains: orientation, registration, attention/calculation, recall, language, and visuospatial perception/praxis (copying a figure consisting of two intersecting pentagons). For purposes of the present study the MMSE was scored in two ways, total MMSE correctness score and the number of cognitive domains, out of the six, in which an error or errors occurred.

In addition one item, the pentagon-copying task, was scored separately. This was found, in a study of elderly drivers by Marottoli, Cooney, Wagner, Doucette, and Tinetti (1994), to be the MMSE item most closely related to subject-reported adverse traffic events, such as crashes, citations, and incidents of being stopped by the police while driving. Twenty-four percent of subjects who could not correctly copy the design reported adverse events, as compared to 8% of those who could. Using conventional MMSE scoring, 0 would indicate incorrect performance, and 1 correct performance, of the item. In the present study, however, an error was scored as 1 and correct performance as zero to conform with most of the other measures, which were in terms of time or errors. (Scoring of the total MMSE, and scoring of the pentagon-copying item using the graded method described immediately below, were exceptions. In both cases a higher score indicated better performance.)

Dr. West suggested that the pentagon-copying task might be further explored using a graded system of MMSE scoring developed by Teng and Chui (1987), and she rescored this question for all subjects using that method. The graded method as it applies to the pentagon item, unlike conventional MMSE scoring which assigns 1 point only if all sides and angles are preserved and the intersecting sides form a quadrangle, assigns a score of 4 for each five-sided enclosure drawn (unless the longest side is more than twice the length of the shortest side, in which case a score of 3 is assigned). An enclosed figure which is not a pentagon is given a score of 2, and a figure consisting of two or more line segments which do not form an enclosure is given a score of 1. A four-cornered intersection of two enclosures is given a score of 2 and an intersection with less than four corners a score of 1. Thus subjects who would fail the pentagon question using conventional scoring procedures are enabled by use of this method to receive considerable partial credit for partial performance of the task. A perfect score is 10.

Not administered to subjects at the time of the other tests, but previously administered to most of them in connection with another study conducted by BCRA, was the Short Portable Mental Status Questionnaire (SPMSQ). This 10-item test was attributed to Goldfarb (1974) by Mattis (1976), who stated that it effectively differentiates patients with diffuse deteriorative disease and possibly acute brain syndrome from normal elders. In his experience, Mattis wrote, its most discriminating items assess the individual's orientation to time and place and recollection of recent events. In fact most of the test questions are orientation items. (Braekhus et al. found a 12-item test derived from the MMSE to perform predictively as well as the complete test. This shortened version, described in their paper, is different from the SPMSQ and includes several non-orientation questions, including copying a design, presumably the intersecting pentagons of the MMSE.) As administered for BCRA's study, one SPMSQ question, "Where are we now?" was omitted because subjects had been tested in their homes, so a 9-item test resulted. As in the case of the MMSE an individual's score depends upon his or her level of education, but Mattis noted that in general 0 to 2 errors indicate no or only mild cognitive impairment; 3 to 8 errors imply moderately advanced impairment, and 9 or 10 errors marked brain dysfunction. While SPMSQ scores were not used as a predictor in the present study, subjects' performance on the test and the relationship found between SPMSQ and MMSE scores in this sample will be described below.

*WayPoint*. This test was developed by Dr. Michael Cantor (WayPoint Research, Inc.) and copyrighted by him in 1995. It is a modification of Trails B (see the description of the Trail Making test in Part 3 of Janke, 1994). WayPoint presents six exercises in pamphlet form, the first four of which contain 8 numbers and 7 letters to be connected in alternating number-letter order by means of a continuous pencil line, and the last two of which contain 5 numbers and 4 letters to be connected in a similar manner. In some exercises, distracters in the form of small irrelevant pictures are also printed on the pages. Following Cantor's standardized instructions, subjects were directed to "keep going" if they made an error. Performance on each exercise was timed with a stopwatch by one of the volunteer test administrators.

WayPoint was administered twice, one test immediately following the other. The purpose in repeating the test was to see whether drivers with presumed cognitive impairment either failed to improve from the first test administration to the second, or did not improve as much as did cognitively unimpaired subjects.

The test was developed originally to screen applicants for professional driving of trucks, cars and buses, so that those who were collision-prone could be identified and rejected before hiring. The scoring system, which is proprietary, calculates channel capacity or information-processing rate, defined operationally as the average speed per exercise taken (on the first administration of WayPoint) over two exercises thought to be especially indicative, and high vs. low risk of preventable and (separately) nonpreventable collisions, thought to reflect the driver's situational awareness. Since channel capacity (and recoded channel capacity) are speed rather than time measures, a higher score on these indicates better performance. Higher risk, on the other hand, indicates worse performance. Dr. Cantor scored all of the test booklets and made available to us his scores for channel capacity, recoded channel capacity, and risk of each type of crash.

Prior to obtaining Cantor's proprietary scoring of the tests, measures of average time over the six WayPoint exercises were computed by the first author, as well as the subject's number of "error trials," defined as the number of exercises out of the six, for each test administration, on which one or more errors occurred. Because every subject received the same number of trials in the same sequence, the average time measure calculated over the longer and the shorter exercises combined was used for this purpose, although separate time scores for the longer and shorter exercises were also explored.

In three cases, because of a subject and/or tester error, a single page in one of the test booklets was left blank. If the blank page contained one of the longer exercises, the average of the subject's time scores for the three other long exercises in that booklet was assigned to it. If the blank page contained one of the shorter exercises, it was assigned a time score equal to that the subject obtained on the other short exercise in that booklet. Also for study purposes, the preventable and nonpreventable crash risk scores received from Cantor were assigned numeric values of 0 (low) or 1 (high); these were summed to form a single variable called **risk** that ranged from 0 for drivers whose WayPoint performance did not indicate high risk of either type of crash to 2 for drivers whose WayPoint performance indicated high risk of both types.

This study was the first application of the WayPoint test to an elderly driver sample, and the first attempting to relate test scores to road test errors rather than crashes. It is true that several authors have fruitfully used Trails B for this sort of research, but these other studies lacked the complex and innovative scoring system developed by Cantor.

*Perceptual response time (PRT).* This test, from Visual Resources Inc., is the first module of their Useful Field of View or UFOV test (Owsley, Ball, Sloane, Roenker, & Bruni, 1991) actualized on an IBM PC. (The Visual Attention Analyzer actualization of the UFOV test and research using it are described in Part 3 of Janke, 1994.) Part 1 of the UFOV deals with processing speed for stimuli in the fovea rather than visual field; it requires the subject to identify a silhouette rapidly flashed in the central part of the field as representing either a car or a truck. The speed of the subject's motor response is irrelevant; what is timed (by the computer) is the duration of the stimulus, which could range here from 16 to 500 ms. The briefest stimulus duration at which a subject can make the identification correctly 75% of the time is his or her score. Since the PRT test uses an adaptive testing method the number of stimulus presentations is not fixed, but the time to administer it averages about 5 minutes.

This test might ordinarily be administered using a touchscreen, but since we did not have one available a different version was requested of Visual Resources. After either a car or truck was flashed on the computer monitor and any afterimage had been obscured by a random pattern, both the car and truck appeared on the screen and subjects were asked to touch whichever one they had just seen. When they did this the test administrator keyed either a C or a T on the computer, as appropriate. For scoring purposes it was critical not to make a keying error, so this method was considered better than allowing the subjects themselves to key their responses.

*Doron Cue Recognition.* This test had been used at the San Jose site as well; it was the only nondriving test used at both sites, and was chosen because of its demonstrated promise in San Jose. The test, which has three Cue Recognition modules differing in critical stimulus and in required response, is described in Part 2. In this study, at our request, it was scored in terms of time rather than in terms of feet traveled at 55 mph; the two measures are equivalent, however. It is worth repeating here that what was measured in all three Cue Recognition exercises at both sites was recognition time—time to release the accelerator at the appearance of the critical stimulus—rather than reaction time. However a value for recognition time only appeared on the printout of response times if, in addition, the correct steering or braking response had followed accelerator release. Otherwise, a "no response" indicator was printed.

It had originally been planned to administer another Doron test as well, a realistic (though not interactive) simulated trip designed to assess drivers' perception of, and response to, emerging hazards. To facilitate this, several changes to the scoring system were requested of and made by Doron, in addition to the change from distance to time scores. Some information items added to the response printout were time to both the initial response, regardless of correctness, and the first correct response; the form of the initial response, and the strength of activation of steering wheel, accelerator, or brake. As it happened, the hazard perception/crash avoidance test was never used in the study because it was judged by Buck Center staff and volunteer test administrators to be too stressful for elderly people, some of whom might be in frail health. But the changes to the scoring system made to support that test altered the automated scoring of Cue Recognition as well and apparently degraded its performance. In the case of about 25 subjects, at least some time scores registered as zero milliseconds, and in addition numerous trials occurred in which subjects were observed to be apparently performing as expected but their responses did not register properly. This situation may have been exacerbated by use of a relatively large number of test administrators whose training perhaps had not been thorough enough to enable them to detect the nonregistration of subjects' responses.

Toward the end of the study, after some adjustments had been made to the equipment, four subjects with unusable data for a particular Cue Recognition module agreed to take a retest, and their scores on that module were replaced by the new scores. (In the case of one subject all modules were replaced, because only zeroes had printed out for the entire series of tests.) It should be emphasized that this procedure was used only in cases where a module furnished no useful data. In general, when assigning values to time scores suggesting a subject error or equipment failure, the following procedures were used:

1. If the printout did not give a time score because the accelerator was not down, the steering wheel was not straight, or the subject did not respond, a time of a little over 5 seconds (5.008 sec) was assigned, since subjects had a maximum of 5 seconds to respond. An analogous procedure had been used at San Jose, although there the score was in terms of distance rather than time. (The value 5.008 was calculated to be equivalent to the distance score used at San Jose for error trials.)

2. If the printout read zero ms and other information printed out for that trial indicated that no response, or the wrong response, had been given, a 5.008 sec time was again assigned.

3. If the printout read zero ms but other information printed out for that trial indicated that the correct response had been given, the subject's average value for the other trials of that exercise replaced the zero score. This had the effect of ignoring the zero score in finding average time.

*Traffic sign test.* This test was entirely different from the traffic sign test used in San Jose and described in Part 2. It was received from Richard Marottoli, M.D., of Yale University. The paper-and-pencil test, used by him in research, consists of 12 factually oriented questions requiring subjects to check an alternative corresponding to the meaning of each pictured sign, and one judgmentally oriented question in which subjects, shown an intersection with a "no left turn" sign and two "do not enter" signs on the straight-ahead path, were asked to check the alternative corresponding to what they should do (turn right). This was the last question on the test; it pictured a setup used in real life on a closed driving course devised by Jaime Fitten, M.D. (Fitten, Perryman, Wilkinson, Little, Burns, Pachana, Mervis, Malmgren, Siembieda, & Ganzell, 1995), whose research toward predicting the driving performance of elderly people with cognitive or other impairments is described under "tests for drivers with dementia" in Janke (1994).

In the case of one subject a page of the test (not the page containing the intersection question) was omitted, so the rounded average number of errors for the other pages was ascribed to that page. In another case the subject checked every response alternative on the intersection question based on Fitten's work; this was considered an error.

*Driving Information Survey.* Minus the DMV logo, this was the same survey used at the Santa Teresa office site in San Jose. It appears in Appendix B, and has been discussed in Part 2. Much of the survey dealt with driving exposure, but nine of the questions (#10 through #18) specified common driving situations and asked subjects whether and to what degree they avoided these. With the alternative answers (never, sometimes, often, and always) given numerical values 1-4 as shown in the Appendix, values associated with each subject's answers to the nine avoidance questions were summed to give a general measure of his or her overall strength of avoidance. Avoidance of specific driving situations by an elderly person has often been called "compensation," the implication being that drivers compensate (not necessarily consciously) for aging-related deficits in visual and other abilities by avoiding situations that challenge those abilities.

*Driving test*

*Modified Driving Performance Evaluation (MDPE).* The MDPE was the only road test given to Novato subjects. It was administered by a professional driving school owner/instructor not affiliated with DMV, but trained in MDPE scoring by staff of DMV's Training Branch. To facilitate scheduling, subjects took this test either prior to or following the nondriving test battery. Its scoring criteria and score sheet were the same as the MDPE criteria and score sheet appearing in Appendix A, although for BCRA use the score sheet lacked the DMV logo and other departmental identifiers. While this was thus the same type of test used at the San Jose site, the route, centering around BCRA, necessarily differed. However, it had been laid out by the DMV staff member primarily responsible for the MDPE route layout in San Jose and contained similar features.

For the reader's convenience, definitions of three particular types of errors will be repeated here; the MDPE has been described in general in Part 2. It may be recalled that the MDPE included a destination-finding task in which the subject was directed to drive a relatively short distance past the test's starting point and then find his or her way back without direction. If the subject, who had been advised to keep track of where (s)he was going because (s)he would be asked to find the way back, nevertheless seemed to have no idea how to do this or made directional errors without being aware of it, a so-called "concentration error" was scored.

As at San Jose, the study criterion measure used at Novato was total weighted errors on the MDPE, or MSCORE, defined as the sum of total unweighted errors (which the examiner recorded on the score sheet) plus two times the sum of critical and hazardous errors. Possible critical errors, marked by the examiner if they occurred, are printed in the lower lefthand corner of the score sheet and two of these—examiner intervention (e.g., grabbing the wheel to avert a crash) and "dangerous maneuver"—had previously been selected as being "hazardous" errors. When hazardous errors occurred the test was generally terminated; in such a case an unweighted error score of 40 was assigned. The same score was assigned if the test was terminated because of extreme general incompetence of the driver, even if a specific hazardous error had not occurred.

In Novato as in San Jose, fixed numbers of certain types of required maneuvers were included and scored on the test. But it was nevertheless anticipated that this test might be less demanding than the MDPE given in San Jose for two reasons—first, the test was not administered by a DMV driving examiner, which could have made it less stressful than it was—even for volunteers—at the San Jose site. Second, Novato has a relatively rural driving environment; generally the traffic there is light, and it was anticipated that the challenges posed to the driver might not be as great as they were in even the outskirts of San Jose.

## RESULTS

Of the 101 subjects tested at BCRA, 62 were male. Subjects' ages ranged from 72 through 90, with an average age of 78.3. They were a relatively highly educated group; 55 had graduated from college with at least a four-year degree (perhaps having done post-graduate work and/or received a higher degree beyond that); an additional 27 had some college education short of a 4-year degree. Thus slightly over 81% of the sample had attended college. Of the remaining subjects, 14 had graduated from high school but had never attended college, and 5 had less than 12 years of formal education.

Table 1 shows sample averages for nondriving, survey, and road test measures. The variable "frailty" in Table 1 requires clarification. It connotes some degree of physical frailty, inferred from four measures—failure of the tandem stand, failure of the walking exercise, or a history of either Parkinson's disease or stroke (no subject having both conditions). Each measure was binary, with 0 representing pass, not-Parkinson's, and not-stroke, and 1 representing the reverse. Thus scores could range from zero (passed both the tandem stand and the walk, with no Parkinson's disease nor stroke) to three.

It will be recalled that there had been an attempt to recruit cases of Parkinson's disease or stroke who had no known cognitive impairment. However there was a high refusal rate among potential subjects, and in the final sample only two subjects had Parkinson's disease, while only three had suffered a stroke, as mentioned above. Of the two with Parkinson's, one failed the tandem stand and the walking exercise, showing both balance and mobility problems; the other passed both. Of the three with stroke, two failed the tandem stand and one the walk as well; the third passed both tests. Nineteen subjects with neither Parkinson's disease nor stroke failed the tandem stand (the physical exercise this sample found most difficult), 11 the walking exercise, and 5 both tests.

Table 1

Average Scores in Novato Sample

| Measure | Average or % |
|---|---|
| MMSE number correct (maximum 30) | 28.98 |
| % missing the pentagon question | 11.88 |
| SPMSQ errors | 0.70 |
| % failing tandem stand | 26.73 |
| % failing walk | 17.82 |
| % with "frailty" (see text) | 39.60 |
| Time per exercise, 1st administration WayPoint (sec.) | 39.02 |
| Time per exercise, 2nd administration WayPoint (sec.) | 33.63 |
| Improvement, 1st to 2nd administration WayPoint (sec.) | 5.17 |
| Number of error trials, 1st administration WayPoint (max. 6) | 1.61 |
| Number of error trials, 2nd administration WayPoint (max. 6) | 1.55 |
| Channel capacity (range 1.24-6.41) | 3.40 |
| Recoded channel capacity (range 1-5) | 2.55 |

Table 1 (continued)

| Measure | Average or % |
| --- | --- |
| % at high risk, preventable crashes | 26.32 |
| % at high risk, nonpreventable crashes | 28.42 |
| Risk, preventable + non-preventable (range 0-2) | 0.55 |
| Perceptual response time (ms) | 29.80 |
| Sign test errors | 1.94 |
| % missing last question (intersection with several signs) | 19.80 |
| Cue Recognition 1, time per trial (secs.; equiv. to 146.90 ft.)* | 1.82 |
| Cue Recognition 2, time per trial (secs.; equiv. to 170.07 ft.)* | 2.11 |
| Cue Recognition 3, time per trial (secs.; equiv. to 192.28 ft.)* | 2.38 |
| Road test total unweighted errors (range 0-40) | 17.45 |
| Number of critical errors | 0.53 |
| Number of hazardous errors | 0.30 |
| Number of concentration errors (range 0-2) | 0.21 |
| Road test total weighted errors (range 0-56) | 18.89 |

*At assumed speed of 55 mph.

*Simple correlations between selected variables*

Table 2 shows Pearson product-moment correlations between pairs of variables including nondriving and road test scores, the survey measure overall avoidance, demographic variables, frailty, and an indicator variable representing a presumed cognitive problem. This cognitive indicator variable equals 1 for the following: 1) subjects who had attended (and perhaps graduated from) college whose MMSE scores were 25 or less, 2) subjects with no college education but who had graduated from high school and whose MMSE scores were 24 or less, and 3) subjects who had received less than 12 years of formal education (no college, had not graduated from high school) and whose MMSE scores were 23 or less. Otherwise the indicator equals zero. The dependence of MMSE score on educational level is well known, and has been discussed perhaps most thoroughly by Crum, Anthony, Bassett, and Folstein (1993). In this manifestly high-functioning sample, a cognitive indicator score of 1 was assigned to only three subjects.

Table 2

Correlations Between Demographic and Test or Survey Variables, Novato Sample (*N* = 101)

| VARIABLE | Age | Sex | Educ | Avoid-ance | Cogn. problem | MMSE Error areas | Fraility | WAYPT1 average time | WAYPT2 average time | WAYPT1 error trails | WAYPT2 error trails | Channel CAPAC. | Risk | Cue rec. 1 avg. time | Cue rec. 2 avg. time | Cue rec. 3 avg. time | Perceptual-RT | Traffic sign errors | MDPE concen. errors | MDPE WTED. errors |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | — | -.04 | .03 | .17 | -.07 | .11 | .35* | .26 | .24 | .04 | .20 | -.29* | -.06 | .42* | .38* | .41* | .16 | .17 | .29* | .27 |
| Sex (0 = F, 1 = M) | | — | -.07 | -.25 | .02 | .10 | -.08 | -.05 | .03 | -.03 | -.02 | .04 | -.10 | -.07 | .14 | .04 | .05 | -.14 | -.19 | .05 |
| Education (1 most, 4 least) | | | — | -.05 | .26 | .10 | .16 | .10 | .13 | .18 | .20 | -.03 | .11 | .07 | .02 | .06 | -.01 | -.03 | .17 | -.12 |
| Avoidance | | | | — | .04 | .11 | .02 | .17 | .15 | .19 | .16 | -.11 | -.12 | .18 | .06 | .20 | -.06 | .16 | .07 | .18 |
| Cognitive problem | | | | | — | .50* | -.04 | .17 | .20 | .34* | .35* | -.12 | -.01 | .13 | .29* | .27 | .19 | .08 | .41* | .35* |
| MMSE error areas | | | | | | — | .03 | .19 | .21 | .24 | .33* | -.15 | -.12 | .09 | .17 | .14 | .18 | -.06 | .29* | .27 |
| Fraility | | | | | | | — | .21 | .28 | -.05 | .13 | -.20 | -.05 | .10 | .32* | .37* | .36* | .16 | .05 | .20 |
| WAYPT1 avg. time | | | | | | | | — | .88* | .41* | .58* | -.88* | -.25 | .12 | .17 | .28 | .13 | .20 | .28 | .37* |
| WAYPT2 avg. time | | | | | | | | | — | .39* | .64* | -.78* | -.24 | .13 | .18 | .34* | .25 | .16 | .20 | .31* |
| WAYPT1 errors | | | | | | | | | | — | .65* | -.26 | .13 | -.00 | .12 | .15 | .03 | .20 | .22 | .19 |
| WAYPT2 errors | | | | | | | | | | | — | -.40* | -.17 | .17 | .22 | .37* | .21 | .11 | .30* | .24 |
| Channel capacity | | | | | | | | | | | | — | .27 | -.08 | -.11 | -.23 | -.19 | -.21 | -.18 | -.35* |
| Risk | | | | | | | | | | | | | — | -.06 | .06 | -.06 | -.11 | -.10 | -.13 | -.19 |
| Cue rec.1 avg. time | | | | | | | | | | | | | | — | .27 | .54* | .09 | -.03 | .28 | -.00 |
| Cue rec.2 avg. time | | | | | | | | | | | | | | | — | .56* | .35* | .22 | .24 | .20 |
| Cue rec.3 avg. time | | | | | | | | | | | | | | | | — | .31* | .18 | .21 | .22 |
| Perceptual RT | | | | | | | | | | | | | | | | | — | .03 | .08 | .27 |
| Traffic sign errors | | | | | | | | | | | | | | | | | | — | .17 | .07 |
| MDPE concentration errors | | | | | | | | | | | | | | | | | | | — | .19 |
| MDPE weighted errors (MSCORE) | | | | | | | | | | | | | | | | | | | | — |

*Nominal probability .004 or less; significant at .05 level using Bonferroni-type correction.

Several of these measures were closely related or even essentially equivalent due to the testing or scoring methods used. Some of those shown in Table 2 are time on the first vs. the second administrations of WayPoint, and average time per exercise on the first administration of WayPoint—based on all exercises—vs. its near-reciprocal channel capacity, an average speed measure based on two of them. Therefore the number of independent comparisons (of a correlation coefficient with zero) was estimated to be approximately 13. Using a Bonferroni-type correction, correlations showing a nominal probability level of .004 or less—that is, those equaling .29 or more—were considered to reach an experimentwise probability level of .05. Such correlations are asterisked and will be referred to as significant. Correlations of .27 or .28 will be referred to as marginally significant, and those of .20 or more may be considered as approaching significance.

MSCORE, weighted errors on the road test, was most strongly correlated ($r$ = .37) with average time per exercise on the first administration of WayPoint (called "WAYPT1 AVG. TIME" in the table). Not far behind were its correlations (.35) with channel capacity and the cognitive problem indicator defined above. MSCORE was also significantly correlated (.31) with average time per exercise on the second administration of WayPoint and marginally significantly correlated (.27) with age, MMSE error areas, and PRT, perceptual response time. Lower correlations that nevertheless approached significance were with frailty, errors on the second administration of WayPoint, and time scores for Cue Recognition 2 and Cue Recognition 3.

Road test concentration errors were significantly correlated with age, the cognitive problem indicator, MMSE error areas, and the number of exercises on which at least one error occurred on the second administration of WayPoint. The measure was marginally significantly correlated (.28) both with average time per WayPoint exercise on its first administration and with Cue Recognition 1 time. Lower correlations approaching significance were with average time per exercise on the second administration of WayPoint (.20), the number of exercises on which an error occurred during the first administration of WayPoint (.22), and the time scores for Cue Recognition 2 and Cue Recognition 3 (.24 and .21, respectively). Despite its significant correlations with both MSCORE and concentration errors, the cognitive problem indicator was not useful for purposes of analyzing these data, since (as mentioned above) only three subjects in the Novato sample showed definite evidence of cognitive impairment. But (in addition to age) other measures were marginally or significantly related to both road test measures, and were of more general applicability in this sample. These were MMSE error areas and WayPoint1 average time. In addition, WayPoint2 error-exercises almost reached this level, being significantly correlated with concentration errors and approaching significance (.24) in its relationship with MSCORE. It has been noted that Cue Recognition 2 and Cue Recognition 3 approached significance in their relationships with both road test measures, correlation coefficients ranging from .20 to .24.

Although Cue Recognition 1 was completely uncorrelated with MSCORE, its significant relationship with age (.41) and marginally significant relationship with concentration errors (.28) indicate that scores on this module were not random, despite its apparent malfunctioning at Buck Center. More will be said about this in the Discussion section.

*Factor analysis: Measurement dimensions*

As with the San Jose data, an exploratory factor analysis was conducted to identify any underlying measurement dimensions and describe patterns of test interrelationships more concisely. As before, listwise deletion with oblique rotation was used. Factor interpretation was made on the basis of the structure matrix, which as noted contains correlations between factors and variables which are somewhat inflated under oblique rotation (Tabachnik & Fidell, 1983). Here, as in San Jose, the correlations between factors were small, so the inflation is judged probably to be slight.

Table 3 shows eigenvalues and variance percentages for the 15 factors identified. The first seven accounted for 50.1% of the variance, and are described here. Communalities of the variables are not shown, but the majority ranged between .7 and .8, with a low value of .588 for educational level and a high value of .946 for MMSE score.

Table 3

Novato Sample: Factor Eigenvalues and Percentages of Variance

| Factor | Eigenvalue | Percentage of variance | Cumulative percentage |
|---|---|---|---|
| 1 | 5.25492 | 13.1 | 13.1 |
| 2 | 3.85897 | 9.6 | 22.8 |
| 3 | 2.84410 | 7.1 | 29.9 |
| 4 | 2.44089 | 6.1 | 36.0 |
| 5 | 2.11573 | 5.3 | 41.3 |
| 6 | 1.90136 | 4.8 | 46.0 |
| 7 | 1.63174 | 4.1 | 50.1 |
| 8 | 1.53457 | 3.8 | 54.0 |
| 9 | 1.48458 | 3.7 | 57.7 |
| 10 | 1.43143 | 3.6 | 61.2 |
| 11 | 1.29001 | 3.2 | 64.5 |
| 12 | 1.18093 | 3.0 | 67.4 |
| 13 | 1.12308 | 2.8 | 70.2 |
| 14 | 1.09015 | 2.7 | 73.0 |
| 15 | 1.06968 | 2.7 | 75.6 |

Table 4 shows percentages of variance accounted for by each of the first eight factors, and variable loadings whose absolute value equals .30 or more. Variables which did not load this strongly on any of the first eight factors do not appear in the table. As indicated, only the first seven are interpreted; the eighth, with its highest loading on the variable *wearing corrective lenses while driving*, added little to the variance accounted for.

Table 4

Novato Sample Factor Analysis: Structure Matrix
of Variable Loadings on First Eight Factors

| Variable | Variance percentage | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 13.1% | 9.6% | 7.1% | 6.1% | 5.3% | 4.8% | 4.1% | 3.8% |
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 | Factor 8 |
| Avoid freeway | .79 | | | | | -.33 | | |
| Avoid left turns | .77 | | | | | | | |
| Avoid heavy traffic | .71 | | | | | | | |
| Avoid unfamiliarity | .61 | | .30 | | | | | |
| Avoid parallel parking | .56 | | | | | | | |
| Cue Recognition 2 time | | -.83 | | | | | | |
| Cue Recognition 3 time | | -.76 | | | | | | |
| Frailty | | -.74 | | | | | | |
| Age | | -.68 | | | | | | |
| Avoid night | .36` | -.47 | | | | | | |
| MMSE score | | | -.94 | | | | | |
| MMSE error areas | | | .92 | | | | | |
| Pentagons (Graded) | | | | .85 | | | | |
| Pentagons (Binary) | | | .38 | -.64 | | -.39 | | |
| PRT | | -.39 | | -.49 | | | | -.44 |
| Education | | | | .33 | | | | .32 |
| Miles/wk driving | | | | | .80 | | | |
| Hrs/wk driving | | | | | .77 | | | |
| Days/wk driving | | | | | .68 | | | |
| Sign test errors | | -.30 | | | -.39 | -.36 | -.38 | |
| Change in WayPoint | | | | | | -.79 | | |
| Guide signs OK | | | | | | | .76 | |
| Concentration errors | | | | | | -.39 | -.53 | |
| Wear corrective lenses | | | | | | | | .75 |
| MSCORE | | -.39 | | | | | | -.51 |
| WayPt. 1 error-exercises | | | .31 | | | | | |
| SKILL - dark | | .36 | | | | | | |
| Last question, signs test | | | | | | -.42 | | |
| WayPoint 1 average time | | | | | | -.53 | | |
| Cognitive problem | | | .40 | | | | | |
| SPMSQ score | | | | | | -.35 | | |
| Avoid sunrise/sunset | .32 | | | | | | | |
| Avoid rain/fog | .39 | | | | | | | |

Factor 1 may be considered an avoidance factor. The variable loading most strongly on it (.79) is avoidance of freeway driving, closely followed by avoidance of making left turns across traffic. No variables other than avoidance measures loaded on it, and the only avoidance question which did not load on it was avoidance of driving alone (which leaded on none of the factors).

Factor 2 is most closely associated (.83) with good performance (reduced time) on the Cue Recognition 2 test. Other test measures correlating (negatively, in the 'good' direction) with Factor 2 are Cue Recognition 3 time, perceptual reaction time, traffic sign errors, and most interestingly (though relatively weakly) MSCORE, weighted errors on the road test. Performance on the Smith-Kettlewell Low Luminance/Low Contrast test (SKILL-LC), developed by the Smith-Kettlewell Eye Research Institute in San Francisco and previously administered to these subjects as part of another study, also loaded on this factor, its positive direction indicating that better past performance on the dark SKILL card was associated with faster response times or fewer errors on tests used in the present study. Additional variables loading on Factor 2 are (lack of) frailty, (younger) age, and (lack of) avoidance of night driving. The factor may be considered as representing good perceptual and psychomotor functioning, faster information processing, driving knowledge as shown on the traffic signs test, and driving competence.

Factor 3, defined by lower MMSE score and more MMSE domains in which an error occurred, can be considered a cognitive impairment dimension. No other variable approached the strength of the relationship that the MMSE had with this factor, but relatively weak loadings were shown for (greater) avoidance of unfamiliar routes, total number of WayPoint1 exercises on which an error occurred, the cognitive problem indicator, and poor performance on the MMSE pentagon task when scored in a binary manner (0 = correct and 1 = incorrect). Factor 3 correlates -.16 with Factor 2, which has been hypothesized to represent good functional abilities and competent driving.

It should be mentioned once more that the binary scoring of the pentagon task used here is different from that conventionally used. Because on most of the tests in this study higher scores indicated poorer performance, scores for the binary pentagon measure, which was considered separately as well as by means of its contribution to MMSE score, were directionally reversed, with 0 indicating correct performance. (Of course the scoring of the pentagon task was conventional when considered as a part of total MMSE score.) The simple correlation between the separate binary pentagon measure and the Teng and Chui [1987] graded pentagon score was -.48.

Only four variables loaded on Factor 4. The factor is most highly (positively) correlated (.85) with the MMSE pentagon-copying task, as rescored using the 10-point scale described by Teng and Chui (1987). A higher score here indicates better performance. As might be expected, Factor 4 correlates -.64 with the pentagon task using the binary scoring method described immediately above, also indicating that the factor is positively associated with better performance. Factor 4 is negatively correlated with perceptual response time (PRT) and thus positively correlated with speed of perceptual response; it is also (and puzzlingly) positively correlated with educational level, which—since it was measured on a scale ranging from 1 (college graduation) to 4 (less than high school completion)—indicates that the factor is associated with less rather than more education. The factor may be characterized as representing accurate and rapid perceptual abilities, in particular visuospatial ones. Its covariation with (less) formal education suggests that it may characterize persons who perceive and react quickly in traffic situations, rather than more deliberately analyzing or judging them. This behavior should usually (not always) be adaptive in an emergency situation, for example.

Factor 5 is defined by greater exposure in terms of miles, hours, and days per week of driving; it is less strongly associated with making fewer errors on the traffic signs test. It seems relatively clear that the factor characterizes active drivers with knowledge of traffic signs which they were able to demonstrate on a verbal/pictorial multiple-choice test. The factor correlates -.11 with Factor 1, which has been called avoidance.

Factor 6 is associated most strongly (-.79) with change in WayPoint average time score from the first to the second administration. The direction of the relationship is such that the factor is positively associated with a smaller time differential. It is also associated moderately (-.53) with lower time scores (greater speed) on the first administration of WayPoint, suggesting that room for improvement was limited for subjects scoring high on this factor, because their performance was good from the outset. Other loadings, though relatively small (< .50), are consistent with a picture of good functional abilities—notably cognitive ones. The variables involved, and their directions, include making fewer concentration errors on the road test, fewer errors on the SPMSQ, and correctly answering the last question on the traffic signs test, representing the intersection setup used by Fitten et al. (1995). (In their study, demented subjects faced with this situation in a real-world driving test had particular difficulty with it; perhaps one may almost consider difficulty with this task to be an indicator of dementia.) Other measures loading on the factor include correct performance on the intersecting-pentagons task of the MMSE (binary scoring), and lack of avoidance of freeway driving.

Factor 7 is most closely defined by responses to the survey question as to whether guide signs give enough information to help the driver reach a destination on unfamiliar routes. The loading was substantial and positive (.76), the direction of the relationship indicating that guide signs are more often helpful than not. There was a moderate negative loading (-.53) for the variable concentration errors and a weaker loading (-.38) for traffic sign test errors, the direction of both indicating fewer errors. The factor, relating to a form of functional competency, may represent perceptual adequacy (to read the signs) and what is sometimes called a "good sense of direction." Its correlations with the other factors are low.

*Time change from first to second WayPoint administration*

It has been seen that this measure was rather highly correlated with Factor 6. Average time and error measures both tended to be less from the first to the second administration of WayPoint. The mean differences amounted to 5.2 seconds per exercise on the time measure but only six hundredths of an error trial on the error measure. The difference in errors was not significant ($t = 0.46$, $p = .650$), but that in average time was ($t = 9.49$, $p = .000$).

In its association with Factor 6, the most likely interpretation seemed to be (because of the direction of the loading for time over the first administration) that lack of "improvement" from the first to the second administrations of WayPoint represented such expeditious performance on the first that it could not be improved greatly. On the other hand, as mentioned above, it can also be and in fact had been hypothesized that cognitively impaired subjects might fail to show improvement on the second administration of the test for an entirely different reason—less facility in "learning to learn." With only three subjects showing a degree of presumed cognitive impairment this could not be verified, though when the average change scores for the three subjects identified as being to some degree cognitively impaired were inspected, results for two of them were consistent with the above hypothesis. These subjects had MMSE scores lower than those of any other members of the sample. One, showing the lowest MMSE score in the sample (18) and a WayPoint1 average time 0.77 standard deviation units above the mean, showed improvement (lessened time) of only .21 seconds on the second test administration. (Average improvement was, as noted above, a little over 5 seconds.) Another subject, with MMSE score 24 and WayPoint1 average time 0.58 standard deviation units above the mean, slowed by 4.9 seconds from the first to the second administration of WayPoint. The third subject had MMSE score 25 and WayPoint1 average time 1.56 standard deviation units above the mean. There was much room for improvement and in fact this subject showed very marked improvement, reducing average time per exercise by 16.4 seconds. Only five subjects improved more than this individual did.

