STATE OF CALIFORNIA
DEPARTMENT OF MOTOR VEHICLES

CLEARING A ROAD TO BEING DRIVING FIT BY BETTER ASSESSING DRIVING WELLNESS

DEVELOPMENT OF CALIFORNIA'S PROSPECTIVE THREE-TIER DRIVING-CENTERED ASSESSMENT SYSTEM

Technical Report

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This report has two main purposes: (1) describe the development of California's prospective 3-Tier driving-centered assessment system, and (2) present an "ecological perspective" on driver licensing. Driving-centered is an ecological concept—it means taking into consideration when, where, why, and how individual drivers customarily drive. Rather than an endpoint in delicensing drivers assessed as unsafe, 3-Tier fundamentally alters the purpose of assessment to be a *starting point*, if feasible, for extending the safe driving years of functionally-limited licensed drivers.

The 3-Tier system integrates new assessment tools into those currently used by the Department of Motor Vehicles. All renewal applicants required to pass the department's knowledge test are assessed on Tier 1, and those who are found to have a driving-relevant visual, mental, or physical limitation(s) are further screened on Tier 2. Based on these assessments, drivers are classified as driving well, somewhat functionally limited or extremely functionally limited; the extremely functionally-limited drivers are required to pass a Tier 3 road test to be licensed. The results of a small scale pilot study upon which the 3-Tier system was developed showed that somewhat-limited drivers, perhaps because they were less aware of their limitations, were more likely to be crash involved than extremely-limited drivers, who were probably more aware of their limitation(s) and compensated accordingly. In contrast, extremely-limited drivers were more likely to fail an office-based road test.

The report concludes with 22 recommendations for statewide implementation of 3-Tier, including recommendations that the department's R&D branch evaluate the reliability and validity of the current area drive test, and if needed, develop a better one, that this test be available to extremely limited drivers as an option for their Tier 3 road test requirement, and that the department educate somewhat-limited drivers about compensating for their limitation(s).

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PREFACE

This report has two basic purposes. The first purpose is to describe the development of California's prospective 3-Tier Assessment System based on research carried out in four Southern California Department of Motor Vehicles field offices in 2001 and 2002.

The second purpose of the report is to present an "Ecological Perspective" on driving and driver licensing that the first author developed and that is especially relevant to drivers who have been identified as having a "driving-relevant limitation(s)." This perspective views the challenges posed by the driving environment as constantly changing and, therefore, drivers as constantly adjusting the demands of their driving tasks. Compensating for a driving-relevant limitation(s) is always or continuously "done," though with varying degrees of adequacy and consistency. The definitions and relationships among key concepts, such as "driver-centered," "driving-centered," "driving wellness," "driving fitness," and "limitation-naivety", are presented in detail in the Introduction and Rationale Section and elaborated on throughout the remainder of the report.

The Research and Development Branch of the California DMV, in the interest of stimulating discussion about the licensing of functionally-limited drivers, presents the Ecological Perspective without comment. Sufficient empirical evidence has not yet been obtained to accept or reject the individual concepts or broad relationships hypothesized by this perspective. A pilot project currently under way will attempt to obtain that evidence.

For now, readers are encouraged to read this report with care and reflect on the 3-Tier Assessment System developed by both authors and the Ecological Perspective conceptualized by the first author. Readers are further encouraged to use the latter as a heuristic to advance the safe-driving impact of driver licensing by departments of motor vehicles and related services provided by others, especially for customers with driving-relevant limitations.

ACKNOWLEDGMENTS

This project was made possible through the support of the California Office of Traffic Safety and the National Highway Traffic Safety Administration. This report was prepared by the Research and Development Branch, Licensing Operations Division, of the Department of Motor Vehicles. The opinions, findings, conclusions, and recommendations expressed in this report are those of the authors and not necessarily those of the California Department of Motor Vehicles or the State of California.

The authors would like to acknowledge with appreciation the many individuals who contributed to this study. First and foremost we are grateful for the exceptional contributions that were made to the success of this study by all of the Motor Vehicle Field Representatives and Licensing/Registration Examiners who identified and tested the study participants in the four Department of Motor Vehicles Field Operations' study offices: Santa Monica, Costa Mesa, Van Nuys, and Pasadena. They are named in the table below. We are also grateful for the tremendous support of the study-office managers named in that table and the general support of all the staff working in the study offices. Pilot testing was carried out in the Carmichael field office.