*Driving Information Survey results*

As noted above, the driving information survey form filled out by Novato subjects (Appendix B) was the same as that used in San Jose, except that all questions were placed on one sheet of paper and any information identifying DMV, such as the departmental logo, was removed. The following briefly summarizes respondents' answers to the quantitative and qualitative exposure questions on the survey.

In the sample of 101 individuals, one reported not usually driving. The average number of driving days per week for the remainder of the sample was 5.6. Respondents' average reported weekly mileage was 46, and their mean number of hours spent driving in a normal week was 4.2. In fact their reported exposure was quite similar to that of the San Jose sample, and almost identical to that of the San Jose volunteer sample—who, it will be recalled, were 10 years younger on the average but on the other hand predominantly women, who tend to drive less than men. Asked whether they had been a licensed driver (in any state) for more than 5 years, 93% of respondents reported that they had been.

Table 5 shows the distribution of the type of driving most frequently done (that is, the most common reason for driving) and the most commonly used roadway type for the Novato sample, compared to responses of referrals and volunteers in the San Jose sample (right-hand columns of the table). Answers to these questions reflect the respondent's most common type, rather than amount, of exposure.

Table 5

Novato vs. San Jose: Most Frequent Type of Exposure (%)

| | Novato Sample $N = 101$ | San Jose Referrals $N = 102$ | San Jose Volunteers $N = 33$ |
|---|---|---|---|
| Reason for driving | $n = 97$ | $n = 99$ | $n = 32$ |
| to/from work | 2.1 | 13.1 | 9.4 |
| recreation | 13.4 | 5.1 | 3.1 |
| on job | 3.1 | 3.0 | 0.0 |
| errands | 76.3 | 75.8 | 81.3 |
| out-of-town trips | 2.1 | 1.0 | 3.1 |
| none apply | 3.1 | 2.0 | 3.1 |
| Roadway type | $n = 96$ | $n = 98$ | $n = 32$ |
| residential streets | 45.8 | 64.3 | 43.8 |
| nonresidential city | 14.6 | 20.4 | 31.3 |
| freeways | 30.2 | 11.2 | 25.0 |
| county roads | 7.3 | 3.1 | 0.0 |
| none apply | 2.1 | 1.0 | 0.0 |

The Novato sample seems to show a different pattern of driving, in several respects, from that shown by either the San Jose referrals or volunteers, although their responses generally align more closely with those of the volunteers. This might be expected, because in fact they did choose to participate in the present study. They did not report driving to and from work as much as either group in San Jose did, which is probably attributable to their greater average age—78.3. Correspondingly more of their driving was reported to be recreational. But like the San Jose sample, the most frequent type of driving reported by Novato respondents, by far, involved running errands—shopping, keeping appointments (given as examples on the survey form), and the like. It does appear that there is some ambiguity in the question. If a Novato resident drives to San Francisco to go shopping, is that an errand or a trip out of town? The latter interpretation was not our intent, and apparently most of the sample did not interpret the question in that way. But for future work the question would probably need clarification

With respect to roadway type, Novato respondents reported less frequent driving on "nonresidential city streets" and more freeway driving. Novato is a semi-rural area proximate to San Francisco and other urban centers which are reached by driving on freeways. This may account in part for the greater percentage of Novato drivers reporting freeways, and the smaller percentage reporting non-residential city streets, as the type of roadway most commonly used. (If an individual travels to San Francisco, he or she need not necessarily drive on "nonresidential city streets" there—it is possible to park at a Bay Area Rapid Transit station and continue into the city via BART.) Possible sources of ambiguity in this question have been discussed above.

Asked about smoking while driving, 94.1% of the Novato sample reportedly never did; 3% smoked "sometimes," and an additional 3% smoked "often." In this and the following questions, the subject's interpretation of what these terms meant quantitatively was of course critical. Thus there a greater percentage of "often" smoking while driving for the Novato sample than for the San Jose one, but whether the smoking/driving behavior actually differed between the groups is questionable. It is also the case that the San Jose respondents were asked this question by a governmental agency, which may have influenced their answers to some questions.

Degree of avoidance of different kinds of driving situations is perhaps the most interesting information coming out of the survey. Table 6 shows these data for Novato respondents compared with those for San Jose respondents, which are shown in the right-hand columns of the table.

Again, Novato drivers gave answers more similar to those of the volunteers in San Jose than to those of the referrals, who were closer in average age but as a group had a much greater prevalence of impairment. Respondents in Novato, however, did more commonly avoid night driving and heavy traffic "often" or "always" than did the San Jose volunteers; this is consistent with their considerably greater average age. The mean overall-avoidance value for Novato subjects (calculated by summing the values 1 [never] through 4 [always] of answers to each of the nine avoidance questions) was 14.34; this is almost identical to the San Jose volunteer mean of 14.03, and less than the mean for referrals, 18.99.

Table 6

Novato vs. San Jose: Degree of Avoidance (%)

| | Novato sample $N = 101$ | San Jose referrals $N = 102$ | San Jose volunteers $N = 33$ |
|---|---|---|---|
| Avoid: | | | |
| night driving? | *n = 101* | *n = 101* | *n = 33* |
| never | 32.7 | 26.7 | 42.4 |
| sometimes | 38.6 | 22.8 | 48.5 |
| often | 21.8 | 23.8 | 9.1 |
| always | 6.9 | 26.7 | 0.0 |
| rain or fog? | *n = 101* | *n = 99* | *n = 33* |
| never | 33.7 | 22.2 | 27.3 |
| sometimes | 53.5 | 45.5 | 66.7 |
| often | 12.9 | 24.2 | 6.1 |
| always | 0.0 | 8.1 | 0.0 |
| sunrise/set? | *n = 101* | *n = 100* | *n = 33* |
| never | 57.4 | 39.0 | 63.6 |
| sometimes | 37.6 | 29.0 | 30.3 |
| often | 4.0 | 19.0 | 6.1 |
| always | 1.0 | 13.0 | 0.0 |
| driving alone? | *n = 101* | *n = 102* | *n = 33* |
| never | 77.2 | 60.8 | 78.8 |
| sometimes | 16.8 | 27.5 | 18.2 |
| often | 5.9 | 8.8 | 3.0 |
| always | 0.0 | 2.9 | 0.0 |
| left turns? | *n = 100* | *n = 100* | *n = 33* |
| never | 56.0 | 40.0 | 42.4 |
| sometimes | 35.0 | 31.0 | 54.5 |
| often | 6.0 | 10.0 | 3.0 |
| always | 3.0 | 19.0 | 0.0 |
| heavy traffic? | *n = 101* | *n = 102* | *n = 33* |
| never | 46.5 | 29.4 | 39.4 |
| sometimes | 36.6 | 40.2 | 57.6 |
| often | 13.9 | 20.6 | 3.0 |
| always | 3.0 | 9.8 | 0.0 |
| freeways? | *n = 101* | *n = 101* | *n = 33* |
| never | 68.3 | 39.6 | 66.7 |
| sometimes | 25.7 | 29.7 | 30.3 |
| often | 5.0 | 13.9 | 0.0 |
| always | 1.0 | 16.8 | 3.0 |
| parallel parking? | *n = 101* | *n = 102* | *n = 33* |
| never | 61.4 | 43.1 | 66.7 |
| sometimes | 32.7 | 31.4 | 27.3 |
| often | 3.0 | 17.6 | 3.0 |
| always | 3.0 | 7.8 | 3.0 |
| unfamilar routes? | *n = 101* | *n = 90* | *n = 33* |
| never | 52.5 | 13.3 | 30.3 |
| sometimes | 37.6 | 50.0 | 60.6 |
| often | 8.9 | 22.2 | 3.0 |
| always | 1.0 | 14.4 | 6.1 |

*Distinguishing frail from nonfrail subjects: Logistic regressions*

The Novato sample was divided into groups of frail and nonfrail (by study criteria) subjects. None showed cognitive impairment; the three subjects with a cognitive impairment indicator of 1 were omitted from the analysis. “Frailty” here meant that the subject had failed the tandem stand, failed the walking exercise, had Parkinson’s disease, or had suffered a stroke. Most of those categorized as frail met only one of these criteria, and usually it was failure of the tandem stand. Such individuals, if otherwise unimpaired, would not generally be considered frail, although their balance was impaired to some extent. Nevertheless it was of interest to determine whether tests or survey items could differentiate the two groups. Forward-selection logistic regressions with an entry significance level of .10 were conducted separately for test measures and survey items. In both cases age and gender were included in the pool of variables for consideration but not forced into the model.

*Test measures*. This model used data from 50 nonfrail and 35 frail subjects, 85 in all. Four measures entered the model—Cue Recognition 2 and Cue Recognition 3 average times, WayPoint average time on the first test administration, and MSCORE. Neither age nor gender entered the model. Table 7 shows the standardized parameter estimates, chi-square and p values, and odds ratios for these four variables.

Table 7

Logistic Regression: Test Variables Discriminating Between Frail ($N = 35$) and Nonfrail ($N = 50$) Novato Drivers

| Variable | Stand. parameter est. | Chi-square | *p* | O.R. |
|---|---|---|---|---|
| WayPoint avg. time | 0.277 | 3.205 | .0734 | 1.098 |
| Cue Recog. 2 avg. time | 0.402 | 4.933 | .0263 | 2.048 |
| Cue Recog. 3 avg. time | 0.344 | 3.973 | .0462 | 2.012 |
| MSCORE | 0.414 | 5.479 | .0192 | 1.092 |

The odds ratios indicate that each additional second in average time per exercise to complete the WayPoint exercises increased the odds of being frail by 9.8%. Each additional second between appearance of the critical stimulus and a subject's accelerator release on Cue Recognition 2 increased the odds of being frail by 105%, and on Cue Recognition 3 by 101%. (Note that this is a different metric from the one used at San Jose for these test measures, and their odds ratios are correspondingly larger.) Each additional point in MSCORE increased these odds by 9.2%. It is notable, though not unexpected, that frailty is associated with poorer road test performance even after adjustment for performance on promising nondriving tests.

*Survey measures*. This model used data from 57 nonfrail and 37 frail subjects, a total of 94. After adjustment for age (gender, unlike age, did not enter), the only variables entering the model were degree of avoidance of night driving and reported frequency of smoking while driving. Both of these were measured on scales ranging from 1 (never) to 4 (always). Table 8 shows statistics for the variables entering the model.

Table 8

Logistic Regression: Survey Variables Discriminating
Between Frail (*N* = 37) and Nonfrail (*N* = 57) Novato Drivers

| Variable | Stand. parameter est. | Chi-square | *p* | O.R. |
|---|---|---|---|---|
| Age | 0.199 | 2.204 | .1376 | 1.088 |
| Avoid night driving | 0.261 | 3.513 | .0609 | 1.673 |
| Smoke while driving | -2.351 | 0.002 | .9600 | 0.000 |

Table 8 shows that each additional year of age increased the odds of frailty by 8.8%, and each additional point on the four-step scale of avoidance of night driving increased those odds by 67.3%. The aberrant result for smoking is an artifact of this particular sample, which happened to include no subject with any degree of frailty, as defined above, who ever smoked while driving. Of the nonfrail, only six reported smoking, three "sometimes" and three "often." Figure 1 shows, for the total sample, the distribution of subjects' ages and their responses to the night-driving avoidance and smoking questions, by frailty status.

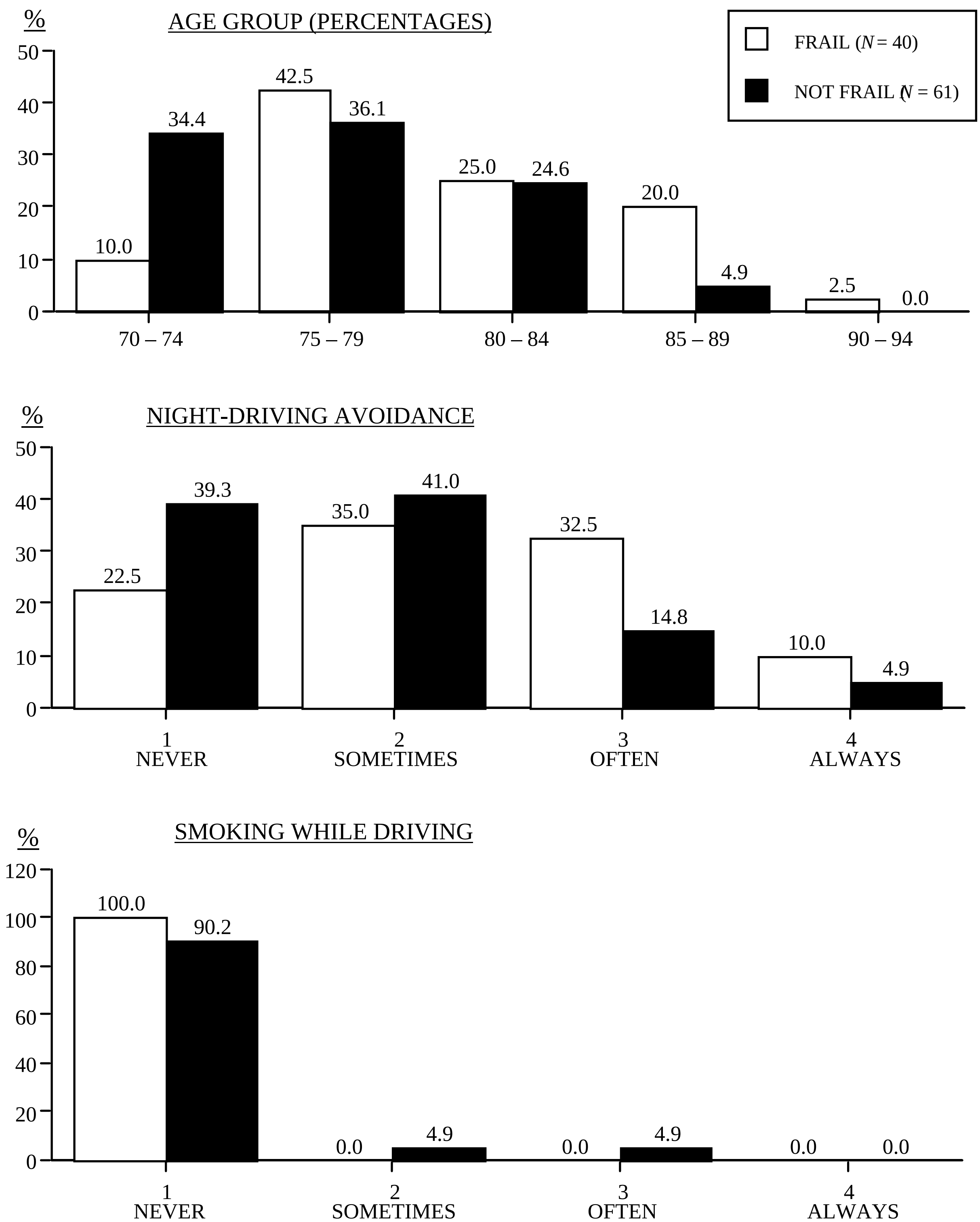


Figure 1 . Age groups, night-driving avoidance, and smoking while driving by frailty status.

In a second logistic regression on survey measures which omitted the smoking question, only age and avoidance of night driving entered. The odds ratios for these variables changed slightly; they were now 1.104 (each year of age increasing the odds of frailty by 10%) and 1.577 (each point on the night-driving avoidance scale increasing those odds by 58%).

*Multiple regression results*

The major goal of the study was to find measures which would predict subjects' road test performance—specifically, their weighted errors (the measure referred to here as MSCORE). Using forward regression and an entry significance level of .05 only two measures entered, yielding a multiple $R$ of .42 and adjusted $R^2$ of .16. These were WayPoint average time over all exercises on the first test administration (i.e., WayPoint 1) and perceptual response time (PRT); $N$ was 96. Relaxing the entry significance level to .07, the average number of cognitive domains represented on the MMSE in which subjects made at least one error (MMSE error areas) also entered, yielding a multiple $R$ of .46 and adjusted $R^2$ of .18. (The six domains are listed above in the description of the MMSE. For the entire sample, the average number of domains in which one or more errors occurred was 0.782.) There were again 96 subjects in this model, which is illustrated in Table 9. Neither age, gender, nor frailty entered the multiple regression model.

Table 9

Multiple Regression: Prediction of MSCORE Using
WayPoint 1 Average Time and MMSE Error Areas ($N$ = 96)

| Variable | $B$ | Beta | Part correl. squared | $t$ | $p$ |
|---|---|---|---|---|---|
| PRT | .0372 | .1979 | .03733 | 2.08 | .040 |
| WayPt1 avg. time | .2543 | .2991 | .08605 | 3.16 | .002 |
| MMSE error areas | 1.9184 | .1792 | .03032 | 1.88 | .063 |

Multiple $R$ = .45560; adjusted $R^2$ = .18173; $F$ = 8.03285; signif. ($F$) = .0001.

Within the sample of 96 subjects entering the model, it is interesting to note that the pentagon-copying task with binary scoring was uncorrelated with MSCORE ($r$ = .007); using the graded scoring recommended by Teng and Chui (1987) it was still not significant at -.092. Table 10 shows, for the entire sample, simple correlations of the binary and graded measures of pentagon-copying performance with five road test measures. Note that the binary scoring method used here (0 =

correct and 1 = incorrect) fails to show consistently positive correlations with these error measures, as it should if there were a true relationship of whatever magnitude. While correlations for the graded method are at least directionally consistent (negative correlations being expected in this case), they also offer little support for a relationship between the MMSE task and road test performance.

Table 10

Simple Correlations of MMSE Pentagon Task with Road Test Measures
(Binary Scoring versus Graded Scoring)

| | Unweighted errors | Hazardou s errors | Critical errors | Concentration errors | Weighted errors |
|---|---|---|---|---|---|
| Binary scoring | .1055 (*p* = .294) | -.112 (*p* = .267) | -.0295 (*p* = .771) | .2680 (*p* = .008) | .0007 (*p* = .994) |
| Graded scoring | -.0676 (*p* = .502) | -.1426 (*p* = .157) | -.2110 (*p* = .035) | -.0917 (*p* = .372) | -.1026 (*p* = .310) |

Channel capacity and WayPoint1 average time were highly correlated, as noted above. Therefore the former was substituted for the latter in multiple regression models to predict MSCORE which were otherwise the same as before. This reduced the number of subjects to 91. Using an entry probability level of .05, channel capacity and MMSE score, rather than MMSE error areas, entered, yielding a multiple $R$ of .41 and adjusted $R^2$ of .15. (The correlation between MMSE score and MMSE error areas in this sample of 91 subjects was -.87.) Use of an entry probability level of .07 allowed the further entry of PRT, with results as given in Table 11.

Table 11

Multiple Regression: Prediction of MSCORE
Using Channel Capacity and MMSE Score ($N$ = 91)

| Variable | *B* | Beta | Part correl. squared | *t* | *p* |
|---|---|---|---|---|---|
| PRT | .0368 | .1925 | .03553 | 1.97 | .052 |
| Channel capacity | -2.2140 | -.2594 | .06265 | -2.62 | .010 |
| MMSE score | -1.9002 | -.2223 | .04709 | -2.27 | .026 |

Multiple $R$ = .45358; adjusted $R^2$ = .17834; $F$ = 7.51153; signif. ($F$) = .0002.

The level of predictability is almost identical to that shown in Table 9, where the model used WayPoint average time over all exercises rather than channel capacity, and MMSE error areas rather than MMSE score. Adjusted $R^2$ remained .18. The relative importance of the measures changed to some extent; the unique contribution of the WayPoint test is slightly less in Table 10 and that of the MMSE measure greater, possibly attributable to the somewhat different mix of subjects entering each of the models.

## DISCUSSION

The tests given at Novato enabled a statistically significant and nontrivial degree of prediction of MSCORE. This finding was especially welcome because despite the effort to recruit individuals with Parkinson's disease, stroke, or dementia the subjects eventually obtained composed a rather homogeneous group, well educated, high-functioning in terms of cognitive performance, and generally healthy. They were two years older, on the average, than referrals in San Jose, but performed much better (with an average weighted error score 11 points lower) on a roughly equivalent road test. They were a decade older than the San Jose volunteers, and yet their average weighted error score was only about 3 points higher. Of course reasons have been suggested for the Novato road test's possibly not being as demanding as the MDPE given in San Jose, and these may have contributed to subjects' generally good performance.

From the point of view of prediction, the most promising test at the Novato site proved to be WayPoint. Its promise, as demonstrated in Novato, is consistent with that of Auto-Trails in San Jose, and consistent also with Odenheimer's (1993) finding that both parts A and B of Trail Making correlated significantly with road test performance, in a small but heterogeneous group of elderly drivers. The work of Stutts, Stewart, and Martell (1996), showing a relationship between performance on Trail Making and crash experience, has been noted in Part 2.

In administering WayPoint at Novato, the testers recorded subjects' times by means of a stopwatch. While that was sufficient for study purposes, in order to use the test in a field office environment it would seem much better to automate it in the manner of Auto-Trails. Whether an analogous kind of automation (i.e., a touchscreen) should be used is questionable in the case of this test. The lines subjects drew from numbers to letters to numbers in WayPoint frequently went through the boxes containing other letters or numbers and partially obscured them. The lines themselves became distracters as subjects progressed through the test, making it more difficult and perhaps more valid. This form of distraction would not have occurred had a touchscreen like that used in Auto-Trails been employed. If future research determines that part of the validity of WayPoint is due to confusion that can be engendered by intersecting lines, it would be beneficial to develop or use an automated method in which the subject traces a path between stimuli on the screen which remains visible, perhaps using a light pen, so that the path itself can function as a distracter.

There is considerable evidence, not only from the present project, suggesting that tests based on Trail Making—Auto-Trails, WayPoint—can help to predict performance on a road test. They demand no extensive or expensive equipment. Of the subject they demand no great motor dexterity but, rather, good conceptual tracking and attentional focus, the ability to scan a visual display quickly and accurately, the ability to retain in memory one's place in an abstract sequence, and—in the case of Trails B and WayPoint—the ability to shift attention in alternating between abstract sequences.

Visual Resources' perceptual response time (PRT) test was, next to WayPoint, the best predictor of MSCORE, with a unique contribution to $R^2$ of 3% (Table 3) after adjustment for age. Hennessy (1995) earlier found that this test, the first module of the UFOV, explained 4.1% of the variance in prior crash involvement for drivers aged 70 or more, after adjustment for age (as here, within the range 70+), gender, and reported amount of exposure. While there were no indications that the test should be used routinely to assess drivers of all ages, Hennessy felt it would have merit for this older group and suggested that in order to avoid controversy it be administered not to drivers of a particular age, but rather to drivers who fail the Snellen visual acuity test. (Snellen failures are, as it happens, primarily older drivers.)

Since the test has been actualized on a PC it has become much more accessible to licensing agencies than it was before. Several such brief, PC-based tests could be administered as part of first-tier licensure screening, and where they predict road test errors as well as impairment status they could perhaps even obviate the need for a second tier. Along these lines, McKnight and Lange (1997) commented that it would probably be possible to reduce the number of tests in their APT battery and still obtain acceptable reliability, allowing the battery to become part of the regular license renewal testing process, presumably as applied to drivers of all ages. Use of an adaptive testing method is critical, they stated, so that testing time would be but a few minutes for the great mass of drivers without serious impairment. They noted the need for a second tier of testing for those with an enhanced probability of such impairment, but if further research shows that some of their screening tests also function well to predict road test errors, it is possible that many applicants could be spared the need to take second-tier tests.

A test that will predict behavior on the road should be a timed test, as the PRT is. Untimed tests have value for screening purposes, but they cannot be expected to predict driving performance well. In using a Pelli-Robson wall chart to measure low-contrast acuity as we did at San Jose, for example, subjects frequently were able to make out some of the letters in the bottom rows of the chart if they gazed at it for an extended period of time. But in a driving situation perception must be immediate, or nearly so. A feature of the PC-based PRT that seems especially promising is its possible adaptation to presenting stimuli at varying levels of contrast between figure and ground. If this were done, not only could perceptual speed for high-contrast stimuli be accurately timed, but also perceptual speed under degraded visual conditions. The equipment for administering such a modified PRT should be well within the reach of many, if not most, licensing agencies.

Both MMSE score and MMSE "error areas" helped to predict MSCORE, as shown in Tables 9 and 10. Use of the latter measure—the number of cognitive domains in which an error or errors was made on the Mini-Mental State Examination—was based on an assumption that the greater the number of areas of impairment in cognitive functioning the greater the likelihood that road test performance would also be impaired. Of course MMSE error areas was highly correlated with MMSE score, and in different models each made a unique contribution to prediction, similar in magnitude to that of the PRT measure. The 20-item MMSE can be shortened without losing its good diagnostic properties according to Braekhus et al. (1992); their 12-item version of the test, using the most discriminative items, has been mentioned above. However it is still time-consuming to administer the test, and from a licensing agency standpoint it is questionable how the public would react to being asked such questions as *What county are we in?* and *What year is it?*, or to being asked to repeat or write a sentence. Although none of the Novato subjects objected to this, the same probably would not be true for unselected license applicants, especially if they believed that a test apparently unrelated to driving was being administered to them because of their advanced age. The MMSE, or a shorter mental status test like the one suggested by Braekhus et al., might be more palatably administered, and better interpreted, by an individual's personal physician than by their DMV, though the knowledge test itself could be modified to test more fully applicants' cognitive status. This idea will be elaborated in Part 6.

An approach apart from tests is to build into the application process itself brief checks on cognitive status which appear to be an intrinsic part of the process. This idea, suggested by Sheila Prior of the American Association of Motor Vehicle Administrators (AAMVA), will also be discussed more fully in Part 6.

The study of Marottoli et al. (1994) has been mentioned briefly above. Studying the predictive value of various tests for driving hazard, they administered the MMSE and tests of physical performance to 283 drivers selected from a cohort of community-living adults aged 72 or more. They reported that the MMSE item most closely associated with self-reported adverse traffic events in the year following testing was the design-copying task, in which testees are asked to copy pictured intersecting polygons. The relative risk for those unable to copy the design, after adjustment for driving frequency and type of housing, was 2.7. In the present study the criterion was different, and the binary pass/fail score on the pentagon item did not relate to road test weighted errors ($r$ = .0007 in the full sample; $p$ = .994). However, good performance on this item does demand a modicum of visuospatial perceptual ability, and of all the MMSE items the pentagon question superficially appears to be the one most relevant to driving.

It seemed at least possible that a graduated method of scaling performance on this item would make it more sensitive to the kinds of decrements that cause drivers to make errors in their on-road performance—the vast majority of which do not result in a crash, a citation, or being stopped by police. Accordingly, the question was rescored by Dr. West according to the method of Teng and Chui (1987), described above. This new score had a simple correlation with MSCORE in the full sample of -.1026 ($p$ = .310); in the multiple regression analysis it similarly failed to enter the model to predict MSCORE. This does not eliminate the possibility, however, that a battery of visuospatial tests including the pentagon task might be predictive. With respect to this single task, the small size and relative homogeneity of the Novato sample militated against identifying relationships which would in fact hold for the broader population.

The Doron Cue Recognition tests did not prove to be as useful for prediction of MSCORE in Novato as they had in San Jose. None of the modules entered the Novato multiple regression model, though it will be recalled that in San Jose, using the old scoring method, the Doron tests proved to be among the best predictors. At Novato the first module of the Doron Cue Recognition test was particularly unreliable, and because of numerous invalid (e.g., zero) scores it was eliminated from the variable pool in the multiple regression and factor analyses. (Cue Recognition 1 was included in the pool for the logistic regression to predict frailty, but unlike the other two Cue Recognition modules it did not enter.) This unreliable functioning was no doubt brought about in great part by the scoring changes that had been implemented, though perhaps in part it was also due to mechanical factors or insufficient instruction of test administrators. Nevertheless, the fact that age and concentration errors correlated significantly with Cue Recognition 1 time scores strongly suggests that these scores were not entirely invalid; they apparently contained some true-score variance. Something about the interaction between certain subjects and the apparatus may have been critical. A similar observation was made in connection with the MultiCAD tests given at San Jose; zero-time readouts and meaningless numbers in place of valid time measurements appeared much more likely to occur in the case of drivers whose performance on this test battery otherwise was poor due to functional disability.

Perhaps it needs to be stressed that although Cue Recognition 2 and 3 functioned better than Cue Recognition 1 at Novato, and their relationship with MSCORE was considered to approach significance, any change in the scoring system which affected Cue Recognition 1 would have affected these other modules as well. Thus it seems likely that nonrandom error was introduced into these tests also, making scores on them less predictive of on-road driving performance than they would otherwise have been. Nevertheless the factor analysis showed that the highest loadings on Factor 2, which was related to various indices of adequate perceptual and psychomotor functioning, as well as to MSCORE, were for Cue Recognition 2 and Cue Recognition 3. (Lesser) frailty also loaded strongly on this factor, as did (lesser) age. Whatever nonrandom error existed could very well have been related to functional effects of the aging process, and this is consistent with the finding of significant correlations between all Cue Recognition modules, including the first, and age. It may be recalled from Table 2 that age was marginally significantly related to MSCORE in this generally healthy subject sample, whose functional disabilities were perhaps more likely to be related to "normal aging" than to disease.

Accepting the basic validity of the Cue Recognition tests, and assuming that whatever problems exist in the area of response registration will be corrected, it may still be possible to improve the reliability of Cue Recognition when used with the elderly. It is possible that older, possibly frail, subjects tended more commonly to rest their foot on the accelerator instead of depressing it in a positive manner, undetected by inexperienced test administrators. From the instructions, it is unclear how far the accelerator should be depressed—to the floor? at least halfway? more than halfway? This level of detail is not given, and yet it is critical that subjects be given every chance in practice trials to understand the task, in order to minimize the need for careful monitoring by test administrators who, in a field office environment, may be unmotivated and undertrained. This does not negate the fact that part of the task is understanding and being able to follow the instructions. Subjects in San Jose who could not do that did not do as well on the road test either.

Studies at the two sites, San Jose and Novato, have identified tests that, at the least, deserve further scrutiny in a more extensive study. We have argued that in addition to those entering the multiple regression equation at Novato, the Doron Cue Recognition tests deserve further consideration based on their performance at San Jose, their high loadings on Factor 2 for the Novato sample (see Table 4), and the tests' apparent link to frailty, which is also linked to road test performance (see Table 7).

Auto-Trails also showed considerable promise and should be further investigated, and if possible a version of Trails B (or WayPoint) using automated timing should be devised and studied. It can be predicted that a test based on Trails B, since it demands greater cognitive skills through its requirement to remember one's place in both a letter and a number series and switch from one to the other, will function more effectively to detect mild cognitive impairment than one based on Trails A—without the need, as with the SPMSQ or complete MMSE, for asking older drivers what may seem to them to be impertinent questions. (On the other hand, it has been seen that MMSE measures added to prediction of MSCORE over and above the contribution of WayPoint time measures, and WayPoint error measures did not enter either the model of Table 9 or that of Table 10. A record of MMSE score from the driver's physician might well be used as one factor in making a decision whether to require—or to allow, if impairment is great—a road test.)

The PRT test also might be an excellent candidate for a second-tier battery, and its modification to enable measurement of perceptual speed under low-contrast conditions seems potentially of substantial benefit. Finally, the Scientex MultiCAD battery showed much promise at San Jose, even though the version used there was subject to operational problems that would have made it difficult for DMV field office staff to administer the tests in a consistent manner. This battery certainly deserves further consideration (though not necessarily for licensing agency use; see the discussion in Part 6), and will no doubt receive it in Scientex' ongoing research.

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# PART 4
# Effects of Driving Cessation or Limitation on the Older Adult
**Sandra Winter Hersch**

The primary intent of this study was to investigate the potential effects of forced driving cessation on the self-esteem and locus of control of the older adult. It was hypothesized that the loss of a driver's license is associated with a decrease in self-esteem and a more externalized locus of control. Age, gender, health, previous amount of driving, and reported amount of avoidance of specific driving situations were used as covariates. As a secondary aim, the reported effects of forced cessation of driving versus that of receiving new restrictions on the driver's license was studied. Through surveying both the involved drivers and their family members or friends, effects of the DMV's action on the mobility, life style, and emotional equilibrium of subjects and their significant others were assessed. It was hypothesized that license restriction impacts these factors less adversely than does license cessation. Section A will deal with the primary study and section B with the secondary one.

## A. DRIVING CESSATION AND THE OLDER ADULT

As people age, they begin as a group to experience cognitive declines which may interfere with safe driving. Safe driving skills start to deteriorate at about age 55, and more significantly so at about age 75 (Malfetti & Winter, 1990). There may come a time when it is no longer safe for an older adult to drive.

Malfetti and Winter (1990) emphasized how important a driver's license is for the independence, satisfactory lifestyle, and mental health of older adults. They reported that a considerable number of older people would "rather die" (p. 58) before giving up their driver's license. Further, if a driver's license exam is failed, the person's self-esteem suffers, lifestyle changes, and he or she may just "give up" (p. 6).

Being able to drive may be seen as central to a sense of freedom and control over one's environment. Without a driver's license, one must depend on others, such as family, friends, and public transportation, to meet basic transportation needs. This dependence may be harmful to an older adult's sense of autonomy and self-esteem.

Berger, speaking about a work in progress on "The Mobility Consequences of the Reduction or Cessation of Driving by Older Persons," stated that there is a relatively small amount of literature on the emotional effects of driving cessation associated with aging (personal communication, September 13, 1996). One related study by Thompson (1996) compared the quality of life of drivers and former drivers who chose to stop driving. Quality of life refers to an assessment of life satisfaction according to what people feel is most important in their lives. This study found that drivers were able to go more places than former drivers, but that quality of life was more influenced by health than by driving. However, the study did not include drivers who were forced to give up driving due to license revocation.

In Carp's (1971) study, older adults were found to have strong negative feelings about the anticipation of losing a driver's license, but to have more neutral feelings if they had already stopped driving. It was proposed that this was due to "defensive memory work" (p. 103). In other words, the loss of a driver's license is so unpleasant that the older adults blocked or repressed the memory of the unpleasantness.

In Eisenhandler's (1990) qualitative study, 50 elderly people were interviewed. These people admitted that their drivers' licenses gave them a sense of control and independence, and they refused to give up driving despite health problems. For these older adults, the ability to continue to drive was a way "to ward off an old age identity" (p. 7). The inability to drive made them aware of age and isolation from friends and activities.