Three-Tier Study Offices and Staff

Study offices	Office managers attached to study	Study LREs	Study MVFRs
Phase I (Jun–Dec 01)			
Santa Monica	Michael Dillon IV Elizabeth Hernandez III Pete Carranza I	Lola Craven Danny Mersiehazen	Loraine Gilliam Antonia Montes
Costa Mesa	Marilyn Busell V Lynn Sosa III Rosa Casas I	Sharon Langerman Dinah Heimos	Charise Slach Frances Ward
Phase II (Jan-Jun 02)			
Van Nuys	Robert Nelson IV Mark Dragan III Rosie Romero I Dolores Orrante I	Lee Carlson Jake Duran	Elsa Gutierrez Ana Martinez Odilia Moreno-Zunigo
Pasadena	Dixon Jones V Elizabeth Fenner III Mary Millsaps I	Aaron Lee Lashonda Thompson	Leila Giraldo Debbie Pulley

Headquarters Field Operations managers, John Rooney (III) and Babette Williams (V), supported the study offices in carrying out various data collection activities. Hannah Lee (University of California Los Angeles graduate student) and Harrison Tanji (Van Nuys Driver Safety Office) served as local study coordinators for study phases I and II, respectively. They were both exceedingly competent in the day-to-day running of the study.

Clifford J. Helander, retired and former Chief of the Research and Development Branch and David J. DeYoung, Chief of the Research and Development Branch, provided general direction. David DeYoung and most especially Leonard Marowitz (Research Manager II) reviewed earlier drafts of the report and provided valuable comments for improving the study report. Mary Bobo, an undergraduate student assistant from California State University, Sacramento, contributed to the development of two checklists for law enforcement use in informing the Department of Motor Vehicles of its reasons for considering any particular driver hazardous enough to warrant a reexamination. Douglas Rickard, Staff Services Analyst and Debbie McKenzie, Associate Governmental Program Analyst in the department's Research & Development Branch, formatted the report.

And finally, we are especially grateful to Jane Stutts, retired and former Associate Director for Social and Behavioral Research, University of North Carolina and Judy Geyer, Research Associate, University of California Berkeley Traffic Safety Center, for their review and comments on an early draft of this report.

HIGHLIGHTS

Would you be surprised to learn that among older driver-license-renewal applicants the ones who we need to worry the most about would likely pass a road test? That's what we predicted when we looked at driving from an ecological perspective. In an ecological perspective, drivers are viewed as actively adjusting the demands of their driving environments and the demands of their driving tasks in accordance with their perception of their driving-relevant abilities and limitations. We confirmed this and other ecology-driven predictions with our study of California's prospective three-tier driving-centered assessment system. Driving-centered is an ecological concept—it means taking into consideration when, where, why, and how individual drivers customarily drive. The traditional approach to assessment, taken by most DMVs, is driver-centered. Traditional assessment is focused on the accurate identification of high-risk drivers. It is an *endpoint* in the controlling and delicensing of these problem drivers. Traditional assessment does not take into consideration when, where, why, and how individual drivers customarily drive. The driving-centered Three-Tier Assessment System (3-Tier) described in this study report represents fundamental changes in the approach and objectives of driver assessment.

3-Tier is offered as the answer to the following fundamental question posed at the beginning of the study:

> How can the DMV better identify and assess licensed drivers of any age who have acquired a driving-relevant functional limitation(s) so that the DMV, together with physicians, driving-rehabilitation specialists, and others can aid such drivers, if feasible, in driving safely by referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting (conditional licensure), and so on?

Rather than an endpoint, 3-Tier fundamentally alters the purpose of assessment to be a *starting point* in extending the safe driving years of functionally-limited licensed drivers. This repurposing requires screening licensed drivers for marginal as well as more severe driving-relevant limitations. Marginally-limited drivers need to be educated about recognizing and avoiding the periodic everyday convergence of factors (for example, the darkly clothed pedestrian at dusk inside the upcoming faded crosswalk) that substantially elevate the crash potentiating effect of their particular limitation. Repurposing assessment as a *starting point* also requires assessing drivers identified as having acquired a severe limitation(s) for whether they can manage to drive safely despite their limitation(s) under reasonably-specifiable licensing conditions.

Driving-relevant functional limitations are decrements in driving wellness. Driving wellness is a phrase designed to focus attention on preserving and proactively improving driving-relevant functional abilities. A driver assessed as "driving-well" would be a driver deemed free from driving-relevant functional limitations. The degree of driving wellness varies in accordance with the number, kinds, and severity of limitations in driving-relevant abilities, such as contrast sensitivity—the amount of contrast a driver needs to quickly detect objects that are important to safe driving, like other cars and pedestrians. Assessing a driver's contrast sensitivity is a necessary part of assessing the driver's degree of driving wellness, since good contrast sensitivity is critical to noticing potential road hazards under numerous everyday low-contrast viewing conditions, such as a light car in the fog, a dark car in the shade, or a darkly-clothed pedestrian at dusk inside the upcoming faded crosswalk.