Persson (1993) and Campbell, Bush, and Hale (1993) explored older adults' decisions to stop driving. In Persson's (1993) study, focus groups of older adults agreed that driving was most important for "independence, convenience, and mobility" (p. 90). These groups strongly felt that older adults themselves should make the decision to stop driving, but that physicians' recommendations would be accepted and family members should also discuss concerns related to driving.

Campbell et al. (1993) focused on medical reasons that older adults stop driving, and found that highly disabling conditions, including macular degeneration, syncope, a limitation in daily activities, stroke sequelae, Parkinson's disease, and retinal hemorrhaging were associated with about half of all decisions to stop driving. However, most of the subjects in this study who had stopped driving reported that they stopped driving voluntarily and not due to medical conditions.

The most important theme running through these studies is that the ability to drive is important to feeling in control of one's life. Eisenhandler (1990) referred to the possession of a driver's license as an "asphalt identikit" that allows older adults to maintain a non-age related identity. The loss of this identikit begins a "dependency career" (p. 2), in which the individual must rely on others for transportation. The driver's license is a symbol of freedom and competence.

*Self-Esteem and the older adult*

Self-esteem has been defined by Coopersmith (1981) as the personal judgment of worthiness that the individual makes and maintains about him/herself. According to this author, self-esteem is important in that it is associated with personal satisfaction and effective functioning.

The numerous losses and stressors an older adult must face work to erode self-esteem. Chene (1991) used the example of a person who is faced with retirement. If that person is strongly attached to the work ethic, he or she may feel less valuable and therefore suffer lowered self-esteem.

There have been a number of studies examining the effects that losses and stressors have on the self-esteem of older adults. One such study by Krause, Jay, and Liang (1991) examined the effects of financial strain on the psychological well-being of older adults. This study found that as financial problems increased, older adults experienced a diminished sense of self-worth. Flett, Harcourt, and Alpass (1994) examined the effects of chronic lower leg ulceration in the elderly. Older adults with chronic lower leg ulceration had significantly lower levels of self-esteem than older adults without the ulceration.

Other studies have examined this topic with specific gender and ethnic groups of older adults. For example, a study by Cogen and Steinman (1990) examined erectile dysfunction (loss of potency) in elderly men. They reported that about half of the men with potency problems noted a loss of self-esteem. Tran, Wright, and Chatters (1991) studied black older adults and found that a large number of stressful life events had significant negative effects on self-esteem.

*Locus of control and the older adult*

The concept of "locus of control" was introduced by Rotter (1966) in the context of social-learning theory. Locus of control is defined as a person's expectancies for internal versus external control of reinforcement. Internal control refers to the perception of one's behavior as causing an event. External control refers to the perception of an event as not being a result of one's behavior but of some outside force (such as chance, luck, or other people).

Persons lacking a sense of control (a high external expectancy) may be prone to apathy and despair because they believe they have no control over their environment (Feist, 1990). On the other hand, a sense of control (an internal expectancy) is associated with positive outcomes such as emotional well-being, successful coping with stress, good health, and desired behaviors (Thompson & Spacapan, 1991).

The older adult's feelings of control over his or her environment may be undermined by losses and stressors. Referring again to Chene's (1991) example of a person who is faced with retirement, he or she may not see continuing work as an option and may therefore feel less control over the environment (in addition to lower self-esteem, as mentioned above).

A number of studies have examined the effects of losses and stressors on feelings of control in older adults. For example, the study by Krause et al. (1991) found that financial strain resulted in a decline in feelings of control in older adults. Reich and Zautra (1991) found that belief in the ability to control the events in life is influenced by experiences, such as disability. Hamm, Bazargan, and Barbre (1993) found that urban black elderly with cardiovascular disease had worse scores on a health locus of control question than urban black elderly without cardiovascular disease.

*Hypotheses*

It was expected that older adults who had their license revoked would have a lower self-esteem than those who kept their license, and that older adults who had their license revoked would have a more externalized locus of control than those who kept their license.

## METHOD

*Subjects*

The subjects were 65 people aged 60 or older. These subjects had been reexamined by the Department of Motor Vehicles (DMV) for a driver's license because they were referred (by physicians, family members, police, DMV field office staff, etc.) due to possible health-related driving problems. Some of these subjects were previously involved in a test validation study for older drivers with possible health-related driving problems (Janke & Eberhard, in press). Based on their performance on the reexamination, the subjects either kept their driver's license (unrestricted or restricted) or lost their driver's license. Subjects who had a driver's license (unrestricted or restricted) constituted one group ($n$ = 35) and were coded as 1 for the analysis. Those who had lost their driver's license constituted the other group ($n$ = 30) and were coded as 2 for the analysis. Male subjects were coded as 1 and female subjects were coded as 2 for the analysis.

*Variables*

The quasi-independent variable in this study was the DMV determination of whether subjects lost or did not lose their driver's license. This was a non-random assignment of subjects, because the variable depended upon performance on a driving examination. The dependent variables were self-esteem and locus of control.

Also included were age, gender, self-reported health status, amount of previous driving, and reported amount of avoidance of specific driving situations, (Hennessy, 1995; Janke & Eberhard, in press) also called driving avoidance behavior, as covariates. These variables were chosen as covariates because it was suspected that they would also be related to self-esteem and locus of control (Coopersmith, 1981; Flett et al., 1994; Hamm et al., 1993; Montag & Comrey, 1987; Reich & Zautra, 1991; Thompson & Spacapan, 1991; Tran et al., 1991). Self-esteem was measured by the Coopersmith Self-Esteem Inventories. Locus of control was measured by Rotter's Internal-External Control of Reinforcement Scale. The covariates were obtained though the DMV's Driving Information Survey (Hennessy, 1995; Janke & Eberhard, in press) given at the time of the driving reexamination.

*Instruments*

The Coopersmith Self-Esteem Inventories were developed to assess attitude toward oneself in general and in more specific contexts (such as social and academic). This instrument is composed of 25 generally favorable or unfavorable statements about the person, which they mark as "like me" or "unlike me." The possible scores range from 0 (*lowest self-esteem*) to 100 (*highest self-esteem*). Reliability, stability, and construct validity of the test are well supported by research (Anastasi, 1988).

Rotter's Internal-External Locus of Control Scale (I-E Scale) was developed to determine the individual's generalized expectancies for internal versus external control of reinforcement. This instrument was constructed within the context of social-learning theory (Rotter, 1966). It is a forced-choice self-report inventory composed of 29 statements. The possible scores range from 0 (*most internal*) to 23 (*most external*). Split-half, Kuder-Richardson and retest reliabilities of total scores cluster around .70 (Anastasi, 1988).

The Driving Information Survey was developed by the DMV to elicit information from subjects about their driving habits (Hennessy, 1995; Janke & Eberhard, in press). The information derived from this survey included age and scores for health, amount of driving, and amount of situational avoidance behavior in driving. For health, the possible scores range from 1 (*excellent health*) to 4 (*poor health*). For amount of driving, the possible scores range from 1 (*0 to 9 miles per week*) to 7 (*351 to 500 miles per week*). For amount of driving avoidance behavior, the possible scores range from 9 (*never avoiding any of 9 driving situations*) to 36 (*always avoiding each of 9 driving situations*).

*Procedure*

Each subject was given the Driving Information Survey either in person before the driving reexamination or by mail during the week before the driving reexamination. After the DMV had determined whether the subjects retained a driver's license or not and made their decision known to the subject, each subject was given the Coopersmith Self-Esteem Inventory and Rotter's Internal-External Control of Reinforcement Scale, either in person at their homes or by mail. All subjects filled out the instruments without help from the experimenter.

## RESULTS

Refer to Table 1 for all means and standard deviations for license status groups by the dependent variables self-esteem and locus of control, and by the covariates age, health, previous amount of driving, and amount of driving avoidance.

Table 1

Mean Scores for Kept-License and Revoked Groups by Dependent Variables and Covariates

| Variables and covariates | Kept-license | | Revoked | |
|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* |
| Self-esteem | 75.20 | 18.22 | 73.73 | 13.23 |
| Locus of control | 6.74 | 3.59 | 9.23 | 2.73 |
| Age | 76.74 | 8.42 | 80.50 | 7.36 |
| Health | 2.11 | .51 | 1.83 | .59 |
| Amount of driving | 3.51 | 1.42 | 3.37 | 1.69 |
| Driving avoidance | 18.43 | 6.01 | 20.03 | 7.52 |

There were 38 (58%) male subjects and 27 (42%) female subjects. In the kept-license group there were 25 (66%) males and 13 (34%) females. In the revoked group there were 10 (37%) males and 17 (63%) females.

Table 2 shows correlation coefficients for all pairs of variables.

Table 2

Correlations Between Pairs of Independent Variables, Dependent Variables and Covariates

| Variables and covariates | *N* = 65 | | | | | | |
|---|---|---|---|---|---|---|---|
| | Locus of control | Self-esteem | Age | Gender | Health | Driving amount | Driving avoidance |
| DL status | .36** | -.05 | .23 | .28* | -.25* | -.05 | .12 |
| Locus of control | — | -.09 | .13 | .14 | .25* | -.17 | .11 |
| Self-esteem | | — | .06 | .20 | -.31** | .10 | -.21 |
| Age | | | — | .15 | -.26* | -.17 | .29* |
| Gender | | | | — | -.09 | -.37** | .31** |
| Health | | | | | — | -.01 | .16 |
| Driving amount | | | | | | — | -.53** |

*$p < .05$; **$p < .01$.

A between-subjects multivariate analysis of covariance (MANCOVA) was performed on two dependent variables: self-esteem and locus of control. Adjustments were made for five covariates: age, gender, health, previous amount of driving, and previous amount of driving avoidance. The quasi-independent variable was driver's license status. Analysis was done through SPSS+PC for Windows.

The assumption of multivariate homogeneity of variance was tested using Box's M. The assumption was met, $p = .079$. The assumption of univariate homogeneity of variance was tested using the Bartlett-Box procedure. The assumption was met for self-esteem, $p = .081$, and locus of control, $p = .131$. The assumption of multivariate homogeneity of regression was met, $p = .457$, and univariate homogeneity of regression was met for self-esteem, $p = .904$ and locus of control, $p = .131$. The covariates age and gender were judged to be reliable for covariance analysis. The covariates health, previous amount of driving, and previous amount of driving avoidance were all self-reported, and the reliability of these measures may be suspect.

The combined dependent variables were significantly related to the combined covariates with the use of Wilk's criterion, $F(5, 58) = 2.99$, $p = .002$, Hotelling's criterion, $F(5, 58) = 3.09$, $p = .002$, and Pillai's criterion, $F(5, 58) = 2.88$, $p = .003$. The combined dependent variables were also significantly related to driver's license status with the use of Wilk's, Hotelling's and Pillai's criterion, $F(1, 58) = 9.64$, $p < .001$.

To further determine the utility of the covariates, multiple regressions were run for each dependent variable, with the covariates acting as multiple predictors. Using a strict Bonferroni correction, alpha was set at .01. Males had marginally higher self-esteem scores than females, $t(58) = 2.49$, $p = .016$, and those with better self-rated health scores had more internal locus of control scores, $t(58) = 2.72$, $p = .009$.

Effects of driver's license status on the dependent variables after adjustment for all covariates was investigated in univariate analysis. After adjustment for covariates, the adjusted means of self-esteem scores were 77.53 for the kept-license group and 71.40 for the revoked group, and the adjusted means of locus of control scores were 6.34 for the kept-license group and 9.64 for the revoked group. Using a strict Bonferroni correction, alpha was set at .025. Results of the univariate tests are summarized in Table 3.

Table 3

Univariate Analyses of Covariance of
Dependent Variables Adjusted for Covariates

| Dependent variable | Univariate *F* | *df* | Significance of *F* |
|---|---|---|---|
| Locus of control | 16.42 | 1/58 | .000 |
| Self-esteem | 2.30 | 1/58 | .135 |

## DISCUSSION

Consistent with the hypothesis, the results of this study indicate that older adults whose driver's licenses have been revoked have a more external locus of control than those who have kept their licenses. It is as though the feeling of freedom teenagers have when first given the ability to drive is the same feeling taken away from older adults when their ability to drive is taken away. Even those subjects who were fortunate enough to be able to pay drivers to take them wherever they wanted to go stated that they felt very limited and not as spontaneous. One subject felt so limited by the lack of a license that she agreed to stop taking pain medication and endure her chronic headaches in order to have her license renewed. Some subjects went so far as to say "they took away my life when they took away my license."

However, contrary to the hypothesis, older adults whose licenses have been revoked do not have a lower self-esteem than those who have kept their license. These findings support the theory and related research of Brandtstader and Greve (1994). Their theory holds that there are adaptive and protective mechanisms that can account for a resilience of self-esteem in old age. These mechanisms work to stabilize a person's self-esteem despite the losses and changes faced in the later years of life. This theory was tested in cross-sectional studies which supported the notion that self-esteem is stable in later life (Brandtstadter, 1992). Changes are seen by the older adult as negative yet inevitable. Brandtstadter and Greve (1994) noted that although it is plausible to believe that these experiences would lower self-esteem, this belief is not necessarily true.

Chene (1991) stated that self-esteem differs from feelings of competence. This could help to explain why the population of this study, although told that they are no longer competent to drive a motor vehicle, feel a loss of control in their lives but not a loss of self-esteem.

The correlational analysis provided a few obvious results, but also some that were surprising and interesting. The more obvious significant correlations were: (a) previous amount of driving negatively correlated with amount of driving avoidance (the more a person drove, the less they avoided specific driving situations), (b) amount of driving avoidance correlated with age (the older the subject, the more they avoided specific driving situations), (c) driver's license status correlated with locus of control (the revoked group had a more external locus of control), (d) previous amount of driving negatively correlated with gender (females drove less than males), (e) amount of driving avoidance correlated with gender (females avoided specific driving situations more than males), and (f) driver's license status correlated with gender (males were allowed to keep their licenses more often than females). These last few correlations may help to explain each other. If men drive more than women, and women avoid specific driving situations more than men, the men may perform better on the driving reexamination and be allowed to keep their licenses more often partly due to a practice effect. Also, the women were not allowed to avoid specific driving situations on the driving reexamination. Lastly, self-reported health was correlated with locus of control and negatively with self-esteem (as self-reported health improved, locus of control was more internal and self-esteem was higher).

The more surprising significant correlations dealt with the self-reported health of the subjects. Self-reported health correlated negatively with age and driver's license status, or in other words, as self-reported health improved, age increased and drivers' licenses were more likely to be revoked. It is possible that the subjects who were older and subjects who were more likely to have their licenses revoked were being more defensive about their health at the time of the DMV reexamination for fear of losing their driver's license due to health-related problems.

*Implications*

The importance of this study is in the implications it has for society in general and motor vehicle departments in particular. If it is detrimental to the sense of control of an older adult to lose the ability to drive, this may be used as an argument for motor vehicle departments to keep older adults on the road for as long as it is safe to do so. Currently, many motor vehicle departments either give full driving privileges or revoke all driving privileges (Malfetti & Winter, 1990). Some motor vehicle departments may have a restricted (or graded) licensing program, but not use it as much as possible due to the time and expense involved. However, it may be worth the time and expense for motor vehicle departments to extensively use a restricted licensing program, given that the restrictions imposed are appropriate.

Another important implication of this study is how the restriction or the revocation of the license is dealt with by the motor vehicle department. If the restriction or revocation is presented as a way of keeping the person safe, and the older person is treated with caring and respect as in Oregon's enhanced reexamination evaluation program (Jones, 1990), they may leave with more feelings of control. Further, if the person is not simply told that they can no longer drive, but is also given information on community support services (such as meals on wheels) and alternative transportation (such as bus schedules), they may feel a stronger sense of control over their lives in addition to being the recipient of practical help. Gurian (1992) reported that increased access to community programs and services as a result of available transportation helped older adults maintain feelings of independence.

*Limitations*

An issue that arises is that the relationship found between loss of license and locus of control may not be assumed to be a causal relationship. For example, another factor (not adjusted for in this study) may have affected both license status and locus of control. Another possibility is that an external locus of control caused the loss of license. Montag's and Comrey's (1987) study found that an external locus of control was positively related to involvement in fatal accidents. By analogy, this might suggest that the older adults had an external locus of control before they lost their license. A future study might address this issue by administering a locus of control inventory both before the reexamination and after the license has either been reissued or revoked.

This area of study might benefit from future research involving larger samples and samples from offices in other areas than the San Jose area in order to increase generalizability. The addition of a third group of older adults who were not reexamined but chose to give up driving on their own would also be beneficial.

The next section describes the study of effects of license restriction vs. revocation.

## B. RESTRICTING VS. REVOKING THE LICENSE OF OLDER ADULTS EFFECTS ON DRIVERS, FAMILY, AND FRIENDS

This part of the study evaluated an informal graded licensing procedure in which older adults' driver's licenses were restricted when appropriate, instead of being revoked. A graded licensing program (Malfetti & Winter, 1990) attempts to keep older drivers safely on the road for as long as possible by putting restrictions on their licenses, such as driving only in a certain area or driving only during daylight hours. This study sought to determine how satisfying the restrictions would be for the older drivers. It also intended to determine how restrictions on a driver's license or the loss of a driver's license affects an older adult's family and friends.

## METHOD

### *Subjects*

Subjects were 65 people aged 60 or older. They had been reexamined by the California Department of Motor Vehicles (DMV) for a driver's license because they were referred (by physicians, family members, police, DMV field office staff, etc.) due to possible health-related driving problems. Some of these subjects were previously involved in a test validation study for older drivers with possible health-related driving problems. Based on their performance on the reexamination, the subjects either had a driver's license (unrestricted or restricted) or had lost their driver's license. Subjects who had a driver's license (unrestricted) constituted one group ($n$ = 25), those who had a new restriction on their driver’s license constituted a second group ($n$ = 10), and those who had lost their driver's license constituted a third group ($n$ = 30).

The people who filled out the Survey for Family and Friends of Reexaminees consisted of 59 people who were asked by one of the subjects to participate. This group consisted of friends or relatives of the unrestricted group ($n$ = 21), friends or relatives of the restricted group ($n$ = 8) and friends or relatives of the revoked group ($n$ = 30).

### *Variables*

The quasi-independent variable in this study was the DMV determination of whether the subject had a driver’s license, had a new restriction on a driver’s license, or did not have a driver's license. This was a non-random assignment of subjects, because the variable depended upon performance on a driving examination.

### *Procedure*

Subjects were individually administered the Survey for Reexaminees (Appendix C) at their homes. This survey was designed to determine how the status of their driver's license affects their lives. Subjects were also asked to contact family and friends who were affected by their driving status and would also be willing to complete the Survey for Friends and Family of Reexaminees (Appendix D). Subjects, family and friends all had the opportunity to express general frustrations and opinions about driving restrictions or lack of driving privileges.

*Statistical analysis*

An exploratory analysis was used to evaluate the restricted license program for older adults. This analysis focused on the following: places the older adults could no longer go due to driving restrictions or cessation, the perceived safety of older adults and others, the emotional reaction of older adults to driving restrictions or cessation, changes in health and driving habits, alternative transportation used by older adults, and attitudes towards the DMV.

*Effects on family and friends*

An exploratory analysis was also used to determine the effects of driving restrictions and driving cessation on the family and friends of older adults. This analysis focused on the following: how family and friend's lives are affected by driving restrictions or cessation of older adults, the perceived safety of the relative or friend and others, the emotional reaction to the relative or friend's driving restrictions or cessation, and the observation of the relative or friend's emotional reaction to driving restrictions or cessation.

## RESULTS

The restricted group reported five different types of restrictions issued on their driver’s licenses, as shown in Table 4. Each of these subjects had anywhere from one to four new restrictions placed on their driver’s licenses.

Table 4

Type of Restriction for Restricted Drivers

| Type of restriction | Number issued to restricted subjects |
|---|---|
| No nighttime driving | 7 |
| Area restriction | 4 |
| Corrective lens restriction | 4 |
| No freeway driving | 4 |
| Time of day restriction | 2 |

It is not surprising that the restricted group reported much less trouble going places they wanted to go than the revoked group, as shown in Table 5.

Table 5

Difficulty in Reaching Desired Destinations by License Status Group

| Places subject reported difficulty going to | Restricted group | Revoked group |
|---|---|---|
| Grocery store | 0 | 24 |
| Church | 0 | 15 |
| Doctor's office or hospital | 1 | 20 |
| Post office | 0 | 6 |
| Drug store | 0 | 10 |
| Friend's house | 3 | 10 |
| Relative's house | 2 | 13 |
| Vacation or out of town | 3 | 2 |
| Work or volunteer work | 0 | 6 |
| Movie theater or video store | 0 | 4 |
| Mall or clothing store | 0 | 7 |
| Dry cleaner's | 0 | 7 |
| Other | 0 | 10 |
| None | 5 | 3 |

Table 6 shows that while revoked subjects had great difficulty getting to places they needed to go, the restricted subjects had very little difficulty.

Table 6

Difficulty in Reaching Necessary Destinations by License Status Group

| Places subject must go but reported difficulty going to | Restricted group | Revoked group |
|---|---|---|
| Grocery store | 0 | 25 |
| Doctor's office or hospital | 1 | 21 |
| Post office | 0 | 7 |
| Drug store | 0 | 11 |
| Work | 0 | 3 |
| Other | 0 | 6 |
| None | 7 | 4 |

Table 7 shows how often the subjects reported driving now as compared to before their license restriction or revocation. On a scale of 1 to 6, 1 is much more than before and 6 is stopped driving completely. Only two subjects in the revoked group were still driving a little during driving lessons (to try to get their licenses back). All other revoked subjects reported having stopped driving completely. However, other DMV customers who did not fill out the survey have admitted to disobeying their license revocation by saying things such as “you (the DMV) are forcing me to drive against the law by revoking my license” and “I get around just fine. I am driving anyway gambling that I will not be pulled over”.

Table 7

Rated Amount of Driving by License Status Group

| | Restricted group | | Revoked group | |
|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* |
| Amount of driving | 3.40 | 0.70 | 5.93 | 0.26 |

Table 8 shows how safe the subjects feel now and how safe they think others (drivers, passengers, and/or pedestrians) are now, based on a scale of 1 to 5, where 1 is much safer and 5 is much less safe. It is interesting to note that two subjects felt much less safe after their license was revoked. One of those subjects said he was less safe due to having to walk downtown because he can no longer drive. This same man reported others to be less safe. He was probably thinking about his wife, who also must walk downtown now. It is refreshing that a few subjects admitted to feeling safer and thinking others are safer.

Table 8

Perceived Safety by License Status Group

| | Restricted group | | Revoked group | |
|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* |
| How safe the subject felt | 2.67 | 0.71 | 3.08 | 0.63 |
| How safe the subject felt others are | 2.89 | 0.33 | 2.96 | 0.33 |

The emotional reaction of the subjects to their driver's license status is summarized by Table 9. Each emotional reaction is based on a scale of 1 to 5, where 1 is very (angry, happy or relieved) and 5 is not at all. (The kept-license group was not asked whether or not they were angry because it was assumed that they would not be angry about being able to keep their license). Some people in the revoked group said "I am not angry, but I am very upset (or disturbed)." It seemed as though they were reluctant to say they were angry either because anger is not an acceptable emotion to them or because they did not want to say they were angry with the DMV or with the experimenter.

Table 9

Emotional Reaction by License Status Group

| | Kept-license group | | Restricted group | | Revoked group | |
|---|---|---|---|---|---|---|
| Emotional reaction | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| Anger | 0 | 0 | 4.44 | 1.01 | 1.86 | 1.51 |
| Happiness | 2.52 | 1.56 | 2.70 | 1.49 | 4.86 | 0.35 |
| Relief | 1.48 | 0.92 | 2.44 | 1.42 | 4.89 | 0.42 |

Table 10 shows how subjects reported their health as having changed since the DMV decision about their driver's license status. Again, a scale of 1 to 5 was used where 1 is much better and 5 is much worse. The people who reported their health as being worse said things like "I have not been able to sleep," "I have been depressed," and "I have not been able to drive to places where I can exercise (such as the gym or a park where I can walk)."

Table 10

Health Changes by License Status Group

| | Kept-license group | | Restricted group | | Revoked group | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| Changes in health | 2.48 | 0.82 | 2.50 | 0.85 | 3.13 | 0.94 |

Table 11 shows the types of alternative transportation subjects reported using and about how often they are used. These results show that this group of subjects rely on the personal automobile as the main source of transportation.

Table 11

Type and Frequency of Transportation Alternatives

| Transportation type | Less than 1/3 of the time | More than 1/3 of the time |
|---|---|---|
| I drive myself | 7 | 28 |
| Relative drives | 18 | 23 |
| Friend drives | 13 | 15 |
| Bus or para-transit | 13 | 5 |
| Cab or dial-a-ride | 10 | 6 |
| Bicycle | 2 | 2 |
| Walk | 11 | 9 |
| Airplane | 5 | 9 |
| Train or rapid transit | 7 | 2 |
| Hired driver | 0 | 2 |

Table 12 is the report card for the DMV. Again, a scale of 1 to 5 was used for the attitudes about the DMV. For the change in attitude, 1 is much better and 5 is much worse. For the other opinions about the DMV, 1 is very (fair, courteous and concerned) and 5 is not at all.

Table 12

Perception of DMV by License Status Group

| | Kept-license group | | Restricted group | | Revoked group | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| Changes in attitude | 2.63 | 0.64 | 2.60 | 0.97 | 3.77 | 0.73 |
| Fair | 1.36 | 0.56 | 1.60 | 1.75 | 3.37 | 1.54 |
| Courteous | 1.44 | 0.87 | 1.10 | 0.32 | 2.41 | 1.50 |
| Concern | 2.00 | 1.26 | 1.70 | 1.16 | 3.13 | 1.46 |

Table 13 gives correlations of the survey results with driver's license status, to show the magnitude of the relationships described above within this sample. The scale for license status is 1 = kept-license, 2 = restricted license, and 3 = revoked.

Table 13

Correlations of Survey Responses with License Status

| | Driver's license status |
|---|---|
| Number of places subject had difficulty getting to | 0.561* |
| How often subject drives now | 0.940* |
| How safe subject feels now | 0.274 |
| How safe subject thinks others are | 0.100 |
| How angry subject feels | -0.624* |
| How happy subject feels | 0.688* |
| How relieved subject feels | 0.880* |
| How subject's health has changed | 0.330* |
| Subject's attitude about DMV | 0.576* |
| Subject's rating of DMV staff's fairness | 0.625* |
| Subject's rating of DMV staff's courteousness | 0.331* |
| Subject's rating of DMV staff's concern | 0.367* |

*Significant at .01 level

*Effects on family and friends of older adults*

The relationships of people who responded to the Survey for Family and Friends of Reexaminees to the subjects are shown in Table 14. The age difference between the groups may account for some differences between the respondents. For instance, because the revoked group was older, they may have been more likely to be widowed. This may help to explain why the kept-license group asked their spouses to respond more often, and the revoked group asked their friends and children to respond more often.

Table 14

Relationship of Family Member/Friend to Reexaminee by License Status Group

| Relationship | Kept-license group | Restricted group | Revoked group |
|---|---|---|---|
| Husband | 3 | 1 | 3 |
| Wife | 10 | 2 | 7 |
| Son | 2 | 0 | 1 |
| Daughter | 2 | 2 | 7 |
| Friend | 3 | 3 | 7 |
| Other | 1 | 0 | 5 |

Most respondents to the survey for friends and relatives were still driving, as shown in Table 15.

Table 15

Family/Friend Ability to Drive by Reexaminee License Status Group

| | Kept-license group | Restricted group | Revoked group |
|---|---|---|---|
| Able to drive | 17 | 7 | 23 |
| Unable to drive | 2 | 1 | 7 |

The type of lifestyle changes that friends and relatives of reexaminees reported are shown in Table 16. The option of "more time spent with my relative/friend" differs from the rest of the options in that it would possibly be seen as a positive change. However only 11 out of the 38 respondents chose that option, whereas 21 chose "more time and gas money spent," which may be seen as negative. It was assumed that friends or relatives of the group that kept their license would not experience lifestyle changes.

Table 16

Family/Friend Lifestyle Change by Reexaminee License Status Group

| Type of lifestyle change | Restricted group | Revoked group |
|---|---|---|
| More time and gas money spent in driving my relative or friend | 1 | 20 |
| More stress due to increased driving | 2 | 13 |
| More time spent with my relative/friend | 1 | 10 |
| I now must rely on other people for transportation | 1 | 10 |
| Other | 0 | 2 |
| None of the above | 5 | 0 |

Table 17 summarizes how the respondents felt about the subjects' driver's license status. As with the Survey for Reexaminees, each emotional reaction is based on a scale of 1 to 5, where 1 is very (angry, happy or relieved) and 5 is not at all. Some respondents reported "mixed feelings," saying that they were happy because their (revoked) friend or relative was safer, but they were also sad because their friend or relative was upset. Respondents were much more positive in cases where their friends or family members retained the license.

Table 17

Family/Friend Emotional Reaction by Reexaminee License Status Group

| | Kept-license group | | Restricted group | | Revoked group | |
|---|---|---|---|---|---|---|
| Emotional reaction | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| Anger | 4.50 | 1.10 | 4.13 | 1.46 | 2.50 | 1.57 |
| Happiness | 1.86 | 1.15 | 2.50 | 1.60 | 3.90 | 1.21 |
| Relief | 1.48 | 0.93 | 3.00 | 1.77 | 4.03 | 1.43 |

The emotional reaction of the subjects as seen by the respondents to the Survey for Family and Friends of Reexaminees is summarized by Table 18. On average, the respondents' choices were very similar to the subjects' reported emotional reactions. The one notable difference was that the friends and relatives of the kept-license group and restricted group reported the subjects to be much happier than the subjects reported themselves (see Table 9). Again, each emotional reaction is based on a scale of 1 to 5, where 1 is very (angry, happy or relieved) and 5 is not at all.

Table 18

Family/Friend Perception of Reexaminee's Emotional Reaction
by Reexaminee License Status Group

| Emotional reaction of subject | Kept-license group | | Restricted group | | Revoked group | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| Anger | 4.24 | 1.48 | 4.75 | 0.71 | 1.53 | 1.14 |
| Happiness | 1.86 | 1.49 | 2.00 | 0.93 | 4.83 | 1.59 |
| Relief | 1.45 | 1.00 | 2.25 | 1.39 | 4.64 | 0.91 |

Table 19 shows how safe the respondents think the subjects are now and how safe they think others (drivers, passengers, and/or pedestrians) are now, based on a scale of 1 to 5, where 1 is much safer and 5 is much less safe. The responses of the friends and relatives were again similar to the subjects' responses, with the exception of the revoked group. The friends and relatives of the revoked group reported the subjects to be much safer than the subjects reported themselves (see Table 8).

Table 19

Family/Friend Perception of Safety Effect by Reexaminee License Status Group

| | Kept-license group | | Restricted group | | Revoked group | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| Safety of subject | 2.57 | 0.68 | 2.57 | 0.79 | 2.23 | 0.99 |
| Safety of others | 2.81 | 0.60 | 3.00 | 1.16 | 2.67 | 0.84 |

Table 20 shows correlations of family or friends' survey responses with their reexaminee's driver's license status. As noted above, license status is coded as 1 = kept-license, 2 = restricted, and 3 = revoked. These correlations show the magnitude, within this sample, of the relationships described above.

Table 20

Correlations of Family/Friend Survey Responses with Reexaminee License Status

| | Driver's license status |
|---|---|
| Number of lifestyle changes relative/friend reported | 0.701* |
| How angry relative/friend feels | -0.617* |
| How happy relative/friend feels | 0.837* |
| How relieved relative/friend feels | 0.815* |
| How angry relative/friend thinks subject feels | -0.821* |
| How happy relative/friend thinks subject feels | 0.673* |
| How relieved relative/friend thinks subject feels | 0.670* |
| How safe relative/friend thinks subject is now | 0.050 |
| How safe relative/friend thinks others are now | 0.054 |

*Significant at .01 level

## DISCUSSION

*Effects on older drivers*

The Survey for Reexaminees was designed to ask, “how is the restricted license program working for those DMV customers who have restrictions on their licenses?” The results point to the conclusion that the restricted licensing program is satisfying for these customers. As compared to the revoked group, the restricted group reported little difficulty getting to places they wanted and needed to go; they reported being able to drive almost as much as before their new restriction; they did not report being very angry, but did report being somewhat happy and relieved; their health was reported as being somewhat better than before; and their attitude towards the DMV was reported as generally positive. However, because of the small sample size and self-report nature of the study, these results are at best only suggestive.

*Effects on family and friends*

The results of the Survey for Family and Friends of Reexaminees show that whether or not an older adult has the ability to drive a motor vehicle affects many more people than just the older adult. The family members and friends who filled out this survey reported many lifestyle changes due to their loved ones’ inability to drive. Further, they were anything but apathetic. They claimed to have nearly as strong emotions as the subjects themselves, and they were fairly in tune with how their loved ones felt. One limitation of this survey that should be acknowledged is that the family members or friends who responded was chosen by the reexamined drivers, who may have selected those persons most supportive of their continued driving.

Although the survey results make a very positive case for the increased use of license restriction as an alternative to license revocation, at least in terms of customer satisfaction, the small, non-representative sample and absence of driving performance data require caution in interpreting these results. Nevertheless, they substantiate the negative effects which license revocation has on some older drivers and people close to them, and underline some of the potential advantages of a graded licensing program as advocated by Malfetti and Winter (1990).

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## PART 5
## Survey Data: Expert Advisory Panel and AAMVA

*Expert advisory panel survey*

An expert advisory panel was convened at U.C. Berkeley from July 24-26, 1994; names and affiliations of attendees appear in Appendix E. As part of the conference the panel's opinions were solicited in a survey, "Expert Opinion on Age-Related Driving Impairment," also in Appendix E. This survey consisted of statements relating to elderly drivers, with which respondents were asked to express their degree of agreement from 1 (strongly agree) to 5 (strongly disagree), and three open-ended questions asking which agents should play primary roles in an improved assessment process, how these might be coordinated, which licensing tests respondents could recommend for use in distinguishing impaired elderly from license applicants in general, and which they could recommend for purposes of identifying, from among impaired elderly drivers, those who were and were not competent to drive. After the conference a second round of answers to the open-ended questions (with the addition of a supplementary question) was obtained.

Results of the opinion ratings are not presented in full. Questions that dealt with a particular content area were grouped together, and the average ratings in response to each question in each content area are presented for two groups which consisted of 6 health practitioners (mostly physicians and engaged in research as well as practice) and 13 psychologists, most if not all traffic safety scientists. These average ratings, and the questions and content areas to which they correspond, entitled "Survey Summary by Group," are the final document in Appendix E.

In general there was considerable agreement between the two groups of respondents. Propositions on which the most disagreement appeared were the following:

*Licensing agencies must assume the major responsibility in identifying beginning dementia.* Health practitioners rather strongly disagreed with this, with an mean rating of 4.5. Psychologists were almost neutral, but tended to agree more than disagree with the proposition (mean rating 2.7).

*Presently there is adequate justification to subject drivers aged 70 or more to additional testing.* Psychologists rather strongly agreed (mean rating 1.7), but health practitioners neither agreed nor disagreed (mean rating 3.0).

*Abilities decline, so above some age all drivers should pass special tests to renew their licenses.* Similarly to the above, health practitioners were less sure of this than psychologists were (mean ratings of 3.5 and 2.1, respectively).

*[We] should standardize casualty accident rates to adjust for differences in vulnerability.* The idea this question was getting at was that statistics showing increased fatal or injury crashes for older drivers are somewhat inflated because the casualty may be the frail older driver himself (or herself). Age brings more vulnerability to injury or death in an accident. Health practitioners rather strongly agreed (mean rating 1.5); psychologists neither agreed nor disagreed (mean rating 3.0).

*If a group has a low crash rate per year, the state has no real justification for subjecting all its members to special testing.* This gets at the question of measuring a group's hazard by crashes per time period as against crashes per distance traveled. Elderly people in particular, as a group, travel relatively little distance during a given time period, so the group's average crash rate per year can be low at the same time that its crash rate per mile is high. Janke (1994) has argued that if a group's crash rate per year (or other time interval) is low the group is not a meaningful threat *to society*, although members of the group may still constitute a substantial threat to themselves and their passengers when they drive. Health practitioners were essentially neutral regarding the proposition (mean rating 3.2). Psychologists rather strongly disagreed with it (mean rating 4.3).

There is recent evidence on this issue (Dulisse, 1997) which deserves mention, since it provides evidence for older drivers' low degree of threat to other road users (persons outside an elderly crash-involved driver's vehicle). This addresses directly the threat *to society* from elderly driver crashes, as opposed to the threat to individual elderly drivers and passengers in their vehicles; thus the study may indirectly support the proposition above. Dulisse used two methods to estimate risk. First he inspected aggregate Wisconsin data on collision-caused deaths and hospitalizations per 100 million driver miles, as well as driver-miles per year, for groups aged less than 65, 65-74, 75-84, and 85 or more. These data enabled him to estimate the excess risk of an older age group relative to others by calculating deaths, say, per 100 million miles caused by two-vehicle collisions of the older group as compared with those of the group of drivers less than 65, then multiplying this deaths-per-distance-traveled difference by distance traveled per time period for the older age group. Following this procedure, which estimated incident rates per time period, drivers aged 65-74 appeared to impose a negative excess risk of crash-related death or hospitalization on other road users. That is, they did less damage to others than did the younger comparison group. Those aged 75-84 were associated with a slight excess risk of deaths and hospitalizations; this amounted to one excess death every 4 years and a 1% excess in hospitalizations caused by two-vehicle crashes. Drivers aged 85 or more were associated with the highest per-mile incident rates, but because of their very low mileage the actual excess risk they imposed on others was only about 0.5% of two-vehicle collision-caused deaths and hospitalizations. In another set of analyses, individual data specific to particular collisions were entered into probit models used to estimate excess risk. The results emanating from these individual-level analyses, Dulisse stated, provided no meaningful support for a hypothesis that older drivers impose excess risks of serious or fatal injury on other road users. He suggested that part of the small excess risk found in the aggregate analysis may have been a product of confounding.

*[It is] better to use tests to provide feedback and advice, not to restrict or revoke licenses of most elderly drivers.* Health practitioners were neutral to somewhat favorable (mean rating 2.5); psychologists were neutral to unfavorable (mean rating 3.8).

Both groups agreed that unobtrusive observations by licensing agency staff are not sufficient for identifying frail or medically impaired elderly, and that license revocation should probably be considered a treatment of last resort. It is interesting that although psychologists, like health practitioners, felt that informal observations by DMV staff are not sufficient to identify impaired elderly drivers, nevertheless (unlike health practitioners) they did not disagree with the proposition that licensing agencies must assume the major responsibility for identifying beginning dementia. Presumably this was to be through standardized tests.

Answers to the open-ended questions, elicited both before and as a followup to the conference (survey 1 and survey 2), are given more or less verbatim in Appendix F, and will repay careful scrutiny. These are entitled "Assessment of Drivers with Dementia or Age-Related Frailty: Panel's 'Unstructured Expression of Opinion." Also in Appendix F, and equally worthy of careful scrutiny, is the document "Conference Presentation Syntheses." This document contains summaries of the panel's discussion of various topics, developed and presented by selected attendees.

Their syntheses constitute a useful overview of the issues which are motivating present research on elderly drivers and the viewpoints of the leading researchers in the field. The list of topics addressed and the synthesizer for each follows.

1. Do we need an elderly driver assessment system? (Raymond Peck)
2. Geriatrician's tools for assessing patients' driving risk (David Reuben)
3. How can we tell when dementing patients should stop driving? (Allen Dobbs)
4. Occupational therapists' and/or psychological tools for assessing the driving risk of elderly clients (David Gilley)
5. Improving assessment tools for DMVs: Constraints and opportunities. (David Shinar)
6. In a graduated (i.e., graded) licensing system, what conditions (i.e., restrictions) should be tied to specific functional limitations? (Barnie Jones)
7. What improvements can be made in bringing the medically impaired to DMV's attention? (Loren Staplin)

Some points raised in the discussions summarized in "Conference Syntheses" and in participants' views as expressed in answer to the open-ended survey questions will be revisited in a concluding discussion, Part 6 of this report.

*American Association of Motor Vehicle Administrators (AAMVA) survey*

A different type of survey was conducted later in 1994, in which survey forms were mailed to licensing administrators and other authorities. Those to be surveyed were chosen on the basis of their wide knowledge of issues relating to licensing of older drivers, their informed opinions regarding it, and their familiarity with licensing policies and practices in their respective jurisdictions. A list of respondents and the survey form, with responses indicated on it, appear in Appendix G.

Results of this "AAMVA survey" will be discussed only briefly here. Responses were received from individuals representing, or answering on behalf of, all 11 licensing agencies surveyed—Arizona, Connecticut, Florida, Michigan, New York, North Carolina, Ontario (Canada), Oregon, South Dakota, Texas, and Utah. Not all respondents were agency administrators. For example, one respondent, representing Connecticut, was an occupational therapist employed by a hospital but working closely with the state's licensing agency. Another, representing Ontario, was a senior-level researcher employed by the Ministry of Transportation's Safety Research Office.

While almost half of the respondents indicated that elderly drivers, as a group, are considered a driving hazard within their agencies, none personally felt that the group was definitely a hazard. However, respondents representing 9 jurisdictions personally felt this way to some degree.

Many license restrictions or requirements applied to elderly drivers were mentioned, the most common being corrective lens restriction (all jurisdictions), periodic medical or vision reports from a clinician (all jurisdictions), time-of-day restriction (10 jurisdictions), special equipment or devices (9 jurisdictions), and periodic reexamination including a road test (9 jurisdictions). Those most rarely used were restriction to driving only for specific purposes (4 jurisdictions), a shorter license term for elderly people (2 jurisdictions), restriction to driving with a "copilot" (3 jurisdictions), and periodic reporting by the driver on his or her medical status and treatments (3 jurisdictions).

Ten of the 11 jurisdictions supported formal or informal graded licensing for the elderly, and perceived benefits to accrue both to the driver, in terms of preservation of independence, and to the licensing agency, in terms of making it easier to monitor the driver. Over half of the jurisdictions responding reported that they had a formal graded licensing program, although in one case it was only for young drivers and in another only for novice drivers of any age.

The question of whether to give special or additional licensing tests to drivers solely on the basis of advanced age is a sensitive one. Five respondents, representing Connecticut, Texas, New York, Florida, and Oregon, felt that public resistance and/or expense would be too great to allow this, although Oregon also stated that it probably could be done, presumably with great difficulty. (Oregon’s reexamination program is well known, but drivers are not compelled to undergo reexamination on the basis of age alone.) One respondent (Michigan) stated that such special testing would be perceived as age discrimination, unless the need for it could be supported by results of valid research studies. Another respondent (New York) felt that the proposal was "unfair, unsubstantiated, and unreasonable"; New York has only one age-related licensing practice, by which drivers below age 18 are restricted to daylight driving. (Of course in addition it can be presumed that all jurisdictions have minimum driving ages.) Three other respondents, representing Utah, North Carolina, and Arizona, felt that testing on the basis of advanced age probably could be done, though it might require law changes. Respondents from South Dakota and Ontario stated definitely that it could be done; in fact, in Ontario it currently is done.

California was not included in the survey, but its law specifically prohibits using age as a criterion for requiring a road test upon renewal. However, California law also requires that drivers aged 70 or more renew their licenses in person rather than by mail; this has been mentioned in Part 1. This may be considered to represent a form of age-based testing, although renewal tests are also required of drivers who do not qualify for renewal by mail on account of other reasons, and the tests given to the elderly are no different from those which drivers of any age are, or might be, required to take. Management has expressed the view that whether or not California would consider selective use of tests as a “pre-screen” to a road test would ultimately depend upon the validity and operational feasibility of the screening test.

Respondents were asked what criteria are used within their agencies to require selected drivers of advanced age to take a road test in order to renew their licenses. Some criteria were mentioned which do not ordinarily arise synchronously with license renewal (e.g., police referral, report from physician); these will not be discussed here. Reported criteria relating more closely to renewal were driver self-report on the application (10 jurisdictions), apparent confusion or disorientation observed in the agency office (10 jurisdictions), an earlier-reported (to the licensing agency) disorder that might impair driving (10 jurisdictions), physical frailty observed in the agency office (8 jurisdictions), an earlier-reported (to the agency) progressive disorder that might impair driving (8 jurisdictions), and poor performance on a non-driving renewal test (4 jurisdictions). Predictably, no jurisdiction refrained from ever requiring a driver of advanced age to take a road test on the basis of some criterion, and California, for example, uses all of the above factors as bases for requiring a road test.

In contrast to questions asking what practices their jurisdictions follow, respondents were also asked to give their personal opinions regarding circumstances under which special or additional tests should be administered to elderly applicants. Answers are given on the summary sheet. Generally speaking the circumstances mentioned (e.g., medical reports, poor driving record) did not include advanced age alone, with the exception of the group of respondents representing Oregon, who felt that anyone aged 80 or more should undergo a cognitive skills test, and the respondent from Michigan, who believed that special testing would be beneficial for all those aged 85 or more. Respondents were also asked what medical conditions they believed health professionals should mandatorily report to the licensing agency. Nine of them felt that seizure disorders, dementia, vision disorders, and stroke should be so reported. A majority of the respondents also felt that insulin-dependent diabetes mellitus, Parkinson's disease, and heart disease should be mandatorily reported. However, one respondent, representing South Dakota, felt that no medical condition should be. The Michigan respondent emphasized that diagnostic labels are not an adequate predictor of safe driving ability, and that therefore referral should occur after a functional assessment in cases of the conditions listed in question #11 (see Appendix G). (Conditions added to the list by this respondent were Alzheimer's disease, arthritis, chronic lung disease with hypoxia, psychiatric illness, and sleep apnea.)

No jurisdiction with a violation point system took action against driving privileges of the elderly at a point level lower than that used for other drivers. (The recommendation of Gebers & Peck, 1992—that the licensing agency administer interventions based on driving record at an earlier point in the case of elderly drivers than for the population in general—is discussed in Part 6 of Janke, 1994.)

With respect to medically impaired elderly, 6 jurisdictions never referred frail or dementing older drivers to rehabilitation facilities, but the others did so either occasionally or commonly. Seven jurisdictions had guidelines for testing the driving abilities of such drivers.

Respondents representing four jurisdictions stated that dementing drivers can be licensed—if, for example, a medical professional judges the patient safe to drive and/or the patient performs acceptably on a road test. Generally speaking, these would be people in the early stages of dementia. The majority (7) of respondents, in expressing their personal opinions, agreed that some drivers with mild dementia can function well enough to drive safely. This is congruent with licensing practice in California, as described by Janke (1994).

The majority of respondents also reported no recent or pending law or procedural changes in their jurisdictions relating to licensing elderly people, but 3 jurisdictions did report such changes, one a study in progress.

The beliefs, policies, and practices of licensing agencies served as an indicator of the degree to which elements in a proposed assessment system are likely to be accepted. Survey results showed that while there was almost an even split among jurisdictions as to whether testing solely on the basis of advanced age might be feasible, when answering on the basis of their own beliefs the respondents showed a definite preference for using something other than, or in addition to, age as a criterion to justify testing. Those who believed that administering special tests to people above a certain age would be beneficial recommended very advanced ages as the trigger for such testing. The opinion was given that current tests are not valid predictors of safe-driving ability, especially for drivers with cognitive loss; this would imply an element of unfairness in subjecting, on the basis of age alone, one segment of the population to special testing and to the risk of losing the driving privilege.

However, if tests predictively valid for driving performance or driving record could be found or developed, and if they were operationally feasible and not overly time-consuming, the responses described above suggest that many jurisdictions would be willing to adopt them. A relevant question here is whether such tests—probably brief and superficial ones—can be valid predictors. This consideration led to the idea of staging in terms of tiers of tests. In such a system the first-stage screening tests, either of all drivers or only of those beyond a certain age, might not have high reliability and validity, but they might still serve a useful function in triggering referral to more extensive and better tests, including actual driving tests. These ideas also will be revisited in Part 6.

## REFERENCES (PART 5)

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## PART 6
## Research and Policy Implications

This concluding section will discuss study implications for policy and research, citing applicable findings of the present project and other investigators, and will recommend tests which proved to be predictively useful in San Jose or Novato and are judged to be practicable for licensing agency use. Because of the very preliminary nature of the project these are, of course, only tentative suggestions. Nevertheless they might be used to construct a workable assessment system for drivers with aging- and driving-related impairments (or those with driving-related impairments regardless of age) and to implement this system in a licensing agency. Note that we have used the term “workable” instead of “model”; as knowledge and technology advance and affordability increases, what is considered a model system today may be outmoded tomorrow. Perhaps a realistic short-term goal would be to develop a system substantially better than present licensing tests.

*Research and developmental needs*

The studies described above were limited pilots, and at most could identify certain tests as showing promise. To verify that those or other tests will function consistently and effectively to identify impaired drivers, predict road test performance or, in the case of the road test itself, allow valid decisions to be made regarding the driving competency of individuals as opposed to groups, will require an extensive research program.

It may be asked at the outset whether the driving hazard imposed by elderly drivers as a group is sufficient to warrant such a research program. Aggregated crash rates over a given period of time are low for the elderly (Gebers, Romanowicz, & McKenzie, 1993) and in current numbers, at least, they do not seem to represent a significant threat to the wider public (Janke, 1994; Dulisse, 1997). To a great extent this is because, more than younger people, they limit their own driving and thereby reduce their risk (Hakamies-Blomqvist, 1994). However, the crash rates per distance traveled are relatively high for older people (Gebers et al.), so even if it can be assumed that there is, and in future will be, very little excess risk to other road users attributable to the group of elderly drivers because of their self-restriction, there may still be legitimate concerns regarding excess risk to physically vulnerable elderly drivers themselves and their (perhaps equally vulnerable) passengers. Hennessy's (1995) study of vision tests administered to drivers of a wide range of ages suggested to him that the self-restriction of the group aged 70 or more tends to be less than wholly adequate to compensate for worsening impairments of multiple visual abilities critical to safe driving. The average crash rate per year for older drivers as a group does begin to rise somewhat around the age of 70, and this may be due to an increasing number of severely impaired people within that age group—people having not only vision problems but also, in some cases, other impairments tending to impair driving. The most important of these are probably cognitive, because in affecting judgment they affect the adequacy of the driver's compensatory behavior. Of relevance to this issue, Johansson, Bronge, Lundberg, Persson, Seideman, and Viitanen (1996) found, in a matched case-control (suspended vs. not suspended) study of drivers over age 65, that case subjects with crashes on record showed significantly more cognitive impairment (as shown by the MMSE, clinical dementia rating, and performance on cube-copying and recall tests) than did control subjects without crashes; their cognitive impairment was also greater than that of case subjects with moving violations on record but not crashes.

Short of an extraordinarily resource-intensive effort, it can be seen that research to select and validate better (not necessarily the best possible) tests would be useful to licensing agencies. For purposes of increasing the adequacy of compensatory behavior in drivers who are not cognitively impaired, providing knowledge of their test performance in relationship to that of others and suggesting appropriate "advisory restrictions" may have a salutary effect. This implies a need for reliable, valid, and (very important to a licensing agency) easily administered nondriving tests. Insofar as possible test scoring should be automated, and interpretable results should be immediately available to licensing agency staff so that drivers can be apprised of their performance. It will be recalled that an automated version of WayPoint was recommended in Part 3, to obviate the need for error-prone stopwatch measurements. The need for additional development of the more complex simulator-type measures has also been stressed; in their present form it may not be feasible for driver licensing agencies to administer them.

This need is particularly compelling because such tests, everything else being equal, potentially have more ecological validity than others; good performance on them requires a combination of abilities very similar to those used in real-world driving. An ecologically valid test may well show more value in predicting on-road performance, including response to emergencies that would rarely arise on a road test, than would a battery of more abstract exercises, a point made by Schiff and Oldak (1993).

In seeking to find better methods of assessing elderly drivers, there are undeniable research problems in the proliferation of small-sample studies, each using different tests. Our present study is an example of this. Nothing truly definitive can be concluded; estimates of population parameters are inflated without the possibility of cross-validating relationships; the studies at our two separate sites are not comparable because of the different test batteries used and the differing populations of participants. What seems needed above all for more informative studies is selection of a limited number of test domains and tests, and validation of those tests using a large probability sample. Other research tasks remain before an assessment system is finalized. Norms and pass/fail cutoffs for licensing purposes need to be developed. Once these are determined for a specific test battery, it should be possible to simulate the flow of drivers through the three (or whatever number of) tiers of the assessment system so that an agency can estimate, for example, how many individuals will be required to take a road test.

If research into elderly driver performance assessment is judged to warrant—and obtains—a large resource base, several large probability samples would be desirable, representing for generality several jurisdictions. This would also allow simultaneous evaluation of different candidate assessment batteries and cross-validation of results. But since many tests tap very similar functions or dimensions of behavior relevant to driving, it should be possible on the basis of what is now known to put together and set about validating a battery which taps those functions and is likely to be better than those most licensing agencies presently have.

One study it would be interesting to pursue (assuming that registration of responses is made fully reliable) would involve use of a scoring change made by Doron at our request, specifically our request to score both the initial response made to a critical stimulus and the first correct response. This change would apply to any Doron test, not only Cue Recognition; in fact it was requested specifically for the purpose of scoring the hazard perception/response (crash avoidance) test we had planned to give. Informal observation of the response printouts indicated that on some occasions a subject's first reaction was to press the accelerator harder. Serious crashes caused by this sort of error on the part of an elderly driver are often given wide media coverage; is the error more characteristic of the elderly? Is it more characteristic of certain individuals—that is, do some people, because of impairments, personality type, or some other factor, show a consistent tendency to make this kind of error when faced with a sudden need to react? Answers to these sorts of questions would have intrinsic psychological interest as well as important implications for driver licensing.

The Doron tests, and simulation tests in general, would be much more suitable for licensing-agency use if they were converted to a personal-computer format. In converting such tests as Cue Recognition the stimuli should perhaps still be viewed on a wide projection screen, because it may be that compression of stimulus displays to the size of a computer monitor takes away from an essential feature of these tests—the rapid scanning of a spatially extended stimulus field which they (like the real-world driving task) require. In any test-conversion project, it seems that research to determine what functions are being measured by the converted test as compared to the original one should proceed hand-in-hand with the development. That brings the discussion to a general consideration of what is measured by specific tests, a question whose answer is sometimes approached through using the techniques of factor analysis.

The nondriving tests explored in this project typically measured a hierarchy—perhaps better, a linked sequence—of actions whose performance implied certain abilities. In the MultiCAD visual function tests, for example, for good performance it was necessary to comprehend the task, discriminate the presence of a stimulus in one location vs. the absence of a stimulus in two others, form a correspondence between the position of the stimulus (one of three faces of a traffic signal light pictured on a screen) and the position of one of the three response buttons on the hand-held keypad, and push the correct button before the 5-second time limit ran out. Disregarding guessing, if any element in this chain was incorrect or overly delayed then the final response was incorrect or missing. All of these types of abilities may be involved and even inextricably linked in driving, so for purposes of predicting driving performance it is not necessary, and perhaps even counterproductive, to separate them. But for greater theoretical understanding which might allow diagnosis or remediation of a particular type of driving-related problem, it would be desirable to engage in basic research on a wide variety of tests to better understand exactly what abilities they are measuring. It seems unlikely that this can be done through factor analyses like the purely illustrative ones presented here, even if a sufficiently large sample is involved. A better start might be obtained through rational analysis of the tasks which are involved in responding to test demands. This might be accomplished through something like the Critical Decision Method of Klein, Calderwood, and MacGregor (1989), a procedure for efficiently gathering data from knowledgeable performers on the bases for proficient performance of naturalistic tasks.

With respect to driving tests specifically, there are additional research areas that deserve attention. Alternative or supplemental forms of the test could be explored. One form might be an off-road skill test which would be taken by impaired drivers prior to going on the road, in order to determine whether road-testing would be too hazardous. Such a test, which could be conducted in a field office parking lot, might include, e.g., parallel parking between cones, completing a three-point turn, and backing. While some might argue that crashes are unlikely to occur during such maneuvers in the real world and therefore it is unnecessary to test them, drivers' execution of the maneuvers would give examiners information as to how well they appreciate spatial relations and physically handle their vehicles, as well as the extent and efficacy of their visual checking of the surrounding field. Additionally, further research on the kind of closed-course driving test that incorporates cognitive exercises or response to emergency situations would be welcome, even though this kind of test would probably not be feasible for operational use by a licensing agency. Such tests are probably more valid than the analogous simulator exercises and have been used with good results by Fitten, Perryman, Wilkinson, Little, Burns, Pachana, Mervis, Malmgren, Siembieda, and Ganzell (1995) and by Dobbs et al. (in progress), among others. Given the current interest in dementia, more research into destination tasking would be useful as well, comparing road tests using different types of destination tasks to a "standard" test on samples including cognitively impaired and cognitively intact drivers. It will be recalled that the MDPE included a destination-finding task, and findings of the present study indicated that a certain type of error ("concentration") made on this task was more characteristic of subjects who were cognitively impaired.

*Policy implications*

Ecological validity of tests has been mentioned above as a factor making for better prediction of driving performance. One facet of the driving task is the need for timely response to stimuli, and therefore tests which use response time in addition to response correctness to measure performance are more ecologically valid than others, everything else being equal. Even in the applicant-screening phase, ecologically valid tests may be preferable to those presently given, such as the current California knowledge and vision tests given to renewal applicants. If the vision test were automated response time could be captured, and data from the present study suggest that this would tell us something important about the adequacy of the applicant's visual functioning. In the knowledge test there is little interest in determining how fast applicants can read the questions and the alternative answers, but an automated knowledge test which not only minimized the verbal aspect of the test but timed applicants' responses (perhaps to icons including pictures of signs and diagrams of driving situations) might indicate the saliency of applicants' knowledge and also through its tapping of cognitive adequacy have enhanced predictive value for their driving performance.

For drivers who fail or perform only marginally on nondriving tests, a road test is widely regarded as the gold standard of driving competency. Failure of this test, however, need not always lead to withdrawal of licensure for drivers with detected driving-related impairments. In place of license withdrawal there can be graded or conditional licensing; i.e., imposition of appropriate restrictions or conditions on the license (Malfetti & Winter, 1990). Research needs to be done on how to assign suitable restrictions based on test performance, but also policy makers should be aware that, in a broad sense, any measure that reduces exposure will reduce risk. Very practical research and policy concerns arise with respect to restrictions. For instance, if an area restriction is being considered, how can it be assured that the examiner will be sufficiently familiar with the test area to administer a valid test? Would restriction to an area delimited by a particular radius be better or worse than restriction to particular roadways, considering both subsequent driver record and reported satisfaction of the driver's mobility needs? Do older drivers generally adhere to their restrictions, or do their driving records show traffic citations or crashes in certain areas or at certain times of the day that would not appear if compliance were perfect?

It has been mentioned that, for graded licensing purposes, the assessment system should furnish information to drivers upon which they (or their close family members, in case driver judgment is impaired) can base an informed decision as to the type of driving situation to avoid, and ultimately as to whether driving has become too dangerous to be undertaken at all. At its best, a graded licensing program would offer feedback to drivers on their test performance relative to that of others, counseling on problem remediation and ways in which to compensate for problems that cannot be remediated (along with suggestions for alternative mobility options that might be used in conjunction with the ultimate compensatory strategy, giving up driving). It would also offer suggestions to the licensing agency of appropriate license actions, including imposition of restrictions. Absent such testing and counseling, it may be a good rule for older experienced drivers to avoid driving situations in which they are becoming uncomfortable; even if they do not know why this is so, there is probably a good reason for their discomfort. Part 4 of the present report has suggested, not surprisingly, that impaired drivers and their families are much more satisfied if workable accommodations such as agreed-upon avoidance of specific situations can be arrived at than if the driving privilege is totally withdrawn.

Some possible license restrictions were considered briefly in Part 1. A more controversial type of restriction that might be considered for cognitively impaired drivers is the requirement to drive only when another adult, acting as navigator or copilot, is present. California DMV has never seriously considered this, because it considers the license to be issued to an individual, not to a collective. However in California novices driving on an instruction permit are required to be accompanied by a licensed adult; even after licensure, over the last decade it has been possible to restrict drivers aged less than 18 to driving only in the company of a licensed adult for a period of time after their second traffic conviction or crash in 12 months. This may establish some California precedent, and it has also been mentioned in Part 5 that in the AAMVA survey (Appendix G) three jurisdictions reported at least rare use of such a restriction. One justification for the restriction might be that it would keep drivers with directional confusion (characteristic of some forms of dementia, and not unheard of in 'normals') from becoming lost. If a driver of any level of cognitive functioning becomes lost and is consulting a map or looking for street signs while driving rather than focusing on the traffic situation, he or she is probably more likely to be involved in a crash. The kind of confusion caused by dementia, and its results, can be much more severe, making use of a navigator even more valuable. On the other side of the coin, institutionalized use of such a license restriction would entail problems of assuring the competence of the navigator or copilot and of determining where the legal responsibility would lie if an accident occurred.

In the absence of a human guide, navigational problems may eventually be mitigated by technology. And going beyond simple navigational assistance, Michon, Smiley, and Aasman (1990) have reported a project to develop a Generic Intelligent Driver Support (GIDS) or automated adaptive co-driver system, which would be capable of personalization to the individual driver. It would model the driver's representations of the driving task and prevailing circumstances, in addition to driver characteristics such as age, experience, and functional deficits. However, this promising system is as yet unrealized, and the degree to which it or similar systems could be used by drivers with substantial cognitive impairment is unknown.

Identification of drivers who might be considered for graded licensing has been discussed only in terms of test failure or report by physicians or others to licensing officials. It could also come about through use of an age-mediated point system. The latter was recommended by Gebers and Peck (1992) as a means of identifying high-risk older drivers, who could then be influenced in some way by the licensing agency. Their proposal was based on the finding of an interaction between age and violation point level; given the same number of violation points, older drivers showed a greater subsequent crash rate than did younger ones. Therefore departmental intervention was recommended to occur at a lower point level for drivers above, say, 70 years of age. Gebers and Peck suggested that an initial intervention, once a high-risk older driver has been identified by means of violation point count, might consist of an educational brochure or self-assessment guide designed to encourage the driver to think about his or her driving performance, and how various measures including self-restriction might improve it. A second-level intervention, they suggested, might be reexamination to diagnose the driver's deficiencies and perhaps, on the basis of this, to initiate remedial or license control actions. Among the latter they listed imposition of restrictions by the licensing agency.

It seems entirely appropriate and just that driving record inspection be one way in which a high-risk older driver, perhaps unidentified either by tests or by outside reporting sources, might enter a graded licensing system. This method of identification, unlike indiscriminate age-based testing, would select the very drivers whose impairments were causing them to have problems on the road. Equally impaired drivers who were already compensating adequately for their deficits would not be selected. A possible limitation of this strategy, however, lies in the unreliability of driving records—crashes are frequently a matter of being in the wrong place at the wrong time, and an element of luck is also involved in having one's traffic infraction become a matter of public record. This almost assures that only a minority of potentially unsafe drivers who are actively driving can be discovered through inspection of recorded crashes and traffic convictions. Gebers and Peck estimated on the basis of their data that, if a criterion of 3 or more accident or conviction points during the prior 3 years (associated with elevation of risk for older drivers) is considered, only 2% of the population of drivers above age 60 and 1% above age 70 have records meeting that criterion. Although it is possible that this small percentage simply reflects the small percentage of unsafe older drivers on the road, given the insensitivity of traffic records this seems unlikely.

An issue that has not been sufficiently addressed is that of administering additional tests to drivers on the basis of advanced age alone. California does have a degree of age-based testing for older drivers, in that those aged 70 or more must pass vision and knowledge tests to be licensed, while younger persons who are allowed to renew their licenses by mail can avoid them. It might be feasible in California to impose additional non-driving tests solely on the basis of age, since present law appears to forbid only examination of "driving ability" on the basis of age alone. (Of course, it is possible to interpret this wording as non-driving examination of more fundamental abilities necessary for driving.) Table 1 in Part 1 has shown that some states do impose age-based testing. In the AAMVA survey (Appendix G) representatives of 11 jurisdictions were asked whether a (nondriving) testing program, administered solely on the basis of age to identify drivers who would need to take a road test for license renewal, would be feasible in their jurisdiction. Six respondents felt that such testing was either already being done, could be done, or probably could be done in their jurisdictions, although in some cases a law change would be required to permit it. The other five respondents were negative, citing public resistance, expense, and a belief that age-based testing would be unfair. The point was made that this would be perceived as discriminatory unless the need for testing could be supported by valid research studies; elsewhere it was commented that current tests themselves are not reliable and valid predictors.

It may be argued that physical and mental impairments become common enough at advanced ages to justify requiring older license applicants to make a special demonstration of their competency before being relicensed, but the idea is repugnant to some people. It would be preferable to have some objective indicator of impairment on which to base the testing requirement, and this would be the beauty of, for example, an age-mediated point system used in conjunction with other methods, such as physician report or a formalized objective system of recording customer behavior in the field office. Failure of standard relicensing tests can be another objective indicator, and jurisdictions that do not routinely administer such tests are overlooking an obvious opportunity to identify possibly impaired drivers of any age. Other indicators are family, court, or police reports. Certainly these personally or professionally concerned individuals should at least be authorized to report drivers of questionable ability and thus initiate an inquiry by the licensing agency (this is not the case in all jurisdictions; for physician report in particular, see Table 1 in Part 1). The issue of legally requiring report by physicians of certain conditions is too complex to be addressed here, although it may be noted (Appendix E) that the health practitioners (mainly physicians) on the project advisory panel held as a group an essentially neutral position on the subject of mandatory physician reporting.

We believe that the procedures recommended in the next section for first-tier screening purposes could be applied to applicants of any age, although older persons would no doubt predominate among those performing poorly. If impairment is suspected, results of the San Jose study support a second tier, or system of more intensive testing, before a road test is given. In San Jose both non-driving and driving performance proved to be very heterogeneous among older drivers suspected of impairment (referrals), and, keeping in mind the probable inflation of population parameters discussed above, road test performance was predictable from non-driving tests.

If individuals' driving privileges are withdrawn, one concern is that less safe means of transportation will be adopted, which lead to even more injuries and fatalities than if some driving were allowed. This concern was raised in the study of the second author described in Part 4, and evidence for such an effect comes from a paper by Hakamies-Blomqvist, Johansson, and Lundberg (1996). Hakamies-Blomqvist et al. studied the traffic safety effect of medical screening for older drivers in Finland by comparing risk indices there and in Sweden, which has no age-related screening for licensure. (In fact, in Sweden individuals are granted a license for life, although in uncommon cases their driving privilege is revoked in response to a physician's report.) As risk indices, Hakamies-Blomqvist et al. studied not only the injury and fatality rates of private car drivers and passengers but also the fatality rates of unprotected road users (e.g., pedestrians, bicyclists). They found no difference in the crash risk of older drivers in Finland and Sweden, even though those licensed in Finland would be expected to be "the cream of the crop" of older drivers. At the same time they found more than twice as many traffic fatalities in Finland among unprotected road users aged 65 or more. The authors concluded that there are no safety-related reasons to implement age-related medical screening of the type practiced in Finland, and that such screening may even have a negative overall safety effect. Rather, they stated, any such licensing controls should focus on specific diagnostic subgroups known to have increased risk, and the negative traffic safety effects of the shift away from driving for those losing their licenses should be neutralized by offering safe transportation alternatives.

As impaired people or their families wrestle with questions of whether or when to give up driving and how to cope if that happens, it is helpful to be able to consult knowledgeable and empathetic counselors. In Oregon the licensing agency itself offers this (Milton, 1997; Part 5 of Janke, 1994). Oregon's program uses six driver improvement counselors who sensitively assess drivers, determine whether they should give up driving and, if so, help them move more easily into the new role of nondriver. Counselors inform these clients as to what transportation options may be available, how they can draw upon family or friends, and how they can become a part of community and senior citizen networks. Drivers in the program, which is seen by them as being more personalized and less threatening than the older "standard" one, appear somewhat more likely to give up driving voluntarily than those going through the standard program—though after entry into either, subsequent traffic incident rates drop dramatically, with crash rates typically being less than 20% and violation rates less than 15% of the pre-intervention rate (Jones, 1990).

*Recommended tests and procedures*

At both sites the numbers of subjects and the representativeness of the samples were inadequate to give valid prediction; moreover, as stated above there was no opportunity for cross-validation—a necessity before making any final testing decision, in order to avoid the capitalization on chance that occurred in these pilot studies. Recognizing this limitation, a battery of tests will nevertheless be recommended for consideration, based on findings at San Jose and Novato. A three-tier battery will be assumed, though this is not a necessity (see the discussion in Part 3).

Several tests showed promise—for differentiating the groups, predicting performance on the road, or both of these. There is also evidence that three of the tests, the Pelli-Robson, WayPoint, and PRT, are related to crash experience, as shown respectively in studies by Brown, Greaney, Mitchel, and Lee (1993), Cantor (in press; Stutts, Stewart, and Martell [1996] also found this for a test similar to WayPoint), and Hennessy (1995). A similar conclusion can be drawn from the extensive body of work (e.g., Owsley and Ball, 1993) on the UFOV test, of which the PRT test is a part.

*First tier.* For several reasons, the first tier of testing should be brief. One reason is that if they are brief enough, tests in a first-tier battery could become a routine part of renewal licensure for all, avoiding any flavor of age discrimination. It is recommended, first, that in addition to knowledge and high-contrast static acuity tests as used in California, the Pelli-Robson test of low-contrast acuity be administered. Hennessy (1995), studying various vision tests, pointed out that routine low-contrast acuity screening would facilitate for older people the early detection of progressive visual disorders—cataract and glaucoma are two of these—and thus make it possible to treat the degenerative process before it affected high-contrast acuity. Interestingly, he found that low-contrast acuity had crash-predictive value not only for drivers aged 70 or more but also for those aged 26-39, perhaps due to the "contact lens syndrome." For these reasons inclusion of the Pelli-Robson in a routine vision screening process is strongly recommended.