Based on the Tier 1 and Tier 2 assessment of driving-relevant visual ability, mental ability, and physical ability (the locomotor/manipulative abilities necessary for operating vehicle controls), 3-Tier sorts drivers into one of three driving-wellness categories:

- Driving-Well—free from driving-relevant functional limitations.
- Somewhat Functionally Limited—one marginally-limited driving-relevant functional ability.
- Extremely Functionally Limited—two or more marginally-limited driving-relevant functional abilities and/or one or more severely-functionally-limited driving-relevant functional abilities.

Tier 1 is brief and very easily administered. Four assessment tools (ATs) comprise Tier 1:

- DMV's current Snellen test of visual acuity.
- Chart-based test of contrast sensitivity.
- Brief cognitive screen (recalling social security number).
- Structured observations for physical limitations.

Driver license renewal candidates who are unsuccessful on Tier 1 must complete a computer-based assessment of perceptual-response time (processing speed) on Tier 2. Tier 2 is also comprised of one other AT, the department's current written knowledge test of safe-driving practices and the laws and rules of the road. The latter AT would seemingly have fit naturally on Tier 1 but had to be placed on Tier 2 because a departmental decision was made to automate the knowledge test; thereafter, it more naturally fit with the other Tier 2 computer-based AT. In an operational system, driver-license-renewal candidates successful on Tier 1 would go on to take the knowledge test on Tier 2. Licensure is contingent on passing the knowledge test. Drivers who are successful on Tier 1, but who fail the knowledge test two or more times before passing it, would also be required to complete the computer-based assessment of perceptual response time.

In order to renew their license, drivers who are sorted into the extremely-limited driving-wellness category are required to pass a Tier 3 road test. 3-Tier makes a distinction between driving wellness and driving fitness. Even an extremely functionally-limited driver may be assessed on Tier 3 as "driving fit." Driving fit means that the driver's level of risk for making a critical driving error (CDE) would be expected to be consistently small in that driver's customary driving environments and conditions and for that driver's customary driving practices. A CDE is an action or inaction which has a high probability of precipitating an adverse-driving event if the consequences of the CDE are not attenuated by such factors as a lack of conflicting traffic. Adverse-driving events include the following negative outcomes: forcing other road users to take evasive action in order to avoid a crash, actually colliding with them, or nearly colliding with them. The degree of driving fitness is the level of risk for making a CDE. The degree of driving fitness is contingent on how well the driver manages—by regularly searching/scanning for hazards, slowing down or speeding up, and so on—the different ongoing everyday challenges to maintaining a low level of risk for making a CDE. These everyday challenges derive from the combined effects of four factors:

- The driver's driving-relevant limitations (decrements in driving wellness).
- The driver's driving-relevant abilities—especially proficiency in compensating for the fitness-diminishing effects of decrements in driving wellness.
- Ongoing changes in the demands of the driver's customary driving tasks (making left turns, merging with high-speed traffic, and so on).
- Ongoing changes in the demands of the driver's customary driving environments and conditions.

The last three factors *moderate*—attenuate or exacerbate—the fitness-diminishing effect of a decrement in driving wellness. For example, a driver assessed in a DMV field office as having *severely*-limited contrast sensitivity should not be expected necessarily to be at an elevated risk for making a CDE. Such a driver may routinely avoid driving in low contrast viewing conditions such as dusk or dawn, residential streets at night, and when it is foggy or raining. Nor, as indicated above, should a driver assessed as having *only* a *marginal* decrement in contrast sensitivity (and who has no other decrements in driving wellness) be expected *always not* to be at an elevated risk for making a CDE. Even though a driver's level of risk for making a CDE is a function of his or her degree of driving wellness, the degree of driving fitness is *not determined* by the degree of driving wellness. There is potentially a great difference between a driver's expected risk for making a CDE, given their driving-relevant limitations, and a driver's actual risk for making a CDE.

Unlike measuring driving wellness in the DMV office, determining whether a driver is "driving fit" (consistently small level of risk for making a CDE) requires an assessment of the driver, with whatever driving-relevant abilities and limitations he or she may have acquired, made relative to his or her:

- Customary driving practices (especially compensating practices).
- Customary driving tasks.
- Customary driving environments and driving conditions.

Note that what is "customary" can be changed either by the driver, for example, by getting behind-the-wheel training in fully compensating for limitations, or by the DMV, for example, by restricting the driver from driving at night, dusk and dawn, or when it is foggy or raining.

Lacking in knowledge of ways of fully compensating for a limitation is one of the many factors detailed in the study report that *variably constrain* drivers from consistently and adequately compensating. These constraints on consistently and adequately compensating include mistaken beliefs about aging and driving. Effectively extending the safe driving years of functionally-limited licensed drivers will require that the following three myths—illusions of knowledge—be debunked:

- Older drivers are a functionally unitary group.
- "Old age" causes driving-relevant functional limitations.
- "Older" can be used as a sign of diminished capacity for driving safely.

For example, in the case of the second bullet, expecting an inevitable decline in all driving-relevant functional abilities with advancing age is one of the bases for researchers posing such age-based driver-centered questions as: Are older drivers a problem? or Do older drivers pose a threat to the health and safety of other road users? In merely posing age-based *driver-centered* questions, let alone purportedly researching and answering them, researchers contribute to many older drivers mistakenly expecting a decline in all of their driving-relevant functional abilities with advancing age. In a 2003 California DMV survey, over 85% of the sampled older drivers indicated that "being over the age of 65" is a "sign of diminished capacity for driving safely." Expecting a gradual decline with aging often results in elders failing to seek help from health professionals for driving-relevant functional limitations that could, in fact, be corrected, controlled, or at least slowed in their progression.

This report emphasizes the point that age-based driver-centered questions do not make sense—aging-*associated* "declines" in visual, mental, or physical abilities are neither aging-*determined* nor necessarily irreversible. Aging does not *cause* driving-relevant functional limitations. For example, the study report cites the finding that 37% of the sampled license-renewal applicants aged 70- to 96-years-old performed as well as the 19- to 39-year-old renewals in scoring the shortest perceptual response time (processing speed) that is achievable under the conditions of the study's computer-based test of processing speed.

California's prospective three-tier driving-centered assessment system serves as the starting point for initiating various means of extending the safe-driving years of functionally-limited licensed drivers. By extending their safe-driving years, 3-Tier aids functionally-limited drivers in maintaining their safe mobility which is viewed as a resource for everyday healthy living in our aging driving population.

The study report concludes with 22 recommendations for statewide implementation of a 3-Tier driving-centered assessment system. They are divided into four parts:

- Recommendations directly supported by this 3-Tier study.
- Procedural and policy changes recommended for a 3-Tier system to be effective.
- Complementary recommendations that make general good sense.
- Future multi-phase pilot study.

As noted in the last bullet, a future pilot study is recommended to evaluate the operational feasibility, costs, and customer and staff acceptance of the 3-Tier assessment system described in the 22 recommendations.

The reader is advised that it will be difficult to fully understand the recommendations and their rationales without first reading the study report.

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INTRODUCTION AND RATIONALE

The greatest obstacle to discovery is not ignorance – it is the illusion of knowledge.

Daniel J Boorstin
Washington Post, "The Six O'Clock Scholar" by Carol Krucoff (29 January 1984)

Your ideas are your cage.

Seung Sahn Soen Sa Nim
Only Don't Know: The Teaching Letters of Zen Master Seung Sahn (1982)

Overview

This report describes the development of a three-tier *driving-centered* assessment system and the validation of one way for the DMV to make a *driving-centered* assessment of driving wellness. What is meant by "driving-" versus "driver-" centered assessment is discussed below in this brief overview of the study rationale.

California's prospective three-tier driving-centered assessment system has three primary objectives:

- Screening *licensed* drivers for marginal as well as more severe driving-relevant functional limitations.

- Serving as the *starting point* for *initiating* various means of extending the safe driving years of functionally-limited licensed drivers, if feasible.

- Assessing drivers identified as having acquired a driving-relevant functional limitation(s) for whether they can manage to drive safely despite their limitation(s) under reasonably specifiable licensing conditions.

As recommended by the Older Drivers Project, created in January 2002 by the American Medical Association in partnership with the National Highway Traffic Safety Administration (Wang & Carr, 2004; see also Carr, 2000): "Driving cessation is recommended only after the safety of the driver cannot be secured through any other means" (Wang & Carr, 2004, p. 143). Even so, the overall objective of "3-Tier" is in fact to improve road safety.