Second, there should be unobtrusive observation of applicants' physical or mental "problems" by well-trained staff who can refer persons with one of a list of objectively defined symptoms or signs for further examination. As seen in Table 2, Part 1, no discretionary drive tests, and only five referrals to Driver Safety, were noted in the sample of test results recorded for 1,501 drivers aged 65 or more. Drive tests required on the basis of some impairment (generally a physical one) observed at the field office are categorized as discretionary, or alternatively as a Driver Safety referral, since the driver may be referred to Driver Safety for investigation and possible scheduling of a reexamination. The fact that such cases essentially did not appear in this 25-office sample strongly suggests that observational screening, though authorized, is rarely used in California. Possible reasons for this may be avoidance of customer complaints and also the importance, with a large number of applicants, of not expending time on what may be seen as nonessential activities—i.e., those not mandated by law. The first consideration may be the most pressing. However, if all applicants were subject to observation and expected this, the complaint aspect might be mitigated.

It is easier to observe physical handicaps than mental ones; a suggestion was made by Sheila Prior of AAMVA at the project's Berkeley conference that the counter technician, who in California has the information on a computer screen, ask as a matter of "verification" for applicants' addresses, including ZIP codes. This might achieve two ends—in addition to suggesting memory impairment in some cases it might enable correcting the record of applicants who have moved and not notified the agency. Of course an objective protocol would have to be developed for staff to follow in making any judgment of possible impairment requiring further testing.

Additionally it may be hypothesized that an *adequate* knowledge test given to all renewal applicants would be sufficient to screen out most cases of cognitive impairment. Some states do not administer any such tests to renewal applicants, and this situation should be ameliorated. Moreover, the tests that are used may not be entirely adequate. It should be possible to modify present tests to make them not only tests of crystallized knowledge but dementia screens. For instance, diagrams of traffic situations could be incorporated in the tests in which drivers would be required to state what they should do if they were driving car A, and then what they should do if they were driving car B. The switching of attention and point of view required in such a task might prove to be especially difficult for a person with cognitive impairment, and even without timing applicants' responses as proposed above, such modifications of the knowledge test might prove useful.

*Second tier*. For a second tier, it is judged premature in terms of time and cost as well as reliability grounds to recommend in their present form tests like Cue Recognition or the MultiCAD battery for licensing agency use. Cue Recognition, with the old scoring system, was very useful predictively in San Jose, though the equipment necessary for its administration is costly. MultiCAD also was very promising at San Jose, but it is judged to need further development. Even should this occur it is still questionable whether any licensing agency can afford several simulator-type systems for placement in its field offices, so activities with the aim of converting these tests to a personal-computer format while preserving their validity were recommended above. For present licensing agency use, it is recommended that the second assessment tier, installed on a PC, include an automated form of Trail Making (Trails B, as in WayPoint, might be better than Trails A, as in Auto-Trails) and to supplement this the UFOV test's PRT, or perceptual speed, module, which has been successfully adapted to PC use. If possible, a low-contrast version of the PRT test should be combined with this as discussed in Part 3 (it could potentially replace the Pelli-Robson), and all tests should have automated timing and scoring to avoid error. The timed-response aspect seems very important for the second testing tier; our experience at San Jose indicated that tests demanding a timely response—unlike reading a wall chart, for example—predict driving errors best.

Into the foreseeable future, the more complex simulator tests would probably be better administered by professionals like occupational therapists than by driver licensing technicians. Administering these tests is a demanding task. It is necessary not only to know how to "run" the tests but also how to monitor the subject knowledgeably in case his or her performance is degraded because of an equipment problem, failure to understand instructions, or some other factor. If there is a simple misunderstanding of instructions, it is important for the test administrator to be able during initial practice trials to detect the problem and clarify the subject's task. Long-term experience in administering tests to functionally impaired persons, and in particular the specific test being used, would do much to assure valid results.

Beyond the simulation tests investigated in San Jose and Novato, exceedingly complex simulator systems are being investigated now, although in their present form they appear to be solely research tools. Rizzo, Reinach, McGehee, and Dawson (1997), using the Iowa Driving Simulator (IDS), have reported successfully differentiating elderly subjects with Alzheimer's Disease from non-dementing subjects of the same age by means of crashes and related performance errors on a high-fidelity interactive driving simulator. (Since drivers with possible health problems other than dementia were exposed to realistic road hazards in the scenarios presented by Rizzo et al., perhaps it should be noted that the research assistant who familiarized them with the vehicle controls, remaining in the front passenger seat throughout the test, was “generally” a registered nurse who measured subjects’ vital signs and monitored them for signs of discomfort or fatigue. Such an arrangement was not possible at Novato, its lack being one reason why it was decided not to administer a realistic crash avoidance test on the Doron system.) The IDS itself is expensive enough to be completely out of reach of licensing agencies, but as Rizzo et al. wrote, effective scenarios from advanced simulators might be transferred to lower-cost, standardized, static-base simulators for greater public use and benefit.

Finally, the Cue Recognition tests and the MultiCAD driving video required timely response to a critical stimulus or potentially hazardous situation, respectively. Good performance on these did not necessarily require excellence in vision (although visual abilities obviously played a role), but did demand adequately fast and accurate information processing. In a logistic regression described in Part 2 using second-tier measures, total errors over all the Doron tests (simple reaction time and the Cue Recognition modules) and on the MultiCAD driving video (the gross error measure) differentiated cognitively impaired from cognitively unimpaired referrals. This suggests that cognitively impaired people would also be disadvantaged in actual road tests if potentially hazardous situations arose, and that a timed test of hazard perception and response may be valuable in screening drivers for cognitive impairment. It is strongly recommended that such a test be studied and considered for inclusion in the final second-tier test battery.

*Third tier*. The MDPE, weighted errors on which acted as the criterion measure in our project, appears to be useful for assessing older, experienced drivers whose abilities may be impaired. The weighted error measure MSCORE, as well as the number of concentration errors, were found in logistic regression analyses to discriminate between referrals and volunteers at San Jose. MSCORE also discriminated between frail and nonfrail drivers at Novato. Concentration errors, in addition to differentiating San Jose referrals from volunteers, discriminated between cognitively impaired and cognitively unimpaired referrals.

While the MDPE can probably be improved, it is recommended on the basis of our experience with it that it or a similar road test be used as the standard in evaluating the driving competence of possibly impaired elderly drivers. The area test or ADPE cannot be as standardized as the MDPE; this was pointed out above. However, in its present form it contains component tasks—following multiple instructions, driving to familiar destinations—which, in addition to the usual maneuvers, are recommended for use in any case involving a driver too impaired to drive unrestrictedly who needs to be assessed for driving competence in a limited, less demanding, environment. Such a test is one of the necessary bases of a graded licensing system in its attempt to devise workable tradeoffs between increments of safety and increments of mobility for individual drivers.

It is specifically recommended that the Scientex study currently under way (Staplin, Model Driver Screening and Evaluation Program, in preparation) explicitly consider and, when necessary, further the development of the tests that have been recommended here, then evaluate those tests in a large-scale field trial. While Staplin's study is not limited to the elderly, aging-related impairments—perhaps more than any other kind—will be a focus of its attention. If a useful assessment system is to be put into the hands of licensing agencies within any reasonable time period, it is necessary at some point to cut off the cycle of preliminary pilot studies in which each is provocative but insufficiently informative. An extensive base of field data from which sound conclusions can be drawn is a research necessity.

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# APPENDIX A

## MODIFIED AND AREA DRIVING PERFORMANCE EVALUATION MODULES

*OVERVIEW*

**Introduction**

This document includes basic procedural information concerning the administration of the Modified and Area Driving Performance Evaluation Modules (MDPE and ADPE).

**Contents**

The document is divided into the following sections:



The MDPE and ADPE score sheets appear at the end of Appendix A (pages 231 and 232).

## MDPE AND ADPE

### *GENERAL INFORMATION*

**Background**

The National Highway Traffic Safety Association (NHTSA) is addressing the growing population of aging drivers in the United States (U.S.). They funded the Dementia/Age- Related Frailty Project to create a model system which could be used throughout the U.S.

The AAMVA Advisory Board is sponsoring an effort to develop such a model. California was tasked to develop a model assessment system which would address particularly the dementia aspect of aging as it relates to a driver's ability to continue to safely operate a motor vehicle in today's driving environment.

The driving instrument to best evaluate the effect of dementia on the operator may be a form of the Driving Performance Evaluation (DPE). The department has developed two driving evaluation modules for the purpose of gathering data for this project.

**Evaluation Modules**

A referred applicant will be administered the following modules:

- **Modified DPE (MDPE)**
  The Modified DPE is administered at the field office. It does not include a freeway segment. In place of the freeway segment a merge maneuver is performed on surface streets.

  The Modified DPE includes a Destination Trip. The destination trip begins at the DMV office and involves the examiner's directing the applicant to a destination and then the applicant's reversing the route from memory and driving back to the office.

- **Area DPE (ADPE)**
  The Area DPE is administered in the applicant's community. It does not include a freeway segment or merge maneuver. In place of the freeway segment and merge maneuver is a multiple directions section.

  The Area DPE includes Destination Trip(s). The maximum amount of total time allowed for the Destination Trip portion is 30 minutes. Within the 30 minutes, 1 to 3 destination trips may be performed. The destination trips involve the applicant's driving to a familiar destination (doctor's office, bank, grocery store, etc.) and then back home again. Each trip is to begin at the applicant 's home, unless the applicant takes the same route to more than one destination (bank and grocery store in the same shopping center, etc.)

## MDPE AND ADPE Page 3

### *GENERAL INFORMATION, continued*

**Main Objective**

The objectives of the modules are to determine whether the applicant:

- Has the ability to operate a vehicle competently and safely on any road and/or highway.
- Has the ability to operate a vehicle competently and safely within a certain area.
- Has the ability to operate a vehicle competently and safely on specific streets.
- Has formed proper habits for safe driving.
- Can translate knowledge of traffic laws into actual practice.
- Compensates for any disabling physical conditions that may be present, such as low vision, poor hearing, or loss of limb. Compensation might include use of corrective lenses, extra mirrors, a prosthesis, etc.

**New Forms**

Four new forms have been created for this study.

- Visual Acuity Scores, Class C - used to record the vision test result. This is in addition to keying the results in the Series/1 and recording the vision results on a DL62 or DL 11A.
- Supplementary Test: Traffic Sign Knowledge and Perception. This test will be administered by the Graduate Student Assistant (GSA) assigned to the study. It is in addition to the law test administered by the field office employee.
- Modified Driving Performance Evaluation Sheet used to score the Modified DPE administered at the office.
- Area Driving Performance Evaluation Sheet used to score the Area DPE administered at the applicant's residence.

## *REGISTRATION AND INSURANCE*

**Registration and Insurance Requirement**

All vehicles used must have a license plate located at the rear of the vehicle displaying current registration sticker(s), and must be insured. The following indicates what is acceptable for plates, registration sticker(s), and proof of insurance.

**If any requirement is not satisfied, the evaluation is to be re-scheduled.**

| Item | Requirement |
|---|---|
| Plate(s)/Registration Sticker(s) | California registered or out-of-state registered vehicle must display<br>• at least a rear plate and current sticker(s), or<br>• California Temporary Operation Permit (Reg 19)<br><br>**NOTE:** Presentation of a registration card is not mandatory. |
| Insurance | Evidence of insurance may be:<br><br>• Any document with the insurance policy number or surety bond number and the name of the insurer.<br>• A certificate or acknowledgment of deposit issued by the DMV to a owner who is self-insured or a depositor.<br>• Current insurance binder agreement.<br><br>**IMPORTANT:** For a rental vehicle, the applicant's name must appear on the rental agreement and the contract must not exclude driving tests. |

## MDPE AND ADPE — Page 5

### *ELEMENTS OF THE MODIFIED AND AREA DPE*

**Modified DPE Elements**

The following identifies each scoring segment of the Modified DPE:

| *Element* | *Detail* |
|---|---|
| Pre-drive Checklist | The pre-drive checklist is used to determine whether the driver 's vehicle and the driver's knowledge of the vehicle meet the department's minimum safety standard. |
| Parking Lot Driving | • Reacts safely to vehicles and pedestrians.<br>• Observes signs and lane markings. |
| Backing | Backs a vehicle in a straight line approximately three vehicle lengths. |
| Street Park | Applicant pulls to the side of the road and parks, then pulls back into traffic. |
| Intersections | • two controlled by a light (red, yellow, and green).<br>• two controlled by a stop sign.<br>• two through (straight ahead) intersections not involving stops.<br>• two additional intersections (preferably intersections controlled by traffic lights, but can be any of the above). |
| Turns<br>• four left<br>• four right | • mixed difficulty levels.<br>• at least two left and two right turns should have multiple lanes requiring correct lane choice on approach and finish.<br>• two at signal-controlled locations<br>one left<br>one right<br>• two additional turns (preferably at intersections controlled by stop signs, but may be uncontrolled with limit lines, crosswalks, turn lanes, etc.). |
| Residential Section | minimum 3 blocks; preferably a narrow street. |
| Business Section | • minimum 3 blocks.<br>• moderate traffic density. |

## *ELEMENTS OF THE MODIFIED AND AREA DPE, continued*

**Modified DPE Elements, Continued**

| *Element* | *Detail* |
|---|---|
| Merge | Use a lane drop where two lanes are merging into one. |
| Curve | • preferably a left curve.<br>• lanes should be marked if possible.<br>• must require driver to adjust speed.<br>• located anywhere on the route. |
| Destination Trip | The destination trip begins at the DMV office and involves the examiner's directing the applicant to a destination and then the applicant's reversing the route from memory and driving back to the office. |
| Lane Changes | • one lane change to the right.<br>• one lane change to the left.<br>• located anywhere on the route; preferably at higher speeds. |

**Area DPE Elements** The following identifies each scoring segment of the Area DPE:

| *Element* | *Detail* |
|---|---|
| Pre-drive Checklist | The pre-drive checklist is used to determine whether the driver's vehicle and the driver's knowledge of the vehicle meet the department's minimum safety standard. |
| Destination Trips | Destination trips are those trips that must be made from the applicant's home to a familiar destination and back; i.e., doctor's office, bank, grocery store, etc. At least one of the destination trips should include parking lot driving. The destination trips are the first part of an area evaluation. |

## MDPE AND ADPE Page 7

### *ELEMENTS OF THE MODIFIED AND AREA DPE, continued*

**Area DPE Elements Continued**

| *Element* | *Detail* |
|---|---|
| Turns | • mixed difficulty levels.<br>• at least one left turn and one right turn should have multiple lanes requiring correct lane choice on approach and finish.<br>• two at signal-controlled locations<br>one left<br>one right.<br>• two additional turns (preferably at intersections controlled by stop signs, but may be uncontrolled with limit lines, crosswalks, turn lanes, etc.). |
| Lane Changes | • two lane changes to the right.<br>• two lane changes to the left.<br>• located anywhere on the route; preferably at higher speeds. |
| Multiple Directions | At three different locations, direct the applicant to perform two different tasks consecutively, e.g., turn left at the corner and then make a right lane change. |
| Street Park | Applicant pulls to the side of the road and parks, then pulls back into traffic. |
| Intersections | • two controlled by a light (red, yellow, and green).<br>• two controlled by a stop sign.<br>• two through (straight ahead) intersections not involving stops. |

**Page 8** **MDPE AND ADPE**

## *CONDUCTING EVALUATIONS*

| | |
|---|---|
| **Explaining the Evaluations to Applicant** | Before starting the evaluation, explain to the applicant what will be occurring. Below are statements to use in explaining what is going to occur on the evaluation. Always use statement number 1. The others are suggestions that can be used in your pre-drive instructions to the applicant.<br>1. You will be evaluated on your ability to drive safely and skillfully in different driving situations.<br>2. The evaluation includes noting safe and unsafe driving practices and your ability to make decisions.<br>3. I will be an observer, giving directions ahead of time, such as where to turn.<br>4. If I do not say anything, you should follow the road and signs, unless I ask you to do otherwise.<br>5. I will not try to trick you or ask you to do anything illegal.<br>6. I will be marking the sheet while you drive, but this does not necessarily mean you have done something wrong. |
| **Turn Signals** | Inform the applicant that electric turn signals will be required during the evaluation even on occasions when not actually required by law, i.e., when no other vehicle would be affected by the maneuver. |
| **Use of Brake Pedal** | The department is neutral regarding which foot should be used on the brake pedal. The examiner should only be concerned with the proper control and effective use of the brakes.<br><br>It is not an error when an applicant uses the left foot on the brake (when there is no clutch pedal) unless the applicant is pressing the right foot on the accelerator while simultaneously braking with the left foot. |
| **Giving Directions During Evaluation** | Be sure to speak clearly and distinctly. Always state where to perform a maneuver before you say what to do.<br><br>Do not use phrases or words that are **instructional**, such as light, signal, and stop sign. You are helping the driver by pointing these items out. |

## MDPE AND ADPE — Page 9

### *CONDUCTING EVALUATIONS, continued*

**Giving Directions During Evaluation, continued**

If an applicant fails to follow directions, do not correct the applicant unless the action would result in a hazardous situation. Continue with the evaluation and give directions that will bring the applicant back to the route.

**NOTE:** Give directions, not instructions.

**Suggested Phrases for Giving Directions**

The chart below gives suggested phrases for directions and for referring to the elements.

| *Elements* | *Suggested Phrase* |
|---|---|
| Turn at a intersection with a light. | At the major intersection make a right turn, please. |
| Signal light with other side streets preceding it. | First major intersection. |
| Residential areas; stop, yield, or uncontrolled. | At the first street (or corner) make a right turn, please. |
| Turn at an uncontrolled intersection or one controlled with a stop sign. | At the first (or next) intersection make a left turn, please. |
| T intersection | Cross street, or when road ends. |

**Directions for Destination Trip(s).**

There are two types of destination trips.

The first type is performed at the field office. The examiner will direct the applicant to a designated location and then have the applicant reverse the route and drive back to the office from memory.

The second type is performed at the applicant's residence. The maximum amount of total time allowed for the Destination Trip portion is 30 minutes. Within the 30 minutes, 1 to 3 destination trips may be performed. Inform the applicant to drive to up to three different locations that they drive to on a regular basis; e.g., bank, doctor, church, grocery store, etc. On each trip start from home and return back to home. The applicant selects the location(s) and route(s).

## *SCORING OF EVALUATION*

| | |
|---|---|
| **Scoring Objective** | The score sheets and scoring criteria break down each maneuver into a series of tasks and behaviors that the driver must perform correctly. The scoring criteria provide the examiner with explicit objective cues and standards for deciding if a behavior was performed correctly. If the task and/or behavior is not performed according to the criteria, the examiner marks the appropriate space on the score sheet. |
| **Score Sheets** | The Modified DPE score sheet consists of a pre-drive, nine driving maneuvers, and a destination trip.<br><br>The Area DPE score sheet consists of a pre-drive, five driving maneuvers, and destination trip(s).<br><br>The three principal purposes of score sheets are:<br>• To document the standard of driving required of all applicants.<br>• To make examining techniques and passing requirements uniform.<br>• To record the driving performance results. |
| **Disposition of Score Sheet** | Do not give the score sheets to the applicant.<br><br>For applicants referred by Driver Safety, make a copy of all score sheets. Send the originals to the referring Driver Safety office and give the copies to the GSA.<br><br>For applicants who are volunteers, give all the score sheets to the GSA. |
| **Scoring the Pre-Drive** | The evaluation starts with a pre-drive checklist. Each item has a box next to it. If the vehicle and/or the applicant meets the criteria, check the box for that item. If the criteria are not met, circle the number of the item. |
| **Scoring the Destination Trips** | Using the element criteria (for turns, intersections, etc.), everything is scored on a destination trip. If an error occurs at an intersection or on a turn, the item is marked. |
| **Scoring the Road Test Maneuvers** | For each category, there is:<br>• A list of driver behaviors to be scored.<br>• A 0 is used to mark the driver behavior error beside each behavior within the category.<br>• A bolded letter or number is at the top of each column of 0s. |

**MDPE AND ADPE** **Page 11**

***SCORING OF EVALUATIONS, continued***

**Scoring the Road Test Maneuvers, continued**

Use the following method for tracking when a maneuver is scored:

- Immediately before scoring a list of driver behaviors, circle the bolded letter or number at the top of the column of 0s.
- If the driver performs the maneuver incorrectly, draw a line through the 0.
- If the driver performs the maneuver correctly, **do not** make a mark through the 0.
- If for some reason a maneuver is not scored, draw a vertical line through the entire column of 0s for that maneuver.

**NOTE:** Do not score items unless you actually observe them. If the route or traffic conditions do not permit a maneuver to be performed, draw a line through the entire column of 0s for that maneuver.

**Terminating Evaluation**

The Modified DPE and Area DPE can be terminated immediately if the applicant’s lack of driving skills is creating a clear danger to the motoring public or if the examiner has to intervene to avoid a collision with other vehicles or pedestrians.

If performance on the Modified DPE is terminated for extreme hazard and the examiner believes that familiarity with a specific route would not help, then the applicant need not be scheduled for an Area DPE.

**This should be a rare occurrence, and used only in extremely dangerous situations.**

**Score as You Go**

Mark the score sheet when a driver does not perform a maneuver according to the scoring criteria. ***Do not*** **depend on your memory to do so later.**

**Completing the Modified and Area DPE Score Sheet**

At the end of the evaluation complete the Comments section. Review the scoring form and check that everything is marked clearly and correctly. Be sure you lined out the maneuvers that were not performed during the evaluation. Carefully add up the number of marked 0s and write the total in the NUMBER OF ERRORS space.

**EXCEPTION:** If the evaluation was terminated because of examiner intervention or due to poor driving skills, write Terminate in the NUMBER OF ERRORS space.

## *SCORING OF EVALUATION, continued*

**Always Double Check Calculations**

Before informing the applicant of the number of errors made and before entering the total number of errors in the NUMBER OF ERRORS space, always double check to be sure that you have added correctly.

**Comments Section**

This section provides an area on the score sheet to:

- Describe how the driver failed to meet the specific scoring criteria.
- Describe in detail any driver action or examiner action that resulted in the evaluation's being terminated.

**Informing Applicant of Results**

Use the following chart in informing the applicant of the results:

| *If the applicant has...* | *then tell the applicant they have...* |
|---|---|
| passed | passed this portion of the test, but that all tests will be considered by the Hearing Officer in making the licensing decision. |
| failed | failed this portion of the test, but **that** all tests will be considered by the Hearing Officer in making the licensing decision. |

**NOTE:** For the paid volunteers, inform them of the results and that no licensing decision will be made based on the test results.

**Completing the Driver Safety/Field Referral (DL 11A)**

Complete a Driver Safety/Field Referral (DL 11A) after completing each evaluation. This will result in two DL 11 A's for each applicant who takes the Modified DPE and the Area DPE.

For Driver Safety referral applicants, both DL 11As are sent to the referring Driver Safety office.

For paid volunteer applicants, both DL 11As are given to the GSA.

## MDPE AND ADPE — Page 13

### *SCORING CRITERIA FOR EVALUATIONS*

**Introduction**

The detailed scoring criteria are designed to maximize scoring consistency.

**Pre-Drive Checklist**

This section specifies the requirements for each item on the Pre-drive Checklist. If any one of items 1-8 or 15-17 is not satisfactory, rescheduled the evaluation.

If four or more of items 9-14 are not satisfactory, postpone and reschedule the evaluation.

| *Item* | *Requirement* |
|---|---|
| 1. Driver window | The window on the driver side must open. (If the window is closed, have the applicant open the window.)<br><br>**NOTE:** The window may be closed again after the demonstration. |
| 2. Windshield* | The windshield must provide a full unobstructed field of view for both driver and examiner. |
| 3. Rear view mirrors | The vehicle must have at least two mirrors. One must be located outside on the left side of the vehicle. The other may be located inside center or on the outside on the right side of the vehicle.<br><br>Mirrors must be secure and provide visibility to the rear. |
| 4 Turn signals | Both right and left turn signals in the front and back of vehicle must work. |
| 5. Brake lights | Both brake lights (one on each side of the vehicle) must work.<br>**NOTE: "**Both" does not include the cyclops light on newer vehicles. |
| 6. Tires* | Each tire must have 1/32" tread grooves and two major adjacent tread grooves.<br>**NOTE:** The major grooves are in different locations, depending upon the type of tire. |
| 7. Foot brake | There must be at least one inch of clearance between the pedal and the floor board when the pedal is pressed. |

* In the agreement covering Bargaining Unit 7, Protective Services/Public Safety.

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## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Pre-Drive Checklist, continued**

| *Item* | *Requirement* |
|---|---|
| 8. Horn* | The horn must be:<br>• designed for a vehicle and in proper working condition.<br>• audible from a distance of at least 200 feet.<br>**NOTE:** The horn cannot be a bicycle horn. |
| 9. Emergency/ parking brake | Parking brake handle or pedal sets and releases.<br>If the applicant states that the parking brake does not work or if the brake does not set during the check, postpone the test.<br>NOTE: The examiner is not to test the parking brake while the motor is running and the vehicle is in gear. |
| 10. Arm signals | Correctly demonstrates arm signals for:<br>• left turn<br>• right turn<br>• slowing down or stopping. |
| 11. Windshield wipers | Correctly locates the windshield-wipers switch. |
| 12. Defroster | Correctly locates the defroster switch. |
| 13. Emergency flasher (4-way flashers) | Correctly locates the emergency flasher switch if vehicle is equipped with emergency flashers. |
| 14. Headlights | Correctly locates the headlight switch. |

* In the agreement covering Bargaining Unit 7, protective Services/Public Safety.

**NOTE:** In inclement weather, the applicant must demonstrate that items 11 - 14 are working properly or the evaluation will have to be postponed and rescheduled.

**MDPE AND ADPE** **Page 15**

***SCORING CRITERIA FOR EVALUATIONS, continued***

**Pre-Drive Checklist, continued**

| *Item* | *Requirement* |
|---|---|
| 15. Passenger door* | Passenger side door must open and close properly. |
| l6. Glove box* | Glove box door must be closed and securely shut. |
| 17. Seat belts | • Starting with 1968 passenger vehicles and 1972 house cars and trucks weighing less than 6001 pounds, the vehicle must have seat belts for both the driver and examiner.<br>• Both seat belts must work properly. |

* In the agreement covering Bargaining Unit 7, Protective Service/Public Safety.

**Parking Lot Driving Evaluation**

This section provides the criteria to evaluate the driver's ability to drive through a parking lot.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Parking Lot Driving** | N/A | Traffic check | • Driver is observing traffic (vehicle and pedestrian) ahead, to the left, right, and rear. Indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Yields right-of-way to pedestrians and vehicles when appropriate.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Observes signs and lane markings.<br>• Reacts safely to traffic situations. |
| | | Speed | Drives through the parking lot at a safe speed and in control of the vehicle. |

## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Street Park Evaluation**

This section provides the criteria to evaluate the driver's ability to park a vehicle along a curb and pull back out into traffic.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Street Park** | Entering and Exiting (E/X) | Traffic check E/X | • While entering, driver is observing traffic ahead, to the sides, and to the rear. This is indicated by head and/or eye movement to the left and right and use of mirrors.<br>• While exiting, driver is observing traffic ahead, to the sides, and to the rear. This is indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Checks appropriate blind spot.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Reacts safely to traffic situations. |
| | | Signal E/X | • Activates signal prior to entering and exiting the parking space.<br>• Cancels signal after entering and exiting the parking space. |
| | | Speed E/X | Enters and exits parking space at a safe speed and is in control of the vehicle. |
| | | Parking E/X | • Sets parking brake.<br>• Releases parking brake.<br>If parked on a hill:<br>• Turns wheel in correct direction to prevent rolling.<br>• Vehicle does not roll. (OK to block wheels against curb.) |
| | | Parallel | • Vehicle is parallel to and within 18 inches of curb, without hitting the curb.<br>• Performs maneuver with no more than one correction.<br>• Does not block driveway, etc. |

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***SCORING CRITERIA FOR EVALUATIONS, continued***

**Turns Evaluation** This section provides details on how to evaluate the driver's performance in turning.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Turns** | Approach | Traffic check | • Driver is observing traffic (vehicle and pedestrian) ahead, to the left, right, and rear. This is indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Checks blind spot before merging into bike lane or center left-turn lane.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Reacts safely to traffic situations. |
| | | Signal | Activates turn signal at least 100 ft. prior to turn, but not so early as to mislead other drivers as to intention. |
| | | Speed | • Decelerates and brakes smoothly.<br>• Presses brake pedal without pressing the accelerator at the same time.<br>• For manual transmission:<br>changes gears as necessary to maintain power<br>keeps gear engaged. |
| | | Lane | • Uses designated lane for turn.<br>For right turns:<br>—Enters bike lane where line is broken.<br>—Enters right-turn pocket lane at opening.<br>—Uses the right-most part of right lane. |

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## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Turning Evaluation**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
| --- | --- | --- | --- |
| **Turns, continued** | Approach, continued | Lane, continued | For left turns:<br>—Enters two-way left-turn lane within 200 feet of turn and does not violate the right-of-way of any vehicle already in the lane.<br>—Enters left-turn pocket lane at opening.<br>—Uses the left-most part of left lane.<br>• Stays within lane markings. |
| | | Unnecessary stop | There was no vehicle or pedestrian traffic, signal light, or traffic sign requiring a stop. |
| | | Traffic check | • Driver is observing traffic (vehicle and pedestrian) ahead, to the left, right, and rear. This is indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Reacts safely to traffic situations. |

## MDPE AND ADPE Page 19

### *SCORING CRITERIA FOR EVALUATIONS, continued*

**Turns Evaluation, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Turns, continued** | Stop, continued | Full stop | • Brigs vehicle to a full stop without jerking.<br>• When necessary, brakes to stop for yellow light.<br>• For manual-transmission vehicle, keeps gear engaged. Once stopped, applicant can place the vehicle in neutral.<br>• No movement forward or rolling backward. |
| | | Gap or limit line | • Able to see rear wheels of vehicle in front or has enough room to maneuver around vehicle without backing up.<br>• Stops within 6 feet (about half a car length) from the limit line.<br>• If no limit line, stops within 6 feet (about half a car length) from the corner of the intersection.<br>• Stops without the front-most part of the vehicle being:<br>in intersection<br>over limit line<br>beyond sidewalk or stop sign. |
| | | Wheels straight (left turns only.) | Wheels straight ahead when stopped. |

## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Turning Evaluation, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Turns, continued** | Turn/ Complete | Traffic check | • Driver is observing traffic (vehicle/pedestrian) ahead, to the left, and right. This is indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Yields to vehicles already at or in the intersection or to pedestrians in the intersection.<br>• Accepts right-of-way when it is safe to start.<br>• Reacts safely to traffic situations. |
| | | Steering control | • Turns steering wheel smoothly and with full control of vehicle. (No palming.)<br>• Turns vehicle only the amount necessary (does not over-steer or under-steer). |
| | | Too wide/short | Keeps vehicle within the lane or lane markings. |
| | | Correct lane | Ends turn in the proper lane. |
| | | Speed | • Maintains smooth, safe speed and keeps control of the vehicle.<br>• For manual transmission:<br>changes gears as necessary to maintain power<br>keeps gear engaged.<br>• Makes no unnecessary stops during turn.<br>• Accelerates smoothly after turn. |
| | | Signal | Cancels signal upon completion of turn. |

## MDPE AND ADPE **Page 21**

### *SCORING CRITERIA FOR EVALUATIONS, continued*

**Intersections Evaluation**

This section provides details on how to evaluate the driver 's performance at intersections.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Intersections** | Through | Traffic check | • Driver is observing traffic (vehicle and pedestrian) ahead, to the left, and right. This is indicated by head and/or eye movement to the left and right.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Yields to vehicles or pedestrians in the intersection.<br>• Reacts safely to traffic situations. |
| | | Speed | • Maintains speed without exceeding the posted speed limit.<br>• Maintains appropriate speed for traffic conditions (basic speed law). |
| | | Unnecessary stop | • Stops on yellow light when should have gone through.<br>• Stops vehicle when not necessary. |
| | Stop | Traffic check | • Driver is observing traffic (vehicle and pedestrian) ahead, to the left, right, and rear. This is indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Reacts safely to traffic situations. |
| | | Speed | • Decelerates and brakes smoothly.<br>• Depresses brake pedal without depressing the accelerator at the same time.<br>• For manual-transmission vehicle, keeps gear engaged. |

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## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Intersections Evaluation, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Intersections, continued** | Stop, continued | Full stop | • Brings vehicle to a full stop without jerking.<br>• When necessary, brakes to stop for yellow light.<br>• For manual-transmission vehicle, keeps gear engaged. Once stopped, applicant can place the vehicle in neutral.<br>• No moving forward or rolling backward. |
| | | Gap or Limit line | • Able to see rear wheels of vehicle in front or has enough room to maneuver around vehicle without backing up.<br>• Stops within 6 feet (about half a car length) from the limit line or the corner of the intersection.<br>• Stops without the front-most part of the vehicle being:<br>in intersection<br>over limit line<br>beyond sidewalk or stop sign. |
| | Start | Traffic check | • Driver is observing traffic (vehicle and pedestrian) ahead, to the left, and right. This is indicated by head and/or eye movement to the left and right.<br>• Looks toward other drivers and pedestrians when necessary.<br>• Reacts safely to traffic situations. |

## MDPE AND ADPE 

***SCORING CRITERIA FOR EVALUATIONS, continued***

**Intersections Evaluation, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Intersections, continued** | Start, continued | Yield | • Yields to vehicles already at or in the intersection or to pedestrians in the intersection.<br>• Accepts right-of-way without causing confusion or impeding traffic flow.<br>• Accepts right-of-way when it is safe to start.<br>• Reacts safely to traffic situations. |
| | | Speed | Accelerates smoothly. (Includes proper gear and clutch usage by the applicant if the vehicle has a manual transmission.) |

**Lane Changes Evaluation**

This section provides details on how to evaluate the driver's performance in making a lane change

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Lane Changes** | Lane change | Traffic check | • **Left lane change:** Driver is observing traffic (vehicle and pedestrian) ahead, to the left, and rear. This is indicated by head and/or eye movement to the left and proper use of mirrors.<br>• **Right lane change:** Driver is observing traffic (vehicle and pedestrian) ahead, to the right, and rear. This is indicated by head and/or eye movement to the right and proper use of mirrors.<br>• Checks blind spot.<br>• Reacts safely to traffic situations. |
| | | Signal | • Activates signal prior to lane change.<br>• Cancels signal after lane change. |

## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Lane Changes Evaluation, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Lane Changes, continued** | Lane Change, continued | Speed | • Uses appropriate speed to change lanes without exceeding the posted speed limit.<br>• Uses appropriate speed for traffic conditions (basic speed law). |
| | | Spacing | • Waits for adequate gap.<br>• Leaves space cushion to front and sides.<br>• Maintains space cushion in front and rear of vehicle after lane change. |
| | | Steering control | • Changes lanes by turning the steering wheel smoothly.<br>• Moves to center of lane. |