Historically state motor vehicle departments have served first as gatekeepers: licensing most, but not all, driver license applicants—usually teens. In regards to already licensed drivers, the authors of the 2004 report on the Older Drivers Project observed that:

> Traditionally, traffic safety efforts for the older population have focused on methods to identify unsafe drivers to enforce driving cessation, but driving cessation deprives the majority of older Americans of their primary form of transportation and has been associated with an increase in depressive symptoms. (Wang & Carr, 2004, p. 143)

3-Tier would expand the California Department of Motor Vehicles' (DMV) licensing role to one that includes ***a spotlight on aiding drivers in maintaining their safe mobility*** in our aging driving population. This is one of the U. S. Department of Transportation's (2003) strategies for achieving "safe mobility for a maturing society" (p. viii). Eberhard et al. (2006) noted in this regard that:

> …the preferred policies and practices among government agencies and professional societies, such as the American Association of Motor Vehicle Administration (AAMVA), AARP, AAA (formerly American Automobile Association), American Association of State Highway and Transportation Officials, National Governors Association, and the private sector, have been to find ways to allow older adults to continue to drive as late in life as possible while maintaining safety. (p. 4)

Consistent with the policies and programs of other state transportation and highway agencies, especially those in Florida, Iowa, Maryland, Michigan, and Oregon (Stutts, 2005), Bill Cather, then California DMV Assistant Director for Legislation, made the following pertinent remarks at the March 7, 2005 United We Ride Mobility Summit:

> [California] DMV's mission is *not* to take away your driver's license. Quite to the contrary, our mission is to keep safe drivers on the road and driving for as long as we possibly can.…There are lots and lots of things that we can do to try to keep you mobile and to keep

> you in your own car and still have our primary goal of protecting you and the other drivers on the freeways and highways of our state.…One of the things that we're looking at and constantly trying to do better is assess drivers and facilitate rehabilitative services.…we think that many folks with today's modern medicine can benefit from those rehabilitative services. We want to help facilitate that interaction and make sure that you are aware of the available options. (p. 10, http://www.4tacc.org/MobilitySummit/Proceedings-MobilitySummit-Part1-Draft%20_2_.pdf)

Safe mobility is an aspect of health as a resource/means for everyday living. The constitution of the World Health Organization (WHO, 2007, p. 1) defines health as

> …a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.
>
> The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.

The 1986 WHO Ottawa Charter for Health Promotion (WHO, 1986, p. 1) noted that in order

> …to reach a state of complete physical, mental and social well-being, an individual or group must be able to identify and to realize aspirations, to satisfy needs, and to change or cope with the environment. Health is, therefore, seen as a resource for everyday life, not the objective of living.

Safe mobility as a means for everyday living is *regularly*, and therefore, *safely* achieving one's travel (mobility) objectives which can range from *accessing* life's necessities, such as medical appointments and food, to *accessing* social and cultural experiences (TRB, 2005, p. vi; Dickerson et al. 2007; Oxley & Whelan, 2008). Extending the safe driving years of functionally-limited licensed drivers is the 3-Tier DMV means of aiding drivers in *maintaining* their safe mobility. 3-Tier assessment is intended to serve as a basis for a comprehensive licensing program. Drivers identified as having acquired a driving-relevant limitation(s) would be aided in extending their safe driving years. How? Functionally-limited drivers would be aided in *improving* their driving-relevant functioning (remediation) and in *adequately* and *consistently compensating* for the crash potentiating effects of the specific limitation(s) that they have acquired (Oxley & Whelan, 2008). This aid could take the form of DMV *initiating* a

variety of possible *safe-mobility* interventions.[1,2] Listed immediately below are five examples of safe-mobility interventions. Please note that in initiating a safe-mobility intervention a DMV may or may not involve itself in actually administering the intervention.

- *Referring drivers identified by the DMV as functionally limited for physician-based evaluation and treatment.* Eberhard et al. (2006) note that licensed drivers who have recently acquired a driving-relevant limitation may benefit from being treated by an ophthalmologist, neurologist, orthopedist, neuropsychologist, occupational therapist, physical therapist, podiatrist, or exercise physiologist.

- *Educating drivers about the implications of their specific driving-relevant functional limitation(s) for their driving safely under specific driving conditions and providing functionally-limited drivers with specific ways of compensating for the effects of their limitations.*

- *Encouraging functionally-limited drivers to get behind-the-wheel training in compensating consistently and adequately.* In said encouraging, the driver should be informed that compensating consistently and adequately is best accomplished with the aid of a certified driving rehabilitation specialist (e.g., Wheatley & DiStefano, 2008).

- *Instructing functionally-limited drivers in ways of adapting the drivers' vehicles to each driver's particular limitation(s).* Dickerson et al. (2007) note that, "Some vehicle modifications, such as easy-locking seat belts, visor extenders, steering-wheel covers to improve grip, and seat and back support cushions to relieve back pain or improve line of sight, do not require special training" (p. 582).