**Straight Business/ Residential Evaluation**

This section provides details of how to evaluate the driver's performance in a straight section of a business district or residential area.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Straight Business/ Residential** *(MDPE only)* | N/A | Traffic check | • Watches ahead, to the left, and right for hazards. Indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Reacts safely to traffic situations such as:<br>traffic at entrances to roadway<br>pedestrians<br>vehicles parking. |
| | | Lane position | Keeps in center of lane. |

## MDPE AND ADPE **Page 25**

### *SCORING CRITERIA FOR EVALUATIONS, continued*

**Straight Business/ Residential Evaluation, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Straight Business/ Residential,** *(MDPE only)* **continued** | N/A | Speed | • Maintains speed without exceeding the posted speed limit.<br>• Slows for hazards or obstructions.<br>• Brakes to stop for yellow light when necessary.<br>• Maintains appropriate speed for traffic conditions (basic speed law). |
| | | Spacing | Leaves space cushion to front and sides |

**Merge Evaluation**

This section provides details on how to evaluate the driver's performance in merging.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Merge** *(MDPE only)* | Merging | Traffic check | • While merging, driver is observing traffic ahead, to the left, and/or rear, indicated by head and eye movement to the left and/or right and use of mirrors.<br>• Checks blind spot.<br>• Reacts safely to traffic situations. |
| | | Signal | • Activates signal prior to merging.<br>• Cancels signal after merging. |
| | | Speed | Merges at appropriate speed for traffic conditions (basic speed law). |
| | | Spacing | • Waits for and accepts first available adequate gap.<br>• Leaves space cushion to front and sides. |
| | | Lane position | Moves to center of driving lane. |
| | | Steering control | Merges by turning the steering wheel smoothly. |

## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Curve Evaluation** This section provides details of how to evaluate the driver's performance in negotiating a curve.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Curve** *(MDPE only)* | N/A | Entering speed | • Reduces to a safe speed to enter curve.<br>• For manual transmission:<br>change gears as necessary to maintain power.<br>keeps gear engaged. |
| | | Through speed | • Does not brake unnecessarily while in curve.<br>• Maintains safe speed during curve.<br>• For manual transmission:<br>changes gears as necessary to maintain power<br>keeps gear engaged.<br>• Presses brake pedal without pressing the accelerator at the same time. |
| | | Lane position | Keeps vehicle in lane. |

**Destination Trips** This section provides details of how to evaluate the driver's performance during a destination trip.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Destination Trips** | N/A | Traffic check | • Watches ahead, to the left, and right for hazards. This is indicated by head and/or eye movement to the left and right and use of mirrors.<br>• Reacts safely to traffic situations such as:<br>traffic at entrances to roadway<br>pedestrians<br>vehicles parking. |

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### *SCORING CRITERIA FOR EVALUATIONS, continued*

**Destination Trips, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Destination Trips, continued** | N/A | Speed | • Maintains speed without exceeding the posted speed limit or impeding or blocking the normal and reasonable movement of traffic.<br>• Slows for hazards or obstructions.<br>• Brakes to stop for yellow light when necessary.<br>• Maintains appropriate speed for traffic conditions (basic speed law). |
| | | Spacing | Leaves space cushion to front and sides. |
| | | Lane position | Keeps in center of lane. |
| | | Turns | Performs maneuver according to the Turn Criteria for:<br>• Approach<br>• Stop<br>• Turn/Complete. |
| | | Intersections | Performs maneuver according to the Intersection Criteria for:<br>• Through<br>• Stop<br>• Start. |
| | | Lane changes | Performs maneuver according to the Lane Change criteria. |
| | | Concentration | Can follow verbal instructions and directions without getting disoriented. |

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## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Destination Trips, continued**

| ***Section*** | ***Maneuver*** | ***Item Scored*** | ***Criteria*** |
|---|---|---|---|
| **Destination Trips, continued** | N/A | Parking lot driving | • Traffic check.<br>Driver is observing traffic (vehicle and pedestrian) ahead, to the left, right, and rear. This is indicated by head and/or eye movement and use of mirrors.<br>Yields right-of-way to pedestrians and vehicles when appropriate.<br>Looks toward other drivers and pedestrians when necessary.<br>Reacts safely to traffic situations.<br>Observes signs and uses correct lanes.<br>• Speed.<br>Drives through the parking lot at a safe speed and in control of the vehicle. |
| | | Enter/exit space | • Traffic check.<br>Driver is observing traffic (vehicle and pedestrian) ahead and to the left and right.<br>Looks toward other drivers and pedestrians when necessary.<br>When exiting, looks over appropriate shoulder while backing.<br>Reacts safely to traffic situations.<br>• Speed.<br>Enters/exits space at a safe speed and in control of the vehicle. |

**MDPE AND ADPE** **Page 29**

***SCORING CRITERIA FOR EVALUATIONS, continued***

**Destination Trips, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Destination Trips, continued** | N/A | Enter/exit space, continued | • Braking.<br>Brings vehicle to a smooth stop (does not jerk vehicle).<br>Depresses brake pedal without depressing the accelerator at the same time.<br>• Vehicle position.<br>Enters space without going over the lines or markers.<br>Stops vehicle between the lines and markers.<br>Performs maneuver with no more than one correction.<br>Stops vehicle in a position that would not impede traffic. |
| | | Find destination | Completes destination trip without any directional assistance from the examiner. |

**Multiple Directions Evaluation** This section provides details of how to evaluate the driver's performance in following multiple directions.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Multiple directions** *(ADPE only)* | N/A | Cues needed | Understands directions without the need for additional explanations.<br>One confirming question (a yes-no question, answered yes) is acceptable, but the examiner should not have to repeat the directions. |
| | | Follows directions | Properly completes maneuver safely and without delay. |
| | | Aware of errors | Recognizes driving error and corrects immediately without creating a hazard. |

## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Backing**

This section provides details of how to evaluate the driver's performance in backing.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Backing** *(MDPE only)* | Straight Line Backing | Traffic check | • Checks both sides and rear for traffic while backing three vehicle lengths in a straight line.<br>• Reacts safely to traffic situations. |
| | | Speed | Backs vehicle in a straight line at safe speed and in control of the vehicle. |
| | | Braking | • Brings vehicle to a smooth stop (does not jerk vehicle).<br>• Depresses brake pedal without depressing the accelerator at the same time. |
| | | Vehicle position | Vehicle backs within a 3-foot weave to either side and without hitting curb.<br>**NOTE:** If applicant positions the vehicle too close to the curb for the Straight Line Backing maneuver, allow the applicant to reposition the vehicle away from the curb, prior to performing the maneuver. |

**Critical Driving Errors**

This section provides details of action or inaction by an applicant that constitutes a critical driving error.

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Critical Driving Errors** | N/A | Intervention by examiner | • Any driver action or inaction requiring physical or verbal intervention by the examiner.<br>• Street Park: Makes four corrections to park vehicle. |
| | | Strikes object | Comes in contact with another vehicle, object, pedestrian, or animal when it could have been safely avoided. |
| | | Up and over curb or sidewalk | Drives over the curb or on the sidewalk. |

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### *SCORING CRITERIA FOR EVALUATIONS, continued*

**Critical Driving Errors, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Critical Driving Errors, continued** | N/A, continued | Drives in oncoming traffic lane | Any time the vehicle is in the oncoming traffic lane. |
| | | Disobeys traffic sign, signal, or safety personnel | • At or exceeding a brisk walking speed (4 mph), goes through a:<br>stop sign<br>flashing red light<br>right turn on a red light.<br>• Disobeys other traffic signs and/or lane markings:<br>lane drop<br>painted arrows<br>stanchions, etc. |
| | | Dangerous maneuver | • Any driver action or inaction that could have or did cause another driver or pedestrian to take evasive action.<br>• Neither looks in mirror(s) nor blind spot (over shoulder[s]) during:<br>lane change<br>merge<br>backing<br>pulling from curb or side of road.<br>• Does not move head and eyes for traffic check at uncontrolled intersection.<br>• Kills engine in an intersection.<br>• Any time the vehicle blocks an intersection so that it impedes cross-traffic. |

## *SCORING CRITERIA FOR EVALUATIONS, continued*

**Critical Driving Errors, continued**

| *Section* | *Maneuver* | *Item Scored* | *Criteria* |
|---|---|---|---|
| **Critical Driving Errors, continued** | N/A, continued | Dangerous maneuver, continued | • Street Park: Parks vehicle so far away from the curb that it blocks or impedes traffic.<br>• Drives further than 200 feet in a bike lane.<br>• Drives straight from a designated turn lane.<br>• Unnecessary stop at a green light at an intersection. |
| | | Reaction to school bus | Passes school bus with flashing red lights. |
| | | Reaction to emergency vehicle | Fails to stop for an emergency vehicle. |
| | | Speed | • Too Fast.<br>Drives 10 mph over the posted speed limit<br>Drives too fast for safety.<br>• Too slow.<br>Drives 10 mph under the posted speed limit when road and/or traffic conditions do not warrant it<br>Drives too slow for safety. |
| | | Auxiliary equipment use | Fails to use windshield wipers, defroster, or headlights when either inclement weather or darkness requires it. |
| | | Turning from improper lane | Makes turn from wrong lane.<br>**Exception:** If improper turn is made without merging into bike lane, do not mark automatic disqualification so long as the blind spot is checked. Instead, score under Turns, Approach, Lane. |

# APPENDIX B

## DRIVING INFORMATION SURVEY

Driver License No.: ___ ___ ___ ___ ___ ___ ___ ___

Name: ________________________________

Date Of Birth: _____ / _____ / _____
month day year

**Please check only one box for each question. Thank you!**

1. How many days per week do you <u>normally</u> drive a motor vehicle?
   1 2 3 4 5 6 7
   O Check here if in most weeks you do not drive.

2. How many miles do you drive in a *normal* week?
   0-9 | 51-150 | 351-500
   10-20 | 151-250 | 501-1,000
   21-50 | 251-350 | over 1,000

3. How many hours do you spend driving in a *normal* week?
   0-1 | 10-14 | 25-29
   2-4 | 15-19 | 30-40
   5-9 | 20-24 | over 40

4. Have you been a licensed driver (in any state) for more than 5 years?
   Yes No

5. What type of driving do you *most* frequently do? **Check only *one* box.**
   To and from work | Errands (shopping, appointments)
   Recreational | Trips out of town
   On the job | Check here if none apply

6. What type of street do you *most* often drive on? **Check only *one* box.**
   Residential streets | County roads
   Non-residential city streets | Check here if none apply
   Freeways

7. What type of street do you *least* often drive on? **Check only *one* box.**
   Residential streets | County roads
   Non-residential city streets | Check here if none apply
   Freeways

# APPENDIX B

DRIVING INFORMATION SURVEY (Continued)

8. Do you smoke while you drive?
   Never Sometimes Often Always

9. Do you wear glasses or contact lenses when you drive?
   Never Sometimes Often Always

10. Do you *avoid* driving at night?
    Never Sometimes Often Always

11. Do you *avoid* driving when it's raining or foggy?
    Never Sometimes Often Always

12. Do you *avoid* driving at sunrise or sunset?
    Never Sometimes Often Always

13. Do you *avoid* driving alone?
    Never Sometimes Often Always

14. Do you *avoid* making left-hand turns across oncoming traffic?
    Never Sometimes Often Always

15. Do you *avoid* driving in heavy traffic?
    Never Sometimes Often Always

16. Do you *avoid* driving on the freeway?
    Never Sometimes Often Always

17. Do you *avoid* parallel parking?
    Never Sometimes Often Always

18. Do you *avoid* driving on unfamiliar routes?
    Never Sometimes Often Always

19. Do guide signs give you enough information to help you reach your destination on unfamiliar routes?
    Never Sometimes Often Always
    Not applicable—I never drive on unfamiliar routes.

20. How would you describe your general health?
    Excellent Good Fair Poor

# APPENDIX C

## SURVEY FOR REEXAMINEES

Please complete the following survey to help us gather information. This survey will be kept confidential. It will not be identified to the DMV as coming from you, and will have no influence on your driving privilege. In answering the following questions, please circle the letter corresponding to the ONE alternative that applies best, UNLESS the instructions say you may circle more than one. Use the other side of the page for explanations if needed.

Recently you were reexamined by the DMV and a decision was made regarding your driver's license. If it was decided that you should give up your license <u>or</u> if any <u>new</u> restrictions were put on your license, please answer all of the questions. IF IT WAS DECIDED THAT YOU CAN KEEP YOUR LICENSE WITH NO <u>NEW</u> RESTRICTIONS BEYOND THOSE YOU MAY ALREADY HAVE, PLEASE SKIP TO QUESTION #8 AND CONTINUE FROM THERE.

1. What <u>new</u> restrictions were placed on your license following your recent reexamination? IF MORE THAN ONE RESTRICTION, CIRCLE THE LETTERS CORRESPONDING TO ALL THAT APPLY.

   a. new corrective lens restriction
   b. no night driving (daytime-only driving)
   c. drive only at certain times during the day
   d. drive only in a certain area
   e. no freeway driving
   f. drive only on specific streets
   g. must use special equipment (what kind?)
   h. other restriction (what?)
   i. none apply; I no longer have a license

## LIFE-STYLE IMPACT

2. Are there places you used to drive to that are now difficult or impossible to get to because of your new driving restrictions? PLEASE CIRCLE ALL LETTERS THAT APPLY.

   a. grocery store
   b. church
   c. doctor's office/hospital

d. post office
e. drug store
f. friend's house
g. relative's house
h. vacation/out of town
I. work/volunteer work
j. movie theater/video store
k. mall/clothing store
l. dry cleaner's
m. other (where?)
n. none of the above

3. Are there places you need to or must go to that are now difficult or impossible to get to because of your new driving restrictions? PLEASE CIRCLE ALL LETTERS THAT APPLY.

a. grocery store
b. post office
c. doctor's office/hospital
d. work
e. drug store
f. other (where?)
g. none of the above

4. How often do you drive a vehicle now as compared to before the DMV's decision?

a. much more
b. somewhat more
c. about the same
d. somewhat less
e. much less
f. stopped driving completely

SAFETY

5. Do you think you are safer or less safe now because of the DMV's decision?
a. much safer

b. somewhat safer
c. about as safe
d. somewhat less safe
e. much less safe

6. Do you think others (drivers, passengers, and/or pedestrians) are safer or less safe now because of the DMV's decision?

    a. much safer
    b. somewhat safer
    c. about as safe
    d. somewhat less safe
    e. much less safe

## EMOTIONAL REACTION

7. When you first learned of the DMV's decision, were you angry?

    a. very angry
    b. somewhat angry
    c. only slightly angry
    d. not at all angry
    e. undecided or don't know

8. When you first learned of the DMV's decision, were you unhappy or happy?

    a. very unhappy
    b. somewhat unhappy
    c. undecided or don't know
    d. happy
    e. very happy

9. When you first learned of the DMV's decision, were you relieved?

    a. very relieved
    b. somewhat relieved
    c. only slightly relieved
    d. not at all relieved
    e. undecided or don't know

## HEALTH

10. Has your physical health changed since you learned of the DMV's decision?

    a. much better
    b. somewhat better

c. has not changed
d. somewhat worse
e. much worse

## ALTERNATIVE TRANSPORTATION

11. When you take a trip, such as to the store or on vacation, what types of transportation do you use, and how much? PLEASE CIRCLE ALL LETTERS THAT APPLY, AND INDICATE WHETHER YOU USE THIS TYPE OF TRANSPORTATION ON LESS THAN 1/3 OF YOUR TRIPS OR ON MORE THAN 1/3 OF YOUR TRIPS.

| | | |
|---|---|---|
| a. I drive myself | ____less than 1/3 | ____more than 1/3 |
| b. relative drives | ____ | ____ |
| c. friend drives | ____ | ____ |
| d. bus or para-transit | ____ | ____ |
| e. cab or dial-a-ride | ____ | ____ |
| f. bicycle | ____ | ____ |
| g. walk | ____ | ____ |
| h. airplane | ____ | ____ |
| I. train or rapid transit (RT) | ____ | ____ |
| j. other (what?) ___________ | ____ | ____ |

## ATTITUDE ABOUT THE DMV

12. Has your attitude toward the DMV changed since you learned its decision about your license?

a. much better
b. somewhat better
c. has not changed
d. somewhat worse
e. much worse

13. In dealing with the DMV staff, did you think overall they were fair?

a. very fair
b. somewhat fair
c. undecided or don't know
d. not very fair
e. not at all fair

14. In dealing with the DMV staff, did you think overall they were courteous?

    a. very courteous
    b. somewhat courteous
    c. undecided or don't know
    d. not very courteous
    e. not at all courteous

15. In dealing with the DMV staff, did you think overall they had concern for you as an individual?

    a. very concerned
    b. somewhat concerned
    c. undecided or don't know
    d. not very concerned
    e. not at all concerned

Please offer any comments or suggestions you may have about the DMV or its driver reexamination process. You may write on the other side of the page if needed. Your comments will not be identified as coming from you in any communication to the DMV. Thank you for your help.

# APPENDIX D

## SURVEY FOR FAMILY AND FRIENDS OF REEXAMINEES

Please complete the following survey to help us gather information. This survey will be kept confidential. It will not be identified to the DMV as coming from you, and will have no influence on the driving privilege of your relative or friend. In answering the following questions, please circle the letter corresponding to the ONE alternative that applies best, UNLESS the instructions say you may circle more than one. Use the other side of the page for explanations if needed.

Recently your relative or friend was reexamined by the DMV and a decision was made regarding his or her driver's license.

1. What is your relationship to the person who was recently reexamined by the DMV?

   a. husband
   b. wife
   c. son
   d. daughter
   e. friend
   f. other (what?)

If it was decided that he or she should give up his or her license or if any new restrictions were put on his or her license, please answer all of the questions. IF IT WAS DECIDED THAT HE OR SHE CAN KEEP HIS OR HER LICENSE WITH NO NEW RESTRICTIONS, PLEASE SKIP TO QUESTION #3 AND CONTINUE FROM THERE.

## LIFE-STYLE IMPACT

2. In what ways is your life affected by your relative or friend's license restriction or loss of license? PLEASE CIRCLE ALL LETTERS THAT APPLY.

   a. more time and gas money spent in driving my relative/friend
   b. more stress due to increased driving
   c. more time spent with my relative/friend
   d. I now must rely on other people for transportation
   e. other (what?)
   f. none of the above; my life has not been affected

## EMOTIONAL REACTION

3. When you first learned of the DMV's decision about your relative/friend's license, were you angry?

   a. very angry
   b. somewhat angry
   c. only slightly angry
   d. not at all angry
   e. undecided or don't know

4. When you first learned of the DMV's decision about your relative/friend's license, were you unhappy or happy?

   a. very unhappy
   b. somewhat unhappy
   c. undecided or don't know
   d. happy
   e. very happy

5. When you first learned of the DMV's decision about your relative/friend's license, were you relieved?

   a. very relieved
   b. somewhat relieved
   c. only slightly relieved
   d. not at all relieved
   e. undecided or don't know

## EMOTIONAL REACTION OF RELATIVE/FRIEND

6. When your relative/friend first learned of the DMV's decision, did he/she seem angry?

   a. very angry
   b. somewhat angry
   c. only slightly angry
   d. not at all angry
   e. undecided or don't know

7. When your relative/friend first learned of the DMV's decision, did he/she seem unhappy or happy?

   a. very unhappy
   b. somewhat unhappy
   c. undecided or don't know
   d. happy
   e. very happy

8. When your relative/friend first learned of the DMV's decision, did he/she seem relieved?

   a. very relieved
   b. somewhat relieved
   c. only slightly relieved
   d. not at all relieved
   e. undecided or don't know

SAFETY

9. Do you think your relative/friend is safer or less safe now because of the DMV's decision?

   a. much safer
   b. somewhat safer
   c. about as safe
   d. somewhat less safe
   e. much less safe

10. Do you think others (drivers, passengers, and/or pedestrians) are safer or less safe now because of the DMV's decision?

    a. much safer
    b. somewhat safer
    c. about as safe
    d. somewhat less safe
    e. much less safe

Please offer any comments or suggestions you may have about the DMV or its driver reexamination process. You may write on the other side of the page if needed. Your comments will not be identified as coming from you in any communication to the DMV. Thank you for your help.

# APPENDIX E

Berkeley Conference Attendees
Assessing Elderly Drivers with Dementia or Age-Related Frailty
July 24-26, 1994

Jesse Blatt
U.S. DOT/NHTSA

Thomas B. Cox
Transportation Specialist, AARP-Consumer Affairs

Ann Dellinger
Epidemiologist, National Center for Injury Prevention and Control
Centers for Disease Control

Allen Dobbs
Director, Centre for Gerontology, University of Alberta
Director, Neurocognitive Research Program, Edmonton General Hospital

John W. Eberhard
U.S. DOT/NHTSA

Thomas Galski
Director of Psychology and Neuropsychology
Kessler Institute for Rehabilitation

David W. Gilley
Asst. Professor, Rush Medical School
Rush Institute on Aging

Robert Hagge
Research Manager
CA DMV Research & Development

David Hennessy
Research Program Specialist
CA DMV Research & Development

Mary Janke
Project PI
Research Scientist
CA DMV Research & Development

Barnie Jones
Research Scientist
Oregon Department of Transportation

Susan M. Lillie
Coordinator, Adaptive Driving Program
Occupational Therapy Department
Santa Clara Valley Medical Center

James Malfetti
Emeritus Professor, Columbia University

Maureen Malinowski
Association for the Advancement of Automotive Medicine

Richard Marottoli
Yale University School of Medicine, Geriatrics

Jim McKnight
President, National Public Services Research Institute

Kent R. Milton
Consultant, AAMVA/NHTSA

Germaine Odenheimer
Director, Geriatric Neurology
VAMC/Harvard Medical School

Erik Olsen
Graduate Student, California State University at San Jose

Ray Peck
Research Chief
CA DMV Research & Development

Sheila Prior
Assoc. Director of Driver Services
American Association of Motor Vehicle Administrators

David B. Reuben
Chief, Division of Geriatrics
UCLA School of Medicine

Frank Schieber
Department of Psychology
University of South Dakota

David Shinar
Psychologist
NHTSA and Ben Gurion Univ. (Israel)

Peggy St. George
CA DMV Program and Policy Administration

Loren Staplin
The Scientex Corporation

Constance Williams, MD
Geriatrics and Extended Care
Brockton/West Roxbury VAMC

## SURVEY: EXPERT OPINION ON AGE-RELATED DRIVING IMPAIRMENT

I. General Opinions and Beliefs

Please rate your degree of agreement or disagreement with the following statements relating to elderly driver assessment and identification of impaired elderly drivers. Ratings should be made on the following scale:

1 = strongly agree
2 = tend to agree
3 = neither agree nor disagree
4 = tend to disagree
5 = strongly disagree

1. Physicians and other health professionals should be required by law to report to the licensing agency cases of age-related disorders associated with functional impairments for driving._____

2. There is presently adequate justification for driver licensing agencies to subject drivers aged 70 or more to additional testing._____

3. Physicians and other health professionals should be required by law to report cases of dementia to the licensing agency._____

4. Some drivers with dementia should be allowed to drive in a restricted manner._____

5. The licensing screening standards and types of tests administered should be the same for experienced (non-novice) drivers of all ages._____

6. The physician's role regarding driving should be limited to making recommendations to patients and/or their families._____

7. Most medically impaired elderly drivers can be identified through informal observation by lower-level licensing agency staff if they are trained in what to look for._____

8. The most valid way to determine an elderly person's competency to drive safely is through an actual road test._____

9. One element that should be considered in determining the relative driving competency of different age groups is the degree to which their driving behavior promotes expeditious traffic flow._____

10. The physician seeing a patient regularly is in the best position to identify that patient's disabilities for driving._____

11. Placing more emphasis in driver licensing on detecting age-related medical impairments will have little effect on traffic safety._____

12. Licensing agencies should refer many medically impaired elderly drivers to rehabilitation facilities for assessment and treatment._____

13. Elderly drivers as a group regulate their own driving adequately._____

14. In using casualty accident rates to compare the relative safety risk of older drivers to that of younger drivers, the rates should be standardized to adjust for differences in vulnerability to injury._____

15. A elderly-driver licensing system that uses testing mainly to provide feedback and offer advice on self-restriction is preferable to one that either imposes mandatory restrictions on, or revokes the license of, most elderly drivers._____

16. Since many drivers in the beginning stages of dementia have not yet been identified as such by physicians, licensing agencies must assume the major responsibility in identifying them._____

17. Elderly people generally present driving problems that require special testing for licensure._____

18. To identify dementing drivers, clinical tests for dementia like the MMSE should be used more commonly by licensing agencies than is the case now. _____

19. Frail elderly drivers should be counselled by the licensing agency on ways to reduce their crash risk by severely limiting their amount and type of driving._____

20. The devastating effects on elderly drivers of revoking their licenses are so great that revocation should be considered only as a last resort._____

21. Restriction of driving to a familiar neighborhood would usually be sufficient to enable drivers with mild dementia to drive safely._____

22. It would be desirable to enable licensing agencies to restrict the license of cognitively impaired elderly drivers to driving only with another adult in the car to serve as "copilot."_____

23. If a group—for example the elderly—has a low crash rate <u>per year</u>, the state has no real justification for administering special tests to all members of that group._____

24. Too commonly, assessment of people for their driving safety ignores strategic behaviors like avoidance of night driving and is concerned only with tactical and operational level skills—e.g., vehicle maneuvering ability and short-term driving tactics._____

25. The primary identifying source for a driver with dementia should be the physician._____

26. Abilities necessary for competent driving decline with age, so above some age drivers, even those with no accidents or citations, should be required to pass special tests in order to renew their licenses._____

27. Medically impaired elderly drivers—for example, those with dementia—constitue a substantial safety problem._____

28. The doctor-patient relationship should not be jeopardized by compelling or even encouraging doctors to report patients who are incompetent to drive to the licensing agency._____

29. In identifying frail elderly drivers, unobtrusive observation by licensing agency staff is usually sufficient._____

II. Rating of Specific Tests and Skill Modalities

The rating scale used in part I will also be used in part II. Using this scale, rate your degree of agreement or disagreement with the following statements:

Functions that should be measured in assessing elderly people for their competence to drive include:

30. static visual acuity under normal illumination._____
31. contrast sensitivity._____
32. static visual acuity under low illumination._____
33. visual fields._____
34. dynamic visual acuity under low illumination._____
35. dynamic visual acuity under normal illumination._____
36. acuity under glare._____
37. glare recovery._____
38. ability to find a specific stimulus in clutter._____
39. ability to switch attention from 1 stimulus to another._____
40. ability to sustain focussed attention._____
41. ability to attend to two tasks at once._____
42. abiity to resist distraction._____
43. ability to spot hazards._____
44. ability to switch from one response (or response set) to another._____
45. choice reaction time._____
46. attentional visual field._____
47. judgment in practical situations._____
48. ability to assess own performance._____
49. short-term recall of instructions._____
50. long-term recall of informational material._____
51. recognition memory._____
52. vigilance._____
53. reasoning ability._____
54. orientation to place and time._____
55. ability to find the way to a destination._____
56. ability to perform instrumental activities of daily living (IADLs)._____
57. speed of reaction to a signal._____
58. ability to perform several responses in sequence._____
59. ability to sustain effort over a period of time._____
60. ability to scan and track moving objects visually._____
61. ability to track moving objects using skeletal muscles._____
62. balance while standing or sitting._____
63. ability to walk briskly._____
64. ability to perform activities of daily living (ADLs)._____
65. strength._____
66. response coordination._____

Other (suggest functions which you think should be measured):

III. Unstructured Expression of Opinion

67. A system for identifying medically impaired elderly drivers and instituting more effective driver licensing measures must involve several system components or agents. They can include the licensing agency, the physician, the occupational therapist, the geriatric assessment center, law enforcement personnel, and frequently others. In your opinion, what agents should play primary roles in an improved assessment process, and how might these primary agents be better coordinated?

68. Please list any specific tests you can personally recommend for use by licensing agencies in separating elderly drivers with medical impairments from the total group of driver license renewal applicants.

69. Please list any specific tests you can personally recommend for use by licensing agencies, occupational therapists, or driver rehabilitation specialists in separating medically impaired elderly drivers who are competent to drive from the total group of medically impaired elderly drivers.

## SURVEY SUMMARY BY GROUP[1]

1=strongly agree, 2=tend to agree, 3=neither agree nor disagree,
4=tend to disagree, 5=strongly disagree

| | HEALTH PRACTITIONERS | PSYCHOLOGISTS |
|---|---|---|

Set 1: Licensing agency identification of medically impaired elderly (7,16,29).

| | HEALTH PRACTITIONERS | PSYCHOLOGISTS |
|---|---|---|
| 07. Most medically impaired elderly drivers can be IDed through informal observation by lower-level agency staff, if trained . . . . | 4.5 | 4.2 |
| 16. Licensing agencies must assume the major responsibility in IDing beginning dementia. | 4.2 | 2.7 |
| 29. In IDing frail elderly, unobtrusive observations by licensing agency staff would usually be sufficient. | 4.3 | 4.2 |

[1] The two major groups, roughly defined, are 6 health practitioners (mostly physicians), all of whom also conduct driving-related research, and 13 (driving-related) research-oriented psychol-ogists/social scientists. Some respondents could not be classified as members of either group. This summary compares the first two groups' collective opinions in order to contrast presumed (possibly wrongly) orientations toward treating individuals vs. characterizing groups.

Set 2: What should physicians/health professionals do? (1,3,6,10,25,28)

01. Physicians and other health professionals should be required by law to report to DMV cases of age-related disorders associated with functional impairments for driving.
    3.2 2.3
03. Physicians and other health professionals should be required by law to report cases of dementia to DMV.
    3.0 2.2
06. Physicians' role regarding driving should be limited to making recommendations to patients and/or their families.
    3.5 3.8
10. Physician seeing patient regularly is in best position to ID patient's disabilities for driving.
    3.0 2.8
25. Primary identifier of dementing should be physician.
    2.0 2.7
28. Don't compel or even encourage physician reporting of incompetent patients to DMV.
    3.8 4.0

Set 3: Can some dementing drive? (4,21)

04. Some should be allowed to drive in a restricted manner.
    2.5 2.5
21. Restriction to familiar neighborhood is usually sufficient to enable drivers with mild dementia to drive safely.
    3.5 2.8

Set 4: Is elderly group a threat? (11,13,27)

11. More emphasis on detecting age-related medical impairments will have little effect on traffic safety.
    3.0 3.0
13. Elderly as a group regulate their own driving adequately.
    2.8 2.5
27. Medically impaired elderly—e.g., dementing—constitute a substantial safety problem.
    2.2 2.2

Set 5: Special testing for elderly? (2,5,17,26)

02. Presently there is adequate justification to subject drivers aged 70 or more to additional testing.

3.0 1.7

05. Screening standards and types of tests should be the same for experienced drivers of all ages.

2.8 3.5

17. Elderly generally present driving problems that require special testing for licensure.

2.8 3.0

26. Abilities decline, so above some age all drivers should pass special tests to renew their licenses.

3.5 2.1

Set 6: How to test elderly? (8,18)

08. Most valid way is a road test.

2.5 3.3

18. To ID dementing, DMVs should use clinical tests like the MMSE more commonly.

3.8 3.3

Set 7: Factors to consider in assessing group safety (9,14,23,24)

09. In determining relative competencies of groups, consider the degree to which behavior promotes expeditious traffic flow.

3.0 2.8

14. Should standardize casualty accident rates to adjust for differences in vulnerability.

1.5 3.0

23. If a group has low crash rate <u>per year,</u> the state has no real justification for subjecting all its members to special testing.

3.2 4.3

24. Too commonly, assessment ignores strategic behaviors and considers only tactical and operational skills.

2.0 1.8

Set 8: How to administer licensure testing system? (12,15,19,20,22)

12. DMVs should refer many medically impaired elderly to rehabilitation facilities for assessment and treatment.

2.8 2.2

15. Better to use tests to provide feedback and advice, not restrict or revoke licenses of most elderly drivers.

2.5 3.8

19. Should counsel frail elderly on ways to reduce risk by severely limiting type and amount of driving.
    2.5 1.7
20. Revocation should be considered only as a last resort.
    2.0 1.7
22. Would be desirable to let agencies use "copilot restriction" for cognitively impaired elderly drivers.
    3.2 3.3

# APPENDIX F

ASSESSMENT OF DRIVERS WITH DEMENTIA OR AGE-RELATED FRAILTY
PANEL'S "UNSTRUCTURED EXPRESSION OF OPINION"
SURVEY 1

**Functions which you think should be measured:**

**Thomas Galski—**Visuospatial ability, personality (impulsivity, risk-taking, psychopathy), topographical memory.

**Frank Schieber—**Need some way of measuring mental workload (and/or "reserve capacity") collected while actually driving in a standardized road test.

**James Malfetti—**Except in extreme cases, a road test (as reliable and valid as can be found), either actual or through part-task simulation, should be given as a final evaluation of ability.

**Germaine Odenheimer—**Driving simulation (possibly), traffic sign recognition, visuospatial skills/other mental status tests, useful field of view (possibly).

**David Shinar—**One idea is an attribution-theory type test of excessive tending to blame others––e.g., reckless driving, glaring headlights, impatience.

**Susan Lillie—**Side awareness and rear awareness of space surrounding vehicle; ability to fit with flow of traffic; yield situations, especially left turns. Visual processing speed.

**67. Who are primary agents in system, and how improve their coordination? (DMV, physician, OT, geriatric assessment center, and law enforcement were listed specifically.)**

**Frank Schieber—**Need a quick and dirty 1st-tier screen to detect those who are at risk of sub-par driving capacity. This should be done by 1) DMV and general physicians (perhaps via mandatory reporting). Next, 2nd-tier assessment must be conducted by DMV. (If fail, go to tier 3.) 3rd tier would involve rehabilitation centers and occupational therapists who would do comprehensive assessment/rehabilitation training with followup recommendations re "restricted licensure" (i.e., time, place, reason for travel, etc.). Tier 3 expense would have to be assumed by driver/insurance (private or government)—not DMV!

**Rich Marottoli—**I would include the driver, family and friends in the list as well. Among the professionals, the licensing agency is the only one that has contact with the entire population in question over a given time period, and so should take primary responsibility. The others need to: 1) be aware of what to look for (warning signs) to raise suspicion, and 2) have an algorithm or easily followed system for reporting or following through on their concerns. The licensing agency can act as a central resource for reporting and coordinating more detailed assessment on a regional basis if necessary.

**Ann Dellinger—**Primary agents are 1) driver; 2) DMV; 3) medical personnel; 4) law enforcement personnel.

**Barnie Jones—**I believe that family members are critically important in identifying medically impaired drivers, along with physicians and licensing agencies. Other agents simply do not cast a broad enough net. Also, in Oregon, our experience with referrals from law enforcement suggests that police officers tend to be among the most likely sources of unnecessary reexamination and medical referrals.