[1] Like closing a window on a cold winter's day first permits the heating system to achieve a comfortable room temperature and then the closed window aids in maintaining that room temperature, so do the listed interventions first permit the functionally-limited driver to achieve safe mobility and then the outcomes/results of the interventions aid the driver in maintaining that safe mobility. For example, as will be discussed in detail in the section Ecological Perspective On Driving, safe mobility may be in part maintained by *adjusting* the demands of the driving environment/conditions. Therefore, DMV might aid functionally-limited drivers in maintaining their safe mobility by restricting their driving to daylight hours or restricting their driving to familiar and well-practiced routes. In abiding with such restrictions, the functionally-limited driver would reduce the demands of their driving environment/conditions, and thereby, more readily maintain their safe mobility.

[2] Renewing the license of a functionally-limited driver should be conditional on the applicant demonstrating or providing DMV with certification of s*uccessful* completion of the relevant interventions identified by DMV (Brainin, 1980).

- *Licensing but formally restricting*[3] *functionally-limited drivers to corrective devices, for example, corrective lenses, and/or restricting them to the driving environments/conditions under which they have demonstrated an acceptable level of driving fitness.* These would be tangible and reasonably specifiable licensing conditions such as driving only during certain hours of the day and/or driving only on certain familiar and well-practiced routes[4].

Other approaches to aiding drivers in maintaining their safe mobility, such as ones based on self-assessment are listed and described in AARP's *Promising Approaches for Promoting Lifelong Community Mobility* (Molnar et al., 2007), and in *Strategies and Tools to Enable Safe Mobility for Older Adults* (Eberhard et al., 2006; also see Dickerson et al., 2007; Eby, Molnar & Kartje, 2009; Stutts & Wilkins, 2003, and Stutts, 2005). The website, www.eldersafety.org, is an especially valuable resource for "facilitating safe mobility for seniors."

By incorporating interventions such as these into a systematic licensing program, it is expected that a DMV would effectively extend the safe driving years of functionally-limited licensed drivers. Raedt & Ponjaert-Kristoffersen (2000, p. 517) refer to such an approach as 3-Tier as focusing on **"**possibilities for maximum mobility,**"** in contrast to the traditional approach that focuses predominately on drivers' limitations. Marottoli (2007) and Marottoli et al. (2007) make the following timely observations:

> Much of the literature on crash risk and driving performance focuses on specific diseases or impairments and whether they affect driving safety and mobility. Only recently has attention turned to potential interventions to enhance driving performance. (Marottoli, 2007, p. 5)

> There is a need to identify individuals at increased risk for crashes or poor driving performance and to determine if driving performance can be enhanced and crash risk lowered, thereby, maximizing and prolonging safe driving by older persons. (Marottoli et al., 2007, p. 591)

[3] Restricted/conditional license.

[4] In this regard, Staplin and Hunt (2004, p. 87) note: "One way licensing agencies accommodate drivers with age-related diminished capabilities while still carrying out the mandate for public safety is to impose restrictions that either ameliorate the functional deficits or restrict the exposure of these individuals, effectively and gradually retiring them from driving."

Tuokko, Rhodes, & Dean (2007) echo Marottoli (2007) and Marottoli et al. (2007):

> Little, if any, research with older drivers has gone beyond the identification of the association between health conditions (or illnesses) and driving (e.g. accident rates, cessation of driving). Understanding the manner in which health conditions relate to driving difficulties may prove useful for identifying strategies to promote continued mobility in older adults. (p. 389-390)
>
> Our findings suggest that it may be more fruitful to examine for specific health symptoms [rather than conditions], and relate these to specific forms of driving difficulties. (p. 393)

The traditional DMV-assessment focus on controlling and delicensing unsafe/high-risk/at-risk/problem drivers is here referred to as ***"driver*-centered":** DMV regulates the driver. A driver-centered DMV is focused on the "accurate identification of high-risk drivers" (Eby & Molnar, 2008, p. 4). The 3-Tier focus on extending the safe driving years of functionally-limited drivers is here referred to as ***"driving*-centered":** If off-road *absolute* standards for visual, mental, and physical functioning are met—that is, the driver is *not* "medically impaired," but nonetheless, "medically at-risk" for unsafe driving (Dobbs & Carr, 2005), then the driving-centered DMV would aid/regulate the functionally-limited drivers' *compensating (driving)* by identifying and initiating one or more relevant safe-mobility interventions[5]: referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting (conditional licensure), and so on. *Relevant interventions would be <u>initiated</u> before, and after, on-road assessments. Relevant interventions may be <u>identified</u> before, during, and after, on-road assessments.* With the driving-centered DMV's focus on extending safe driving years, driving rehabilitation and driving assessment necessarily somewhat intertwine (Wheatley & DiStefano, 2008). If drivers are ultimately assessed as unable to drive safely under any reasonably specifiable conditions then they would be delicensed. A driving-centered DMV's focus also includes identifying drivers having only one marginally-limited driving-relevant functional ability (typically *not* deemed "high-risk drivers"). Said drivers offer an opportunity to intervene early *before* their driving-relevant limitation, if not corrected in its initial-stages or not consistently and adequately compensated for, eventually contributes to them and/or other drivers crashing (e.g., Carr, 2000).

[5] As indicated, a driving-centered focus does not preclude the development and use of absolute standards in the delicensing of drivers who are highly unlikely to be able to drive safely under any reasonably specifiable conditions, for example, a driver having a visual acuity worse than 20/200 best corrected with both eyes together or a driver having been diagnosed as likely having moderate (middle-stage) or worse Alzheimer's disease.

Early intervention of course does not guarantee no limitation-related crashes, but rather should attenuate the possibility. Screening only for so-called "at-risk" (of crashing) drivers *due to having developed severe deficits* would be a poor strategy for *maintaining* safe mobility. Salient differences between driver- and driving-centered assessment are detailed in Table 1. Some of the terms used in Table 1 remain to be defined in the remainder of the Introduction and Rationale.

3-Tier's objective of extending the safe driving years of functionally-limited drivers and achieving this objective by aiding/regulating drivers' compensating is rooted in looking at driving from an ***ecological perspective*** (Hennessy, 1992; van Lier, 2004). In an ecological perspective, drivers are viewed *as actively and continuously* adjusting the demands of their driving environments/conditions and the demands of their driving tasks in accordance with their *perception of their* driving-relevant abilities and limitations. This and other aspects of an ecological perspective on driving are discussed below in a subsequent section of the Introduction and Rationale. In reviewing various perspectives on driving, Ranney (1994) made the following pertinent observations that for the most part have remained the case in the ensuing 15 years:

> In the highway safety field, priority has generally been given to identifying risk factors through epidemiological studies of accident causation. The result has been an overreliance on accidents and accident-causing behaviors, and a failure to consider driving behavior within the broader context of transportation for a particular purpose (e.g. to get from home to work). (p. 734)
>
> … ***moving the focus of research away from the driver in isolation*** [emphasis added] and focusing more on the interaction of the driver and driving situations would improve the ecological validity of roadway safety research. (p. 747)

Road safety research is *ecologically valid*, and thus of value for DMV licensing-policy making, to the extent that it incorporates into its methods a consideration of when, where, why, and how individual drivers *customarily* drive (e.g., Shinar, 2007). As indicated by Ranney (1994); Marottoli (2007); and Tuokko, Rhodes, and Dean (2007), road safety research has typically been driver-centered. Road safety research has typically *not* taken into consideration when, where, why, and how individual drivers *customarily* drive.

Table 1

Salient Differences between Driver- and Driving-Centered Assessment

Approach	Assessing driving wellness	Determining whether driving fit
Driver centered (traditional approach) Assessment is an endpoint in controlling & delicensing unsafe/high-risk/problem drivers ***What does this mean for?*** DMV staff: Easy to administer Customer: *Not* aided in maintaining their safe mobility Physician: 'Delicensing' role. Resists working with DMV Researcher: Easy to study[a]	Determine whether 'pass' or 'fail' off-road assessments of driving-relevant functional abilities. Theoretically, the cut scores are crash-predictive.	Theoretically, determining whether a driver is driving fit is not necessary if off-road tests are crash predictive. Nonetheless, a failure of an off-road test may be followed by office-based on-road testing.
Driving centered (3-Tier ecological approach) Assessment is a *starting point* in extending the safe-driving years of functionally-limited licensed drivers ***What does this mean for?*** DMV staff: Challenging & rewarding to initiate relevant interventions Customer: Actively aided in maintaining their safe mobility Physician: 'Intervention' role. Willing to work with DMV[b] Researcher: Challenging to study	If off-road absolute standards are met (visual, mental, & physical), then functionally categorize as: Driving well. Somewhat functionally limited: one marginally-limited driving-relevant functional ability. Extremely functionally limited.	1) Initiate relevant interventions: medical referral, educating, behind-the-wheel training. 2) Conduct on-road assessment. ***Primary objective for—*** Somewhat functionally limited: *early* lowering of barriers to safe mobility—educating about limitation. Extremely functionally limited: Driving-based determination of whether the level of risk for making a critical driving error is consistently small in *customary* driving environments/conditions & for *customary* driving practices[c].

[a] Straightforward experimental design and statistical analyses.

[b] "…unlike the current physician role in assessment and reporting, which is perceived as having many negative effects on patient well-being including loss of license, loss of driving, and decreased out-of-home mobility and activity, interventions have potential psychological and practical benefits in enhancing safety and prolonging safe driving and mobility" (Marottoli, 2008a, p. 135).