In Oregon, family members are one of the most likely sources for referrals of medically impaired elderly drivers. Family members have the opportunity to observe elderly relatives over a long period of time, and consequently may be aware of sporadic conditions or abrupt changes in condition or behavior that licensing agencies and even physicians may not notice.

*An important aspect of the family referral is that the licensing agency can sometimes enlist the cooperation and support of family members*. In Oregon, reexamination counselors often talk first with family members, arrange for them to be present at the evaluation and, if necessary, enlist their participation in an "intervention," persuading the candidate to voluntarily surrender his or her license.

It might be possible to enhance the effectiveness of this resource with basic public information and education concerning if, when, and how to refer an impaired elderly relative. Something along the lines of the AARP self-assessment packet, targeting middle-age people with elderly parents.

Licensing agencies need to do more screening and assessment, both formal and informal. In Oregon, screening at renewal consists of a short medical questionnaire on the renewal application, and mandatory vision (acuity) screening for drivers over 50. About 22 percent of Oregon medical program referrals come from answers to medical questions on renewal applications. In previous years, field office employees received at least brief training in informal screening of renewal applicants. However, that practice has been discontinued in recent years, with the result that fewer applicants are referred based on informal screening, and more of the referrals we receive are inappropriate.

I strongly disagree with mandatory physician reporting of medical conditions to licensing agencies. This practice places the physician in an untenable ethical position, in which patients may forego treatment of serious ailments for fear of being ratted out to DMV. Instead, physicians should take up the issue of road safety and the advisability of driving directly with the patient, and report medical conditions selectively, using their own ethical and medical judgment.

**David Reuben—**All are primary, MDs for identification of medical problems and providing additional information on severity and prognosis, licensing agencies for setting standards for driving competencies and means for assessing them, OTs for referral for in-depth assessment.

**James Malfetti—**Licensing agencies, physicians, law enforcement, caregivers and family. To improve coordination: 1) Bring all in on a written statement describing the problem and their respective roles in dealing with each other for solutions. 2) Hold a conference involving all. 3) Resort to laws if any fail to accept their individual and group responsibilities, with penalties and a clear statement of intent to enforce them.

**Germaine Odenheimer—**Since many older people do not seek medical care and, when they do, physicians are not particularly in tune to identifying dementia, it seems that the most reliable place to identify potential problems is upon licensing. A screening set of tasks that are easy to administer and that have high levels of acceptance by the community would be ideal. The literature seems to suggest that some sort of traffic sign recognition test may correlate with driving behaviors. The test could be designed to incorporate a number of "cognitive" parameters. Once an applicant is found to perform poorly on the screen they should be referred to a center or doctor that specializes in dementia evaluations for a diagnosis and prognosis. A comprehensive road test <u>may</u> still be the best predictor of driving safety. Serial exams are needed.

**David Shinar—**People with close contact with the elderly—friends, relatives; support agencies—e.g., AARP, social centers; licensing agencies—through health professionals, and police. Coordination and expected level of involvement is (or could be) a topic for discussion.

**Loren Staplin—**Primary responsibility for coordinating an improved system for identifying impaired drivers should rest with the licensing agency. A multistage assessment process seems most appropriate, in which a brief battery (emphasizing sensitivity as well as specificity) sufficient to identify gross deficits is administered to <u>all</u> older (55+?) drivers. (High face validity for this battery is also important, to reduce driver resistance.) The initial screening will identify candidates for more in-depth assessment: At the driver's discretion, the personal physician or a rehabilitation facility /geriatric center would perform a followup assessment using <u>standardized procedures</u>. Test protocols, reporting requirements, etc., should be set by the licensing agency, which should also conduct regular program evaluations.

**Susan Lillie—**Physicians will continue to be uncomfortable reporting drivers/patients to DMV until DMV meets societal needs by strongly advocating and implementing graded licensing (especially co-piloting) and a gentler feedback and recommendations system instead of punitive action. Until this point is reached, the burden will fall to DMV to institute change.

(**Lillie**, continued) I think field clinics for identified drivers (that consist of DMV, OTR, and even MD) could give more thorough and <u>functionally</u> based driver review. Regional clinics could conduct such reviews one, two, or more times per month as needed, serve to give drivers the benefit of the doubt and the ability to obtain a graded license to support their survival needs, but also do so in safe environment.

I still think the doctor, DMV, and law enforcement will be the team to identify potential drivers with safety issues, age-related, medically related, or substance abuse-related. I see in large states OTs and DMV as a team, and in smaller states the doctor with DMV as a team.

**Allen Dobbs—**I think that the primary players are the DMV and the physicians. This is only because of their access to information. However, both need a set of guidelines as to the impairments that are likely to lead to driving problems and effective ways of assessing whether the person's impairment indeed reduces their fitness-to-drive to a level of risk sufficient for action. I do not think that the physician would or should do these assessments in the majority of cases. Thus, reporting and referral become primary issues.

**68. What tests to separate medically impaired from normal?**

**Frank Schieber—**Neither of these tests is validated: 1) dynamic sequential search through background clutter, 2) mental effort expended during road test. I have preliminary data for both.

**Rich Marottoli—**Unfortunately, there aren't good screening tests, at least those that fit licensing agency requirements (time, cost, ease of administration) at present that I'm aware of; MMSE and a vision measure (perhaps contrast) are still the most practical despite their flaws.

**Barnie Jones—**In Oregon, reexamination counselors use the MMSE along with several other very simple reaction and short-term memory tests. This seems to be effective in the context of a fairly long (30-45 minute) interview conducted by a moderately well-trained interviewer. In this context, results of the MMSE can be supplemented with other more casual observations concerning the subject's general appearance, alertness and ability to carry on a conversation, to obtain a preliminary assessment of the candidate's mental status. (One of the counselors told me that one correlate of dementia is lack of cleanliness, particularly of the interior of the car - I can neither confirm nor discount this observation.) However, it should be noted that in this stage of the Oregon program, the interviewer's recommendations are not binding, and the MMSE is not a required test for licensing at any stage.

**Germaine Odenheimer—**Traffic sign recognition test, road test if comprehensive and reliable.

**Loren Staplin—**Concerning testing to detect (unspecified) medical impairments affecting vision—recommended tests include static and dynamic acuity, full-range contrast sensitivity (photopic and mesopic). Concerning medical impairments affecting cognition—there is insufficient validation.

**Susan Lillie**—1) A checklist of medical conditions occurring in last 10 years—i.e., check all conditions you have experienced, even if you have fully recovered: stroke, aneurism, heart attack, diabetes, arthritis. 2) Neck/trunk range of motion or mobility.

**Allen Dobbs**—I will bring data with me regarding dementia. I do not think the way to go is to recommend specific tests. Instead it will probably require an integrated set of tests.

**69. What tests to separate safe from unsafe medically impaired?**

**Thomas Galski**—"Cognitively/functionally" rather than "medically": Trail Making Test, Porteus Maze Test, Letter Cancellation Test, Visual Form Discrimination Test, Raven's Progressive Matrices Test, Rey-Osterrieth Complex Figure Test, WAIS-R Block Design Test.

**Frank Schieber**—Can't recommend anything but the road test at present.

**Rich Marottoli**—Road test. Again, not sure that any other test has consistently held up as well in identifying/covering the possible spectrum of impairments.

**Barnie Jones**—No. I have seen research suggesting that "useful field of view" is a promising indicator of the ability to drive safely with dementia, but I have no personal experience with use of this measure.

**Germaine Odenheimer**—Wechsler Memory Scale of the pictures.

**Loren Staplin**—Again insufficient validation; **but,** must demonstrate "ecological validity" re task demands on driver attentional processes—realistic scenarios.

**Susan Lillie**—Road test is the only current effective method identified. If other tools were in existence—MMSE, Symbol Digit, Visual Attention—they could screen those with medical impairments and the most severely affected (by objective score) could be referred to a field clinic for closer review without jeopardizing safety of driver or public.

**Allen Dobbs**—Same as answer to question #68.

ASSESSMENT OF DRIVERS WITH DEMENTIA OR AGE-RELATED FRAILTY
PANEL'S "UNSTRUCTURED EXPRESSION OF OPINION"
SURVEY 2 (7/26/94)

Responses to Questions 67, 68, 69 and (new) 70*

**67. Who are primary agents in system, and how improve their coordination?**

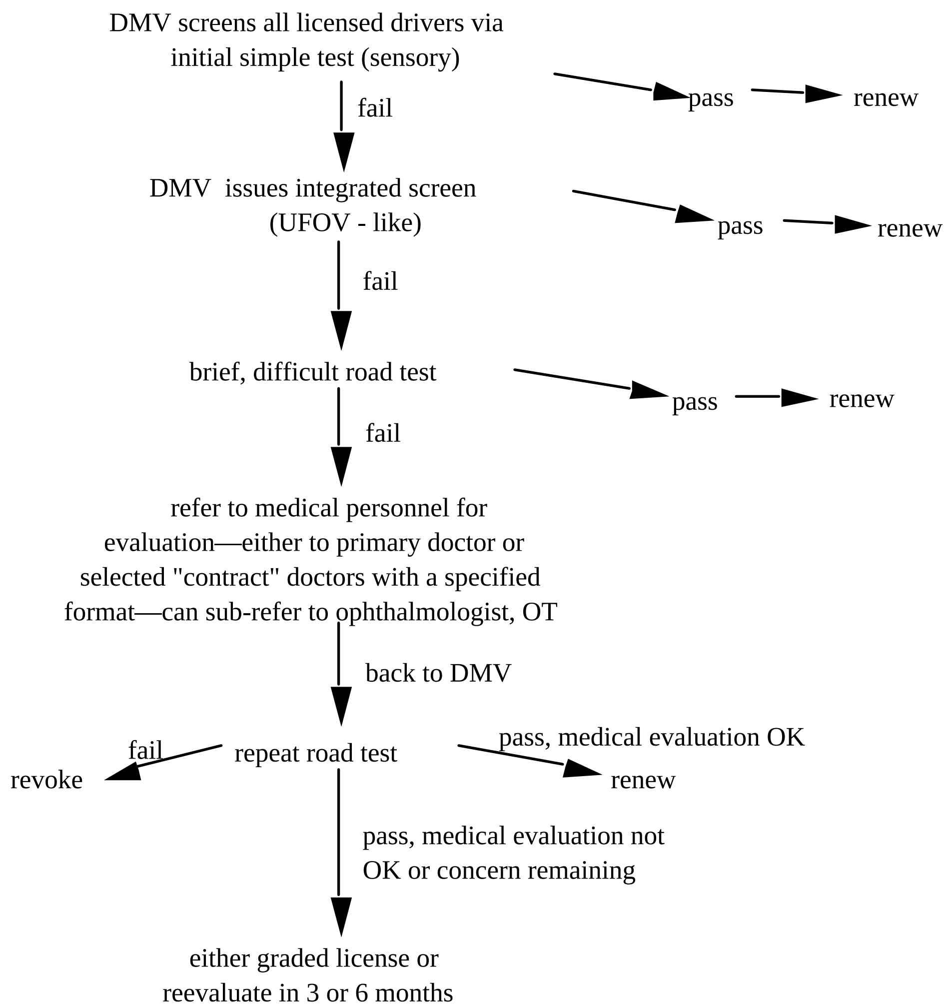
**David Gilley—**The primary responsibility lies with the state DMVs, who must respond promptly and fairly to information supplied by diverse sources. Depending on the value of uniform practice across states, the federal agency might supply basic guidelines and recommendations. However, the final responsibility for the determination of fitness to operate a motor vehicle lies most with the state and/or their fee-for-service agents. At the present time, there is insufficient evidence to drastically change policy and basic license requirements for conditions affecting the elderly. It is, therefore, preferable to explore a detailed special road test or more generalized assessment-center approach for those identified by sources familiar with elderly drivers (family, physicians, law enforcement, etc.). More work is needed to develop the specifics of this special evaluation.

**Maureen Malinowski—**A special regional assessment center might be an addition to the current system. The DMV still seems to be the main entry point, though. Also Pat Waller (Transportation in an Aging Society) talked about a special advisory group, which would include gerontologists, legal staff, and others who could perhaps work in conjunction with the Medical Advisory Board.

**Tom Cox—**Licensing agencies are primary because they are the normal and regular point of contact for all drivers. Licensing agencies' personnel need training to enable them to identify drivers for whom impairment is a possible problem and appropriate mechanisms for further testing and referral as indicated. Physicians, occupational therapists, law enforcement personnel, and family members or caregivers all need to be a part of the system, and all need to be the target audience of a general and continuous campaign to educate the public on driving safety, including older driver safety, and the opportunity and responsibility that all citizens have to actively promote safe mobility of all citizens.

**Rich Marottoli—**Agents in impaired assessment process—a coordinated and prepared screen through DMV takes doctors/medical professionals out of automatic loop (although can refer to them if concerned). See the following:

*67: Who are primary agents, and how improve their coordination?
68: What tests recommended for distinguishing medically impaired from other elderly?
69: What tests recommended for distinguishing safe-driving from unsafe medically impaired?
70: How I/my organization can assist assessment project.




**Ann Dellinger—**Primary agents in licensing system: (1) driver, to self-identify driving problems and to enter system through license renewal at DMV; (2) physician, to provide medical information to DMV if asked, to report patients who are a danger on the road, to report medical conditions if required by law; (3) law enforcement personnel to report suspect drivers if necessary; (4) family and friends, to report drivers with problems and to devise alternative transportation methods; (5) some kind of testing site/personnel system to provide more extensive drive testing when needed; and (6) DMV, to provide licensing tasks and possibly the more extensive drive testing (maybe). The DMV would be the central processing/funneling agency for all of the primary agents; information from all players would land here. To prepare these players, I would look at what other states have done and learn from their successes and failures, then take the methods that worked and incorporate them into a model system.

**Jim McKnight—**The licensing system should be primary, and should integrate a screening process into the regular renewal-reexamination process. There should be a brief (e.g., 5 min.) screening that leads suspect drivers into a more lengthy process.

**Barnie Jones—**As before, I see licensing agencies and family referrals as central, because of the scope of coverage they can provide. However, I now see a different role for specialized assessment centers that would take referrals from licensing agencies to perform a thorough, qualified evaluation of those drivers whose impairment, or its impact on driving, is not clear cut. Today, I think licensing agencies are able to effectively evaluate drivers whose impairments are obvious, but mental status (in particular) is harder to evaluate fairly when functional impairment is more subtle.

**David Shinar—**

| | Initial referral | | | |
|---|---|---|---|---|
| Organization: | DMV | Family/friends (also self) | Doctor/ therapist | Age-based trigger |
| Mechanism/ basis for referral: | Screen test | Subjective evaluation | Medical examination | |
| In depth screen: | Formal test | Answer structured questionnaire | None | |

| | Formal evaluation | |
|---|---|---|
| Organization: | DMV | Medical/OT |
| | Formal special drive test | Provide additional input to DMV plus recommendation |

**Jim Malfetti—**Add health-related specialists (e.g., occupational therapists, psychologists) to primary roles. Also a center to provide training for primary role-players, with a staff (or faculty) competent to train them. Training should include a description of how the licensing agency necessarily organizes their (role-players') inputs in reaching decisions about who uses the nation's roads, and how their input can be organized to facilitate this connection.

**Loren Staplin—**State DMV has the primary role—testing on a periodic basis, at multiple levels, assuming an effective 'entry level' screen.
Playing supporting roles are:

- physicians
- occupational therapists
- physical therapists

These initiate nonperiodic testing through reports to DMV on an ongoing basis, assuming 1) protection from litigation; 2) uniform guidelines; 3) clearly-stated public policy.

Overall coordination: DMV.

**Allen Dobbs—**The broader the participation the better; however, medical practitioners must be involved as central players because of their contact and privileged knowledge. Family members and other lay groups (support groups) are involved also.

Will probably need to refer cases to some assessment center rather than directly to DMV. DMV of course must be involved; it may or may not be the first line of assessment.

Preparation—possibly a task force for physicians would help collect and disseminate information. Educational program is necessary for lay groups.

**Germaine Odenheimer—**Initial port of entry is the licensing process, via
- eye test
- simple questions like: current address? trouble turning neck? trouble turning wheel?
- written exam designed to incorporate cognitive skills, i.e.,
  - traffic signs
  - scenarios

If problems are spotted in any of these areas, then referral to a driving center with physicians to identify medical conditions. Optometrist/ophthalmologist to identify vision problems, occupational therapist or driving rehabilitation specialist to identify functional problems and how to remedy them, and to administer a road test (standardized and validated).

There could be workshops sponsored by National Highway Traffic Safety Administration (NHTSA) at relevant conferences on how to determine driving-related problems. National meetings/regional workshops; i.e., at American Occupational Therapy Association (AOTA), American Academy of Neurology, American Geriatric Society, Gerontological Society of America, Association for the Advancement of Automotive Medicine (AAAM), Transportation Research Board (TRB) workshops with a panel.

**Susan Lillie—**Primarily the agents need to remain
- DMV
- Physicians/health care workers
- Law enforcement

Would like to encourage more <u>family</u> reporting via marketing, forms, and knowledge on how to do so. <u>Confidentiality</u> of the reporting family member, and whether the information reported is confidential or public domain, remains problematic. Coordination needs to be improved by shortening timelines between receipt of report and re-examination.

At DMV—more awareness and education on how problems/diagnoses would manifest themselves, behaviorally and on-the-road, would enhance the ability to identify at-risk drivers.

A process of screening needs to be developed to identify those drivers most at risk, for administration of a special drive test, as in California. Age-related action still lacks adequate research support.

Would like to add preventative/educational component to aid older drivers in self-assessment and recognizing at-risk signs. ADED (driving educators for the disabled), AOTA & CADPD would be ideal, as existing organizations with therapists and driver educators. They could network, for example, with community service groups and make presentations to identified population through volunteerism. I'd be willing to help with this.

**Frank Schieber—**Clearly we need input from diverse sources to identify problem elderly. These sources include: physician, family members, law enforcement, etc. To optimize this process we need mandatory reporting of certain diagnoses and events to a DMV-administered geriatric-based point system. Accumulation of x points (weighted, by the way) would trigger comprehensive on the-road assessment. The point system would dilute "the blame" and provide for the establishment of a pattern, rather than single-point/single-event measures (which can be prone to "false alarms").

**Kent Milton—**Assessment centers—because they are neutral. Have law amended to require doctors to report possibly impaired persons to the assessment centers—licensing agencies being required to accept assessment center findings. Families could bring elder members to assessment center; health care network would also refer. DMVs could also require applicants to undergo assessment at center to avoid circumvention by license applicant. Center personnel would be trained to standards set up by a coalition (AMA, NHTSA, AAMVA, occupational therapists (OTs), etc.).

**Thomas Galski—**Independent assessment centers are primary. Referrals to centers as a result of impaired functions in perception/cognition/ behavior/physical condition from physicians, plus health care facilities (i.e., hospitals), plus licensing agency in state, plus person/family.

Licensing agency is the central processing agent whose decisions about licensing (approvals, restrictions) are made after due consideration from an advisory panel of experts on the relationship of deficits/impairments to actual driving.

**Sheila Prior**—The medical community must take a primary role in assessing drivers with medical impairments. These people are knowledgeable in medical diseases and conditions, are familiar with the patient, and know how the conditions may affect the person's physical abilities. Drivers' license personnel, law enforcement, and road test examiners have only brief encounters with drivers and are not familiar with the signs of medical conditions or their effect on the ability to drive safely. However, this latter group can detect obvious medical problems and can report the driver to the DMV for testing and evaluation.

The medical community and drivers' licensing agencies must work together to make the ultimate decision on a person's ability to safely operate a motor vehicle. Restrictions may need to be added to the license if the person is basically a safe driver but needs to be limited in some way.

Coordinating activities between these two groups will take an intensive effort. The medical community must be made to understand the significance of not reporting problem drivers to the DMV for assessment. Training the licensing agency staff, specifically the people who handle "citation" processing, will also assist. Making these people more aware of medical conditions and their effect on a person's driving ability will assist them in determining a proper course of action, whether it be additional testing, adding restrictions, or removing driving privileges.

**68. Tests to separate medically (functionally) impaired from normal:**

**David Gilley—**My primary recommendations would be in the realm of visual function—acuity, visual fields, contrast sensitivity. A possibility would be a visual-motor tracking test that was face valid for driving purposes. If designed properly, it would be possible to capture the elements of attention, visuospatial skill, and response speed to changes. With appropriate calibration, it could be short and applicable beyond the elderly population, although failure rates among the elderly cohort are likely to be much greater. These tests could then serve as another trigger to more detailed road test evaluation.

**Maureen Malinowski—**Digit Memory Test that Germaine [Odenheimer] mentioned sounds like it might be a tool that could even be done at the DMV. Sensitivity to older drivers needs to be an important part of training for DMV staff before implementation of new procedures, though. Also asking name or date of birth sounds like it would have face validity.

**Ann Dellinger—**I know of no tests that I would recommend for the licensing agency. I suspect that a test of cognitive impairment would be the most appropriate; however, it appears that a short test of cognitive impairment isn't now available. I'm not sure one could be devised to make it practical to implement at a licensing agency.

**Rich Marottoli—**Two avenues are

1. initial screen of 3-5 self-administered pencil and paper tests while applicant is waiting for renewal. Want them difficult enough to spread people out and capture all (or nearly all) impaired; therefore high sensitivity.
2. next step in screen would be an integrated computerized task (like the UFOV [Ball-Owsley] or the EDS [Gianutsos] in brief form).

**Jim McKnight—**I'm not medically qualified and am not familiar with tests for medical conditions. We hope to validate elements of the Automated Psychophysical Test (APT) against measured performance and traffic record. If it is successful we could offer specific subtests for general use by DMVs, OTs, and so forth.

**David Shinar—**Recommended tests/procedures for licensing agencies are
Vision: Contrast sensitivity, low contrast acuity
Perception: Spatial orientation, Embedded Figures, hazard perception
Attention: Divided attention—time sharing and switching
Cognition: Decision making under stress

For other groups:
Ophthalmologists: Progressive eye diseases, cataracts, retinitis pigmentosa, macular degeneration

Neurologists:  Hemineglect
OTs:  Detailed by others
Geriatricians:  Detailed by others

**Barnie Jones—**I would only add that our experience in Oregon suggests that at least the more serious cases of impaired mental status can be identified in the course of a relatively long (45-60 min.) interview that encompasses a series of memory, attention, knowledge tests, and functional evaluation tools, along with more informal observations of behavior and communication ability and on-road performance.

**Jim Malfetti—**Shell Petroleum (years ago) showed traffic scenes (on slides) with the opportunity to detect hazards.  There were standardized scores.  That is all I recall.

It is not specific, but a road test is still my prime candidate unless the applicant is clearly unable to perform safely due to physical or mental conditions.

**Loren Staplin—**Best bets are "intrinsic" measures of
- acuity (static & dynamic)
- contrast sensitivity
- attentional visual field
- selective attention
- choice RT
- fitness (head/neck mobility, arm/leg movement range, response time)

Tests must be implemented in a standardized protocol that is reliable, reasonably brief (≤ 15 min.), and perceived to be fair and valid by driving public.  Therefore test thresholds would lead to minimum performance requirements, using high realism in test stimuli.

**Germaine Odenheimer—**Specific tests include
- Traffic sign test
- Comprehensive road test
- Written test with cognitive slant

**Susan Lillie—**I don't recommend a clerk to be doing cognitive exam/observation. However, as David Reuben stated, use of additional language tests, specifically traffic sign recognition, seems promising as a stage 1 screen.  Embedded figures and serial digits tests could be stage 2, if supported in future research, and a road test stage 3.

I don't like simulators for elder populations due to technophobia and unfamiliarity with such equipment, which results in skewed results!  Psychometric tests seem the way to go for a general gross screen if the right test is selected.  Unsure of which test, due to disparity of research findings.

I feel the best way to go is standardization of drive tests by states.  Big project!

**Frank Schieber—**Based upon information presented the last few days, automated presentation of a revised knowledge test could assess both high-level cognitive impairment and, if computerized, be designed to tap attention impairment (via "intrinsic" measures with response times profiled by computer).

I think mass screening based on the UFOV or other attention switching tests appears quite premature and a lot more likely to yield false alarms than the above (specifically, data from Ball et al. are for a constrained sample—not mass screening. Remember "Bayes Theorem.")

**Kent Milton—**This question is beyond my competency, because my background is in another area. But based on what I heard, the special driving test seems to be the appropriate procedure to identify the unsafe driver. Presumably this special test will be honed into increasing reliability! Concentrating on attention disorders and visual problems in particular—again based on what I heard.

**Thomas Galski—**Re tests by the licensing agency, there are no specific discriminating tests of driving abilities/impairments. Therefore evidence of medical conditions known to have impact on perception/cognition/behavior/ physical condition by history is the only "test" or "trigger" for referral.

**Allen Dobbs—**What is needed are tasks linked to aspects of driving, rather than tasks intended to "predict driving." It is too complex for that. However, a screening task could be developed which was relatively short (5-7 minutes), that moved from one type of assessment to another, that was presented automatically, scored automatically and formatted such that it had high face validity. I think enough is known to begin working toward this with a focus on particular types of attention, executive functioning (including decision making) and memory.

**Sheila Prior—**Quick questions and answers for the DL staff; i.e., "I need to verify your name, address and date of birth." "Please spell your name." "Verify your address and date of birth." Phrasing the question as a verifier vs. "Tell me what it is—I want to see if you know/remember" is much less insulting.

Road signs test administration is a great tool. I also like the triangle test Susan Lillie distributed.

**69. Tests to separate safe from unsafe medically (functionally) impaired**:

**David Gilley—**Basic components should be (1) an interview to determine driving history, supplemented as needed by proxy information (driving behavior, road conditions and length of trip, frequency of use, known problems or potential problems); (2) visual and cognitive function testing to determine fundamental impairment; and (3) a road test. Not all of these components may be available from all sources. Obviously, the minimum available to all concerned parties is a brief, but systematic, evaluation of driving history. Previous problems are going to be the best predictor of future problems. Ideally, some basic guidelines could be widely disseminated to provide guidance for practitioners as to content of this interview. In a pyramid-type schema, this should be at the top of the pyramid.

**Maureen Malinowski—**The closed-route drive tests sounds like it has a place in the process. Perhaps it could be provided more easily at a special assessment center. It's very important to involve the older driver in the process, though. Information about graded licenses should be available to older drivers, too. Perhaps a self-assessment tool for the driver could be incorporated in the process. The format used in Oregon sounds interesting. Providing questions to drivers about their self-regulatory behavior might be another component of the process.

Special drive (road) tests like those done in California sound like positive tools in that they can be less structured (giving a destination and letting the driver figure out how to arrive there) when that seems to be needed. Thought would be needed in how states with different structures might implement it.

**Rich Marottoli—**Need to

- define domain of impairment, severity, possibility of remediation
- refer back to DMV for specialized road test

Need also to consider likelihood of progression—particularly true of neurological conditions. If likely, need to factor in periodic reevaluation.

**Barnie Jones—**Based on my conversations with David Hennessy, I still believe that useful field of view via the Visual Attention Analyzer is promising. No additional thoughts, except that I think I learned several ways to make a road test a better tool than it is today in Oregon.

**Jim Malfetti—**While I heard numerous such tests described I do not know enough about any one of them to recommend it.

**Loren Staplin—**A suggestion is more elaborate batteries of tests addressing the same functions as suggested above, but expanded beyond "minimum qualifications."

**Susan Lillie—**On-road functional performance is the acid test as far as I'm concerned. As above, standardized scoring is needed. And the idea of regional centers for testing is still attractive. Need to be able to provide more personalized road tests, from home to the grocery store for example, which is time consuming and costly. Regional centers would also be costly to start, but could be of great benefit. Would be politically easier to put through with secondary AARP support.

**Frank Schieber—**The Hartford [Insurance Company] prepared a automated version of the Trail Making A task superimposed upon a busy traffic scene. This task holds new promise for detecting the same sorts of visual search problem that UFOV taps, plus additional problems. It might be very useful in physician's office or OT assessment centers. Let's give the test to OTs and see what they find!!!

**Kent Milton—**I have to defer to the medical/research community. What I heard from the doctor(s) was a possibility of conglomerating symptoms to get a potential conclusion of "unsafe driver." OTs apparently have their own regimen. Seems like a task force approach (DMVs, physicians, neuro-psychologists, OTs) ought to develop a standardized test which would be adopted by assessment centers.

**Thomas Galski—**

| | |
|---|---|
| Scanning/attention | Trail Making Test |
| | Cancellation Test |
| Visual acuity/peripheral vision/depth perception | |
| Visuospatial perception/visuopraxis | Rey-Osterrieth Complex Figure Test |
| | Raven's Progressive Matrices |
| Psychomotor speed | Finger Tapping—Digit Symbol |
| Speed of information processing | Digit Symbol |
| "Executive functions" | Self Awareness |
| Higher order cognition: | |
| Planning/anticipation/decision making | |

**Allen Dobbs—**I will provide you with preliminary findings from our research. They are correlations from a wide variety of screening, rehabilitation, neuropsychological and research tasks. What I will provide is a sampling from the array of tasks we assess.

**Germaine Odenheimer—**Tests to separate impaired drivers include
- Careful history of function/driving problems from a collateral source
- History of medical conditions and medications
- Examination of strength, range of motion, proprioception
- Cognitive measures of attention and visuospatial skills

Observation of functional skills
- using a telephone
- writing a check and balancing the checkbook
- driving a car
- selecting appropriate sequence for planning a meal

**Sheila Prior—**From conversations here these last two days, there seem to be a multitude of tests available. However, I think the medical community is better able to answer this question.

**70**. **How I/my organization can assist assessment project**:

**David Gilley—**Role in project would be to evaluate the prevalence and incidence of accidents and motor vehicle violations in major neurodegenerative diseases of elderly—Alzheimer's disease, Parkinson's disease, cerebrovascular disease. As well, we will evaluate complex tests of attention and psychomotor function.

**Maureen Malinowski—**AAAM's experience provides a lot of general background that will be useful in looking at the overview of the issue. Training for driver licensing examiners could implement some of the new simpler tools mentioned, as well as training in dealing with the older driver.

AAAM could also be a link with medical advisory board personnel. Perhaps it could provide a forum for persons involved in that process at the annual meeting.

**Tom Cox—**Role of AARP is to 1) sponsor and supervise research on older driver issues; 2) disseminate information on driving safety and on public policy issues affecting mobility both of drivers and non-drivers; 3) maintain and strengthen its driver retraining program—55 ALIVE/Mature Driving; 4) advocate for the best interests of all Americans on traffic safety and other mobility issues, especially the best interests of older Americans; and 5) continue to participate in and contribute to the effort to develop effective public policies governing traffic safety issues.

**Ann Dellinger—**I think my role as a Centers for Disease Control (CDC) researcher is to provide study design and research projects to help answer some of the nagging questions in the arena of older drivers and medical conditions. For example, do drivers with medical restrictions have fewer crashes, injuries, violations? Also, to provide a population-based perspective to complement an individual physician/patient perspective in this area.

**Rich Marottoli—**Developing criteria for (1) entry into system and (2) medical evaluation for clinicians; assuring that whatever system is proposed and/or implemented is as fair as possible to older drivers and considers impact on their lifestyle/psyche. Am still concerned that the systems proposed identify younger drivers only after they do something "wrong," but older drivers potentially before problems arise. If driving performance criteria are used, how are cutoffs determined?

**Jim McKnight—**We are prepared to offer equipment, facilities and our expertise in all things, living or dead. In fact we will be testing 200 referrals and 200 volunteers on the APT and a special research version of the [California] special drive test (SSDT?). In addition to making results available to CA DMV, we can integrate activities of the two projects wherever it will benefit both.

**David Shinar—**Evaluation research, especially in the domain of vision/ perception/cognition tests. Member of expert panel in this area.

**Barnie Jones**—Given that my new job is only beginning to take shape, it is difficult for me to make any strong commitments. Also, Oregon DMV is going through a very difficult transition and is currently focusing all of its energy on operational issues. However, Pete [Nunnenkamp] is generally receptive to innovation and, to the extent that other priorities are not jeopardized, I think <u>we would be interested in piloting new assessment techniques that can be integrated into our current older driver assessment system</u>.

**Jim Malfetti**—No organization, no institutional role. Perhaps <u>historian</u> would be most appropriate. I could remind procrastinators how quickly one grows old.

**Loren Staplin**—Possible role(s) for independent researchers/contractors include

1. Development of test batteries and apparatus for test station administration at DMV.
2. Development of new test protocols, alternate forms, etc.
3. Program evaluation.
4. Conduct of screenings in jurisdictions which cannot expand staff.
5. Referral and coordination of clients through area aging agencies; counseling for transportation alternatives.

**Susan Lillie**—OTs will continue to play a strong role re older drivers. Such organizations can be utilized to provide education, counseling, recommendations/ referrals via their members. Lots of OTs are willing to provide community service via presentations to special-interest community groups, elder groups, and their families. OTs need to continue to interface with and educate doctors. OTs are currently trying to implement a driving segment into the education system so that all OTs will get baseline information.

Personally—I am vested in this topic and will continue to educate physicians via training hospital, work with California DMV, and work with AOTA toward change. I see myself as a player in this arena for a long time.

Research is important, and I am venturing into research with older drivers, but need support and mentoring to achieve the final goal—a finished project. I hope to continue contributing toward policy development and education of the older driver and drivers with medical/physical impairments.

**Frank Schieber**—I don't think I will play a role in this endeavor as I am growing tired of "spinning my wheels." We need programmatic/research-based efforts designed to meet our objectives—not more in the line of endless initiatives to "build the best system based on currently available knowledge." If you build the most expensive fortress on a hill of sand––it is sure to crumble to the ground at the next high tide!!!

**Kent Milton**—My role is in public affairs. It's becoming more apparent with each session I attend that the broad area of older driver safety/mobility is not well understood by the public and subpopulation. Educational strategies are in order—to engender broader public understanding, to assist older drivers, to made families aware of options/possibilities, to secure the health networks' support (physicians, OTs, home health, etc.). So—much to do in public affairs. (Including assistance to the motor vehicle administrators in advising the public about older driver policies.)

**Thomas Galski—**Personal role is development of compendium of skills/abilities and their relative importance in safe driving. To be followed by development of a standardized methodology for evaluating skills and abilities (probably including development of new "tests" that are not time consuming or costly). Use of information to develop domain-specific and task-specific "rehabilitation loops" to remediate deficits, if possible, and keep as many drivers on the road as possible.

**Allen Dobbs—**Our current research is directly relevant in a variety of ways, most notably:

1. Direct assessment of the effectiveness of a wide variety of rehabilitative, neuropsychological and research tasks for predicting in-car performance.
2. Description of driving behaviours (from in-car performance, not retrospective reports) of young, elderly, and demented persons. This description includes success with which the problems can be induced by different driving situations and concurrent tasks. This can be very instrumental in formulating the type of driving evaluations that are necessary for DMV or other assessment units to provide.

**Germaine Odenheimer—**I can help design surveys for MDs and elderly regarding knowledge, attitudes and actions; educate MDs regarding their role in the process through site visits; and set up workshops at neurology, TRB and geriatrics conferences, AAAM. The Academy of Neurology is sponsoring me to write practice guidelines on dementia and driving, and they have offered to support a survey of neurologists. I am also interested in helping design driver evaluation teams.

**Sheila Prior—**AAMVA can assist in distributing information to state licensing administrators. We can also give "expertise" to discussions and development of policies and procedures. As we have field experience, any recommendation should first be submitted to us to advise/determine whether or not it's feasible. We could also assist with the development of a training program for DMV staff.

# CONFERENCE SYNTHESES

## 1. DO WE NEED AN ELDERLY DRIVER ASSESSMENT SYSTEM? FOR ALL? FOR SOME? (Ray Peck, CA DMV Research Chief)

There was no unanimity on the question of need for an elderly driver assessment system. I believe it depends on the choice of criterion measure—accidents per year vs. accidents per mile. Which measure is relevant and which should be chosen depends on your perspective and what you are trying to do. Another problem is the role of vulnerability. Older people are much more likely to be killed or seriously injured given the same degree of trauma, so part of the increase in their [casualty accident] rates has nothing to do with skill. If we assume that it's all due to vulnerability, then does the state have any responsibility to intervene?

Another issue to discuss is the very definition of competency. A prior California DMV Director argued that the definition should be expanded to include mobility, and certainly one reason why people drive is to get from one point to another. If people drive in a way that is excessively slow for the conditions, they are not driving in a manner that optimizes or promotes mobility. This can cause congestion and conflict—and hence, a potential for accidents in situations where other traffic is forced to slow down or maneuver around them. To what extent should society and decision makers embrace this expanded definition of driving competence? *

Anther consideration I think is not receiving enough attention is the linkage between accident causes among different age groups and the types of competency that can be detected in a licensing exam. Cognitive decline and decline in skill, for example, may be much easier to detect than attitudinal factors like an inclination to take risks, which are already being dealt with by the existing point system and by mandatory actions. So I think you have to look not only at the accident rates of the population and various cohorts, but at the kinds of things that are causing the accidents and whether those things are detectable in a driver licensing exam of any type. There is evidence to show that the role of cognitive decline becomes more important in causing accidents as drivers age, and that variation in cognitive abilities increases with age. And cognitive skills are also very measurable through a driver licensing exam process. This factor was commented upon by a few people but I think it deserves much greater emphasis in developing driver licensing policy.

In California we already have to some extent an age-mediated system. We discriminate against young drivers through the provisional licensing program, and to my knowledge there have been no legal problems. We have some basis and precedent in California and other states and countries for, in some cases, very complex graded licensing systems for young drivers. California also has a law that excludes people from our renewal by mail program at age 70, and apparently that has not been challenged. We are precluded from giving road tests on the basis of age, but we can use correlates of age, and in fact the average age of

* Ed. note : This view of "mobility" is different from the one which regards it as an individual's ability to do necessary travel. It refers rather to societal mobility as indexed by highway congestion or the lack of it.

people in California who receive area and time-of-day restrictions after a road test is 77; very few are under 60.

I think there is a lot of merit in graded licensing, as Jim Malfetti pointed out in his presentation; it eliminates a lot of problems and I think it's also logical because the degree of risk is a quantitative attribute that can be directly affected through restriction of exposure. If you restrict time and place, the amount of mileage is also going to be restricted, and so it follows that you can reduce the risk of an elderly person, even one who is extremely impaired, to almost zero if you limit driving to a particular time of day and highly specific overlearned routes (the so-called "home to market" concept).

It's also possible to consider graded licensing in terms of an advisory model, where older drivers are tested and given information on an advisory basis that they can use to reduce their risk. If this turns out to be as effective as mandatory restrictions, then certainly it has a lot of merit. This ultimately is an empirical question that needs to be investigated.

If we imposed a model system based on age, would it improve safety? There is really no way of knowing without doing it. It's very possible that a great majority of the drivers who would be impacted—at considerable expense—are already aware of their problems and are already restricting themselves. If they are, then the creation of an expensive system that would further test older drivers would really serve no purpose. Again, the question of the need for an elderly driver system cannot be unequivocally answered, based upon the current evidence. In fact, that is why the present study is investigating this issue.

A final issue that needs to be explored is how to make the decision to road-test someone. Most of the experienced drivers road-tested in California are old, but the decision to test is based upon very subjective grounds which vary from office to office and from examiner to examiner. It should be possible to base these kinds of decisions on more actuarially and scientifically valid grounds. One of the objectives of the present study is to explore, develop, and evaluate criteria for determining who should be road-tested.

2. THE GERIATRICIAN'S TOOLS FOR ASSESSING PATIENTS' DRIVING RISK (David Reuben, M.D.)

Fourteen main points were brought out in the discussion:

A. The geriatrician's/physician's perspective focuses on prevention of injury and remediating treatable problems for individual patients, rather than on licensing or public health issues.

B. Standard components of a comprehensive standard medical evaluation can identify relevant deficits that may impact safe driving.

C. These standard components can be augmented by driving-specific historical information.

D. The validity of self-reported information regarding driving problems is suspect. Supplemental information from proxies may be helpful but still may not be accurate, compared to observed performance.

E. None of the standard components of a standard medical evaluation have been demonstrated to be predictive of driving outcomes such as violations and crashes.

F. At best, physicians cannot accurately assess driving risk but may be able to identify patients who need further evaluation.

G. Only a small minority of physicians currently conduct any assessment of driving status.

H. Most physicians don't even systematically assess components of the history and physical examination that are relevant to driving.

I. The vast majority of medical care for older persons currently is, and in the future will be, provided by physicians who are not geriatricians.

J. As the health care system evolves, the length of visits will be shorter and the history and physical examination will be more parsimonious. Hence, addition of driving-specific components will be very difficult to implement.

K. Also, in efforts to increase the efficiency of physicians, increasing amounts of data gathering will be delegated to non-physician professionals and office staff.

L. Once concerns are raised about safe driving, the geriatrician/physician should discuss those concerns with patients and their families and document these conversations.

M. When geriatricians/physicians refer for further evaluation, patients should be informed that this further evaluation may have implications for licensing.

N. In many states, physician referral to the DMV is a last resort for physicians caring for older persons who have medical problems which may be associated with increased risk for unsafe driving.

3. HOW CAN WE TELL WHEN DEMENTING PATIENTS SHOULD STOP DRIVING? (Allen Dobbs, Ph.D.)

The discussion was initiated by asking "Who are the 'we' in the title?" There was a fair amount of discussion about that, and I think that actually there was even more discussion in later sessions on that particular question. I don't think the question was ever answered, but it seemed to me to be a major issue. At least two interpretations of the word were offered—on the one hand "we" seems to refer to the identifiers of the person at risk. These would include people in the medical field or other helping professions, people within the DMV, or other sources, including families. The other interpretation, I believe, was that it refers to who should do the assessment, and "assessment" here seemed again to have at least two parts to it—in-office and in-car. Another question, relating to how to identify the at-risk driver, is whether clinicians should be required to report. The facilitator [Germaine Odenheimer] suggested that if the answer to that is yes, serious questions arise regarding the basis for reporting. There may be a need for independent assessment units so that physicians could report, or refer, patients to driving-assessment/rehabilitation centers rather than to the licensing agency. These centers could make recommendations to the DMV. If assessment is to be done by the physician, Richard Marottoli's [earlier facilitator's] chart contains most of the necessary components, with vision and attentional functions being singled out as being particularly important.

Much of the discussion then turned toward issues of road testing, and what the relationship between in-office testing and road testing might be. Part of the issue was what a test might predict, but it seemed to me that there was perhaps a more detailed question that needed to be answered, and that was what tests predict what. We seem to focus on having tests that will predict driving performance, or accident risk in general, and so forth. But given the complexity of the driving task, maybe that is an unreasonable thing to do. Maybe we should be looking for specific tasks in the office that may predict certain *aspects* of the driving task which, when taken in concert, might be better predictors of driving performance.

I think that six areas of discussion become a key to what we are doing:

A. If we are trying to develop predictors, then the question is to predict what. To some extent this is an issue of whole vs. part. On a road test, for example, are we trying to predict pass vs. fail, or some specific aspect of driving behavior? The criterion is crucial.

B. A need was expressed almost implicitly for standardization of road tests. That became interesting in view of later discussion which pointed toward the possibility of individualizing road tests. This is an interesting issue, and one of the things touched on was the Special Drive Test, where there seems to be considerable emphasis on the driving instructor's or evaluator's constructing a test to fit the needs of the person tested. To me it seems that the more unstructured the test, the more knowledgeable this person would have to be to construct it on the spot. It might be a very valuable exercise to convene an expert panel to see what attributes could be put into a driving test that might tap the different types of factors important in predicting functional impairment. One point that came out was the attempt in the Special Drive Test to engage examinees in conversation, which is a means of usurping some of the driver's cognitive resources in order to see what's left over for dealing with other stimuli. In our own research we do that explicitly, and that gives us perhaps our most valuable information. For example, in one part of a closed-course test a Styrofoam vehicle suddenly comes out in front of the driver's car. A cognitively impaired driver may collide with the dummy car and not notice it.

C. This brings up one aspect of the physician's problem in telling cognitively impaired patients that they must be reported—they may not recognize their limitations. On our test there is one part that nobody can pass; we deliberately built it that way. It's the one part that everyone focuses on after the test. They say, "Gee, I did really well on everything else, but I really screwed that part up and I'm sure I'm not going to pass." I think that we were going to leave that part out at one point, but we left it in specifically for the physicians, because otherwise patients regularly said, “I did very well on the test; I didn't have any problems." In fact the more demented the patients are, the more likely they are to fail to notice any problems, and the exercise that everyone fails gives physicians an opportunity to talk with them about their problems.

D. A fourth thing we talked about was what perspective we are adopting. It seems to me that two very different ones are involved—one is about serving the public, a safety kind of perspective, and the other is an individual kind of perspective. The consequences for the individual, in both views, seem to be very important, not only in terms of the public safety perspective but also in what happens to individuals if their license is in fact suspended. I was very interested to hear, as I understood it, that in California if a person receives a diagnosis of dementia, they have the right to prove that they are competent to drive. This seems to be saying "Your license is revoked until you can prove your competence," which is an interesting twist. I'm not sure that, if it's well known, this may not have a health care repercussion in influencing people not to come in as early for diagnostic workups. At least this possibility should be looked at.

E. We should also be thinking in terms of costs to the individual whose license will be revoked. There is a lack of research on this topic.

F. In counseling, it may be important to instill some attitudes of caution. It may be that the more a person takes training, the more likely they are to have high confidence when they are driving and the less likely they are to take the kinds of self-regulatory measures that are typical of older people. I would be interested in the results of things like driver safety training, 55+, and so on, which really work towards confidence but also have an attitudinal component.

4. OCCUPATIONAL THERAPISTS' AND/OR PSYCHOLOGICAL TOOLS FOR ASSESSING THE DRIVING RISK OF ELDERLY CLIENTS (David Gilley, Ph.D.)

What was proposed was a model with multiple components, essentially three: an interview to obtain basic medical information, functional history, and driving history; a clinical evaluation to specifically test visual function, cognitive function (particularly in the area of attention), visuospatial skills, and psychomotor speed; and lastly a performance-based driving test. The major components of the clinical evaluation and driving test each had several issues associated with it. In terms of clinical evaluation, there is certainly the issue of standardization of test content and administrative procedures in the interests of comparability across sites, as well as collection of normative data and selection of tests on the basis of a model of the driving task. The cost of these evaluations, in terms of time and money and whether or not reimbursement is available for them, was also discussed. Another issue was the question of whether or not adequate criterion-based validity data were available to support any or all of these procedures, and part of that problem was a clear lack of consensus on what the criterion to evaluate a particular test happens to be. Lastly was the issue of face validity—what makes many of these tests relevant, or what makes them appear relevant, to the task at hand of evaluating performance in driving?

In terms of the road test there was also discussion regarding standardization of such things as course length and test complexity, standardization of scoring, considerations of driving style (which may cause examiner discomfort but not enhance crash risk) vs. driving safety, and use of a standardized vehicle rather than the client's own vehicle with its familiar performance characteristics. Other topics were delivery cost (clients frequently pay), possible contracting-out of assessment to driving schools, the training of examiners (and of course the more individually tailored the test, and the more complicated the scoring system, the more training might be necessary), and the question of how much retesting is acceptable, at what cost and under what circumstances. I'm not sure that any final resolutions were reached on any of these issues, but certainly they are basic ones that need to be addressed.

5. IMPROVING ASSESSMENT TOOLS FOR DMVs: CONSTRAINTS AND OPPORTUNITIES (David Shinar, Ph.D.)

The distinction between an opportunity and a constraint is not always clear, but from the point of view of opportunities, it was stated that assessment policies are often driven by, or come about in reaction to, individual traumatic events. These can sometimes be seized as opportunities if at the time DMV has the data to support one approach over another one. An example of this is age-based assessment, which the California DMV didn't particularly have support for, but intuition and one congressman turned things around so as to allow it [in the form of an age cap on the renewal by mail program]. Another opportunity is that states have different approaches and can learn from each other, since they may be equally capable of making certain assessments. Finally, there is a lot of accumulated experience on the part of examiners, and that can be utilized.

Discussion seemed to focus mostly on the constraints. One is that whatever test we come up with must have face validity, regardless of its predictive validity and other kinds of validity. States are tremendously hampered by issues of ease of administration, who should pay for added testing, and cost in general—personnel costs, time spent interacting with the client, space limitations, and capital expenditures. The last are particularly a factor for simulators, which may be very useful in refining assessment criteria but may not be very applicable to a mass screening process. Also licensing decisions involve much more than simply pulling together test results. There are pressures; there are needs; there are political requirements, social requirements—all of these together will converge, and the results found in research on the assessment tests are just one influence on this process.

Finally I put as a constraint AARP's opposition to age-based assessment. It seems to be an open question where to draw the boundary between driver control and the privilege of obtaining a license. Related to that is the question of how we can capitalize on individuals' self-regulation, since there are a lot of data to the effect that as a group older drivers do very well in regulating their own behavior, though this is not necessarily the finding in the individual case. When age-based testing is approved it seems to be by serendipity, rather than a thought-out process related to its justification and feasibility. Can we generate a set of criteria for such testing? Possibly one of them should be how the elderly themselves feel about it, and to find out how they really feel we must be very careful in formulating the questions. Again, AARP's opposition to age-based testing seems to be an age discrimination issue, and if that can be overcome the issue may be moot for the AARP. Another age-based testing issue is the quality of the ecological data we have to support it; at least some people feel that we do not have a strong data base to support age-based testing.

The final issue raised was privatization of evaluation. Nationwide there seems to be a trend toward privatization, and to the extent that that becomes the dominant mode of evaluation, at least in selected circumstances, it may actually eliminate many of the constraints which we talked about before.

6. IN A GRADUATED [I.E., GRADED]LICENSING SYSTEM, WHAT CONDITIONS [I.E., RESTRICTIONS] SHOULD BE TIED TO SPECIFIC FUNCTIONAL LIMITATIONS? (Barnie Jones, Ph.D.)

One thing that surprised me a little bit about the presentation was the finding, in the process of organizing focus groups and holding public meetings and discussing how licensing actions should be handled with older drivers, that a lot of older drivers do not like licensing agencies! You know I've had some nasty things to say about Oregon's licensing programs—particularly their road test and their knowledge test. When you do research in a small state you have to wear many hats, and one of the things that I have done over the years is a DMV customer satisfaction survey. This is a good scientific survey with a representative sample and a high response rate, and people do tell us that they don't like waiting and that we make them wait too long. That rings true, but what may be surprising is that when we ask them about employee courtesy, employee helpfulness, and ability to answer questions, Oregon DMV gets very good marks. In fact, Oregon DMV gets excellent marks. I have two possible explanations for this: one is that most of our customers have recently moved up from California and we're only good by comparison, and the other is that the notion that DMV provides bad service is just another one of those apocryphal stories like the one about big alligators in New York sewers.

Dr. Malfetti started out with a discussion of the concept of graded licensing—where it came from, why it's important, and what it consists of, and what I got out of that part of the discussion is that graded licensing does several things. One is that it avoids the devastating consequences of the absolute denial of driving privileges with losses in mobility and freedom, that the ability to participate in community life that driving confers is very important to older drivers, and that there are issues related to participation and isolation, personal dignity, and the ability to avoid becoming dependent, that are extremely important, in that these social costs need to be weighed against the risks of continued driving. That's what graded licensing does, by imposing substantial restrictions in many cases on driving but retaining a right to drive in order to avoid the devastating consequences of the denial of personal transportation. At the same time it can reduce the risk associated with the driving they continue to do—substantially, we hope—both by reducing exposure overall and especially by reducing certain kinds of critical exposures. It also provides a role for the elderly in the decision-making process, which helps to preserve their autonomy. They are able to participate in deciding which restrictions are appropriate for them and which are not.

There were a number of interesting points, I thought, that came up in discussion. John [Eberhard] pointed out that restriction may make a great deal of sense for drivers whose mental status is good, but that if mental status is the central issue to consider about a person's ability to drive, there is a question of whether they are able to make reasonable decisions about when and where they should drive. Also there is a question of whether or not they will be able to abide by their restrictions once they're issued. Robert [Hagge] had an interesting comment, which is that if examiners are going to be able to make reasonable decisions about what kinds of restrictions—especially geographic ones—are appropriate, that presupposes that the examiner or counselor is able to assess the risk associated with a particular area. While that may be fairly easy in a small town or a rural area, it may become problematic in an urban environment, in that the examiner will not necessarily be able to easily assess what kinds of risk are associated with particular neighborhoods and particular routes. Another interesting point, I think, was that self-imposed restrictions may sometimes go too far. People may be able to give themselves a great deal more latitude than they end up with, under a restricted license. To me that doesn't seem like a terribly important factor, to the extent that if the person retains the ability to continue to drive and they are able to live with that restriction then it may be worth it. I'm inclined to think of this in terms of some kind of basic equation where you can balance the risk reduction against the restriction of mobility, and that even if larger numbers of people end up with more restrictions than would be the case if the only options were revocation or unrestricted driving, the balance overall may still be positive.

7. WHAT IMPROVEMENTS CAN BE MADE IN BRINGING THE MEDICALLY IMPAIRED TO DMV's ATTENTION? (Loren Staplin, Ph.D.)

The point was made that when a licensing agency adds tests the cost is considerable. Also, DMVs are subject to court challenges by disabled people when tests are administered on the basis of disability. In addition to tests there are currently several reporting sources (DMV personnel are one) and procedures by which severe deficits can trigger a reexamination. But the question specifically addressed was what additional procedures might be put in place to bring more people who are medically impaired to the attention of DMVs. John [Eberhard] prompted us with the suggestion that it would be most practical if there were some broad communitywide system which spanned a variety of different groups—OTs and physical therapists were mentioned particularly. That generated a fairly lukewarm response. Issues that had been brought up earlier—what criteria will they use, how standardized will they be, and so forth resurfaced. There was a sort of semi-facetious suggestion that if we had drive-up instead of walk-up renewal processes a video record of the driver's approach to the site could be generated and scored. Not quite so facetiously, we might remember Pat Waller's frequently cited story to the effect that the parallel parking part of the North Carolina exam was the one that was by far the most predictive of subsequent driving performance, and that was of course the part taken off the exam because of public protest. But seriously, any kind of observation of actual driving performance that was part of the renewal process would potentially yield useful information and result in increased numbers of referrals of medically impaired drivers.

Some family referral issues were discussed. These are not accepted in Missouri [because of possible vindictiveness on the part of the person making the report]; on the other hand they are the most common source of referrals of medically impaired drivers in Oregon, and it was observed that relatively few are inappropriate. I'm not sure how they stand in other states, but it was noted that family referrals are based on very many observations, whereas referrals that result from observations by law enforcement personnel, for example, are typically based on only a single observation. The usefulness of booklets provided by the DMV to guide families in how, when, and under what circumstances to report a family member were felt to be very useful tools whose development and distribution should be encouraged.

Some very specific observations were made about expanding the observations made at DMV. A couple of things that were mentioned were, e.g., to observe whether a renewal client demonstrates slowness of response or appears to be confused. These are fairly ill-defined and could span a number of things, but they are things that might enter into a reexamination referral. A couple of suggestions were made about asking for information that could be easily verified. Asking for the person's name could certainly be insulting to some people, but something not quite so direct would be possible. For example, asking for their address, or something else off the driver's license that the person would be expected to know, might not be so offensive and would be easily verifiable. Those kinds of questions could be asked by clerks who are not particularly skilled in observational procedures, and could be interpreted in a more-or-less unambiguous fashion. Lack of understanding of the instructions for vision or attentional tests as referral triggers to be used by "less-skilled" clerks was deemed probably not to be a profitable avenue; it was noted that those kinds of interpretations are difficult even for highly trained clinicians who spend a lot of time doing that sort of thing. It was suggested that if people spend an excessive amount of time in a written test area ("excessive" not being defined) this might serve as a reexamination trigger, and the need for more specific self-report questions with respect to fitness was noted as a desirable thing to bring more people to the attention of DMV. It was mentioned that probably it would be feasible to incorporate some kind of sign understanding task in the vision test—not having to define what a sign means, but more in terms of telling what behavior is appropriate in a specific situation which might be diagrammed, or shown in a slide, or something of that sort.

It was mentioned that a need exists for analysis of groups who are referred for a road test in terms of what percentage in each group fail. After that need was identified, it was noted that in Missouri, among the citations for probable medical problems which are generated each month from agencies outside of DMV, 70% either fail or do not appear for the test. At the end of the discussion, once again John [Eberhard] prompted us to address the question of whether health professionals should be required to report. Again the answer was no, at least at present. In that regard the guidelines for reporting which would be provided to health professionals are essential, and their development was noted in at least one jurisdiction. On that point we closed the discussion.

# APPENDIX G

AAMVA Survey List

Jurisdictions, Respondents, Designations on Response Summary, Positions, and Affiliations

1. AZ – Tom Burch (TB), Manager, Medical Review Program, Arizona Motor Vehicle Division
2. CT – Amy Campbell (AC), Coordinator of Handicapped Driving, Occupational Therapy Department, Gaylord Hospital, responding re Connecticut Department of Motor Vehicles
3. FL – Ed Bleakly (EB), Operations & Management Consultant, Florida Department of Highway Safety and Motor Vehicles
4. MI – Heidi Weber Reed (HWR), Research Section Supervisor, Michigan Department of State
5. NC – Ozzie Gray (OG), Assistant Director, Driver License Section, North Carolina Division of Motor Vehicles
6. NY – Donn Maryott (DM), New York State Department of Motor Vehicles
7. ONT. – Leo Tasca (LT), Senior Research Officer, Ministry of Transportation of Ontario, Canada
8. OR – Melody Sheffield, Driver Safety Program Coordinator, and six Driver Improvement Counselors (OR), Oregon Department of Motor Vehicles
9. SD – Pam Ice (PI), Program Manager, South Dakota Driver Licensing Program
10. TX – John Hall (JH), Inspector, Texas Department of Public Safety
11. UT – K. J. 'Skip' Nielsen (KJN), Bureau Chief, Utah Driver License Division

# AAMVA SURVEY—CA DMV/NHTSA ELDERLY DRIVER PROJECT

California Department of Motor Vehicles is attempting to develop a model assessment system. This system would test drivers with age-related limitations likely to increase crash risk—primarily focusing on dementia and frailty. By means of this survey we are attempting to find out practices, policies, and planned developments within your agency or jurisdiction affecting elderly medically impaired drivers, and your opinions regarding them. **We would greatly appreciate any documentation you can provide relevant to your agency's programs or planned programs for elderly drivers — especially those with medical impairments.**

NAME/TITLE________________________________________
AGENCY____________________________________________
PHONE NUMBER______________________________________

1. Are elderly drivers as a group generally considered a driving hazard among driver licensing staff in your agency?

   *PI, JH, EB, LT, OR,* __5__ yes    *KJN, AC, DM, OG, TB* __5__ no    *HWR* __1__ don't know

2. Do you, personally, believe that elderly drivers as a group constitute a driving hazard?

   __0__ definitely    *PI, AC, JH, DM, EB, OG, TB, LT, OR* __9__ to some degree    *KJN, HWR* __2__ no

3. When your agency either restricts or modifies the license of a particular elderly driver because of advanced age or some medical or vision impairment, what kinds of restrictions or other conditions might be imposed? Please check all that are used, even if only rarely.

   __11__ must wear spectacles or contact lenses (not telescopic lenses) *all respondents*
   __10__ time-of-day restriction *PI, KJN, AC, JH, DM, EB, OG, TB, OR, HWR*
   __7__ area restriction *PI, KJN, JH, OG, TB, OR, HWR*
   __4__ drive only for specific trip purposes *PI, KJN, JH, HWR*
   __2__ shorter license term than standard in jurisdiction *PI, TB*
   __3__ must drive with a "copilot" *JH, EB, HWR*
   __7__ no freeway or expressway driving *(PI said "NA"), KJN, AC, JH, OG, TB, OR,HWR*
   __8__ must have automatic transmission *PI, AC, JH, DM, EB, OG, TB, HWR*
   __8__ must have power steering *PI, AC, JH, DM, EB, OG, TB, HWR*
   __9__ must have other special equipment/devices; e.g., telescopic lenses, steering knob *PI, KJN, AC, JH, DM, EB (outside mirror), TB, OR, HWR*
   __9__ periodic reexamination that includes a road test *PI, JH, DM, EB, OG, LT, TB, OR, HWR*
   __6__ periodic reexamination not including a road test *PI, JH, DM, EB, TB, HWR*
   __11__ periodic medical or vision report from clinician *all respondents*
   __3__ periodic self-report on medical status and treatment *DM, EB, HWR*
   __2__ other (What?)

   LT - For ages 80 & over - vision test or clinician's vision report every year. Automatic transmission restriction allowed but not used. Plastic licenses may not allow codes' being added to license. Ontario does not specifically require adaptive equipment. Typically OT recommends it and driver is then road-tested. If they pass without it, OK. Many are required to take annual road test or submit to regular medical assessments - typically cases prone to deteriorate. If driver self-reports, dept. conducts medical review. Driver may be referred to an OT for assessment.

HWR - Ignition interlock, no alcohol use before driving, limited to specific route.

4. Do you support either formal or informal graded licensing programs for elderly drivers? (*We mean programs in which elderly drivers identified as having physical or mental impairments can be given license restrictions to allow limited driving instead of losing their license to drive.)*

*all but OR* — *OR - they either can or cannot pass regular tests*

__10__yes __1__no

Why or why not?

PI - No alternative transportation exists for these drivers.
KJN - Fosters self-report, preserves independence, helps agency monitor.
JH - Some drivers reasonably safe to issue graded license.
EB - Permits necessary mobility while making risk acceptable.
OG - Mobility without dependence on others important to mental and physical health; restrictions provide this without endangering safety.
TB - Last means of independence for individual. Benefits the dept. since we have knowledge of a handle on their driving - can be better monitored.
HWR - Elderly have needs for mobility and independence. Support progs. meeting these needs and the overriding need for public safety.

5. Does your agency have a formal graded licensing program?

*KJN (only for drivers under 21), AC, JH, OG, LT (novices only), HWR* — *PI, DM (not based on age), TB, OR, EB*

__6__yes __5__no __0__don't know

6. If a program were developed to give special tests solely on the basis of advanced age in order to identify drivers who would have to take a road test before license renewal, would this be feasible in your jurisdiction?

__2__yes, this could be done *PI, LT (currently being done)*
__4__probably could be done (may require law changes) *KJN, OG, TB, OR (see below for more OR)*
__5__no, public resistance is too gr*eat* *AC, JH, DM, EB, OR*
__4__no, expense is too great *AC, JH, DM, OR*
__2__no, other factor(s) (What?)

DM - Unfair, unsubstantiated, and unreasonable. NY drivers are never judged on the basis of age. All drivers are evaluated based on driver record and physical/mental condition. (Except for ages 16-17, restricted to daylight driving.)
HWR - Would be perceived as age discrimination, unless could support the need for special tests with validated, reliable research studies.

7. Within your agency, what criteria are used to require some drivers of advanced age to take a road test in order to renew their licenses?

__0__none—this never occurs
__10__driver's report on license application of a medical condition that might impair driving *all but PI*
__10__apparent confusion or disorientation observed in office *all but LT*
__8__physical frailty, "shakiness," etc. observed in office *PI, KJN, AC, JH, DM, OG, OR, HWR*
__10__earlier-reported physical or mental disorder that might impair driving *all but PI*
__8__earlier-reported progressive disorder that might impair driving *KJN, JH, DM, EB, OG, TB, OR, HWR*
__4__poor performance on a non-driving renewal test *JH, DM, EB, HWR*

__3__other (What?)

KJN - Medical confirmation of self-report, law enforcement report and request for re-exam, report of crash indicating possible impairment, request by family, etc.
DM - Report from medical professional.
OG - Report from physician, crash report and recommendation from law enforcement, letter from family/friends.
LT - Age 70 or more with 2 crashes or 2 moving violations take road, knowledge, vision tests. Age 80 or more take all these tests annually. Clinician report may substitute for vision test. Take into consideration all information including medical reviews, especially if patient non-compliant with medications.
OR - Re-evaluation report request could be submitted by law enforcement, etc.

8. Under what circumstances, if any, do <u>you, personally,</u> believe additional or different kinds of tests—e.g., cognitive tests or special road tests—should be administered to either some or all elderly original or renewal license applicants?

PI - Evaluations that may remove license should be done on an individual basis. Drive test for person's needs. Consult their doctor if potential medical condition.
KJN - OK, if based on criteria other than age alone
AC - Medical reports, accident hx, or poor driving hx. Should evaluate at rehabilitation center, including a road test.
JH - Only if it's determined person has physical or mental problem making them unsafe to drive.
DM - Poor driver performance, obvious dementia, request from family, doctor, or law enforcement.
EB - Individuals with driving record, driver performance or physical condition casting doubt on ability to safely control or navigate a vehicle. But current tests aren't valid predictors, especially for those with cognitive loss. Major problem is in navigating without assistance.
OG - Special road tests necessary with specific route restrictions, not given to elderly in N.C. Specific route restriction might be no 1-way or all 1-way, no multi-lane, no heavy traffic, etc.
LT - Mandatory diagnostic program could ID drivers needing road test, 55 Alive, etc. Our jurisdiction has developed and is evaluating a paper-and-pencil inventory. Also plan to evaluate computerized tests.
TB - All original licensees require standard testing. If fail, give Special Drive Test or Skill Perf. evaluation. Renewal licensees may or may not need special testing outside of vision. Some require special drive test. All are tested if progressive medical condition, or adaptive equipment installed since last test.
OR - Anyone 80 or more should have to pass a cognitive skills test.
HWR - Special testing would be beneficial for all aged 85 or more.

9. If your agency has a point system, can actions (<u>including reexamination referral</u>) ever be taken at a lower point level for drivers above some age than for others?

__3__not applicable *AC, OG, OR* __8__no *PI, KJN, JH, DM, EB, LT, TB, HWR*
__0__yes, at age____ __0__don't know

10. Does your agency refer frail or dementing elderly drivers to rehabilitation centers/facilities for driving assessment and recommendations? ("Frail" refers here to the combined effects of normal aging and medical conditions, when they impair elderly people in performing activities of daily living.)

__6__never *KJN, JH, DM, EB, TB, OR*
__4__occasionally *AC, OG, LT, HWR*
__1__commonly *PI - only after cancel privilege then reexamine*

11. What medical condition(s) should health professionals be required by law to report to the licensing agency? Please check all that apply.

__1__ none
*PI*

__8__ heart disease
*KJN (if 2 or more meds.), JH, DM, EB, OG, LT, OR(with loss of control), HWR*

__10__ epilepsy, other seizure disorders
*AC, OG, LT, TB, OR, KJN, JH, DM, EB, HWR*

__10__ dementia
*all but PI*

__8__ Parkinson's disease
*AC, JH, DM, EB, OG, LT, OR, HWR*

__10__ vision disorders
*all but PI (KJN - some vision disorders)*

__9__ insulin-dependent diabetes
*all but PI & OG*

__10__ stroke
*all but PI (KJN - if impaired vision, cognition, motor ability)*

__7__ other (what?)

PI - individual patients who may be unsafe
OG - alcohol dependency or alcohol-related disorders
JH - any disease that might impair safe driving.
DM - patent "confusion"
OR - degenerative muscle disease
LT - everyone 16 or more whose condition may make it dangerous to drive
HWR - Diagnostic labels are not adequate predictors of ability to drive safely. Therefore referral should happen after a functional assessment with the following diagnoses: Alzheimer's, arthritis, chronic lung disease with hypoxia, psychiatric illness, sleep apnea.

12. Does your agency have guidelines for testing the driving abilities of elderly people with dementia or frailty? (See question #10 for a definition of frailty.)

__7__ yes
*PI, JH(not specific to dementia or frailty), DM, EB, LT, TB, OR*

__4__ no
*KJN, AC, OG, HWR*

__0__ don't know

13. Does your agency ever knowingly license drivers with dementia?

__4__ yes
*KJN, DM, LT, OR*

__5__ no
*AC, JH, EB, OG, TB*

__2__ don't know
*PI, HWR*

If yes, under what conditions may they be licensed?

KJN - MAB recommendation after review; guidelines allow driving consistent with functional ability.
DM - If, in opinion of medical professional, patient is judged safe to drive.
LT - Some drivers with mild dementia-the only reliable predictor is road test.
OR - Early stages of dementia, with follow-up evaluation.

14. Do you personally believe that some drivers with mild dementia can function well enough to drive a motor vehicle safely?

__7__ yes
*LT, OR, PI, KJN, AC, DM, HWR*

__4__ no
*JH, EB, OG, TB*

__0__ no opinion

15. Within your jurisdiction, are there any recent (within the past year) or pending law changes which will affect the licensing of elderly people?

__1__ yes
*AC - vision screen for all renewals*

__10__ no
*all others*

__0__ don't know

16. Within your jurisdiction, are there any recent (within the past year) or pending administrative or procedural changes which will affect the licensing of elderly people?

| | | |
|---|---|---|
| 2 yes<br>*PI, LT* | 9 no<br>*all others* | 0 don't know |

If yes, can you briefly describe what these changes are?

PI - Anyone* can report potentially unsafe drivers to dept. Reexamination, which may include verbal questions testing perception and reasoning as well as a drive test, results in pass, denial, restrictions, revocation, or recommendation for more testing.

LT - We are evaluating a group education and information session as a possible alternative to the mandatory road test. Completion date Nov. 30, 1994. Senior Driver Research Inventory scores of those attending session will be compared to scores of those taking road test. Inventory was developed by MTO's Safety Research Office. Licensing policy changes may or may not be recommended, depending on outcome.

***** - Including DMV staff - dept. highly recommends that driver examiners use this procedure and the recommendation form for reexamination instead of arbitrarily selecting a person for a drive test upon renewal.