[c] For example, can the driver keep from making a critical driving error or a large number of important, but less critical errors, on a content-valid road test (this would include infrequent though important regular destinations)?

The remainder of the Introduction and Rationale is divided into 11 major sections:

- Background.
- Ecological Perspective on Driving.
- Barriers to Maintaining Safe Mobility.
- An Overriding Barrier to Maintaining Safe Mobility—Expecting a Gradual Decline in Functioning with Advancing Age.
- Follow-Up to Age-Based *Driver-Centere*d Questions & Answers: Two Kinds of Logical Errors.
- Screening Drivers for Constraints on Consistently and Adequately Compensating.
- Better Assessing Driving Wellness —Driving-Centered Assessment.
- Operationalizing "Driving Well," "Somewhat Functionally Limited," and "Extremely Functionally Limited."
- Validating the Three Operationalizations for Making a Driving-Centered Assessment of Driving Wellness.
- Two Null Hypotheses.
- Recommendations.

Background

Early Efforts to Conceptualize a Viable Assessment System

As a matter of historical interest two early efforts to conceptualize a viable assessment system will be described. The descriptions are taken from the Janke (1994) review (pp. 220-221).

A model older driver licensing and improvement system

Pursuant to a contract with the National Highway Traffic Safety Administration (NHTSA), Brainin (1980) suggested the following model system for all drivers above some arbitrary age and elderly drivers under that age who have reduced abilities for driving, sometimes because of medical conditions. The system involves distribution of an age-specific manual, consideration of driver history, medical screening, and assessment by nondriving and driving tests before a licensing decision is made.

People enter the model system, Brainin (1980) noted, in a variety of ways. Some states, of course, require road tests for drivers above a certain age. Absent such a requirement, if a state has an in-person renewal process for elderly drivers, license examiners can be trained to spot restricted-ability drivers. Other ways to enter the system are voluntarily; through accumulation of a sufficiently bad driving record; or upon referral from rehabilitation groups, health care personnel, relatives or friends, and others. Each individual entering the system is given a manual specifically geared to older drivers, upon which the later knowledge test will be based.

Prior to testing, each individual's driver record is reviewed. If the reason for any excess of accidents or violations can be determined, a recommendation is made for rehabilitation, corrective action, or license withdrawal. The rehabilitation programs, Brainin (1980) mentioned, can be administered by licensing agencies and may incorporate warnings, discussions with a driver improvement analyst, license restrictions, and/or a specific driver improvement program. More commonly there is either no apparent driving problem or the reason for such a problem is not known, so the driver moves to the next stage.

In the next stage drivers may undergo medical screening and evaluation, although they are first checked by a driver licensing examiner to determine if this is obviously

necessary. Brainin (1980) noted that NHTSA has sponsored examiner-training programs to educate examiners in making this kind of determination. Medical evaluation, if necessary, can be accomplished in several ways—through an examiner's application of preexisting medical criteria, through scrutiny by a medical advisory board, or through an individual physician's examination. In any case, the driver is certified or not certified as being medically fit to drive.

License restrictions are considered if the driver is not medically fit, as are assistive devices and special training. This determination is made outside of the licensing agency. The driving privilege will be withdrawn in cases where no remediation is judged possible, but the individual may be referred to a social service agency for assistance in meeting mobility needs.

If the driver is medically fit, or if rehabilitative measures have been successful, a series of tests must be passed—traffic-law knowledge, an expanded vision test, and an in-car performance test specifically designed for older drivers to elicit unsafe behaviors characteristic of that age group (left-turn difficulties, for example). At all of these testing stages, failure leads to reconsideration of restrictions and other means of reducing risk. Those who fail the performance test for suspected medical reasons (and have not been medically screened before) now go through a second medical screening and evaluation process. Successful completion of this process will allow the driver to retake the performance test. Drivers for whom the conditions underlying their driving problems could not be diagnosed previously may be diagnosed in this stage, given the benefit of knowledge of their test performance.

As a result of the system described above, all drivers will be issued an unrestricted license, a restricted license, or no license. Former drivers who fail may reenter the system at a later date. While Brainin (1980) admitted that his model is relatively complex and costly, and will probably never exist completely, he expressed the hope that it will point licensing in the correct direction—that of maintaining the safe mobility of the elderly driver.

Remedial licensing – NPSRI

National Public Services Research Institute (NPSRI; McKnight & Stewart, 1990) outlined a competency-based driver assessment system, distinguishing four stages of licensing—pre-, new, renewal, and remedial. Our concerns here are with the remedial

licensing stage, which deals with diminishing of competency and ways in which to help drivers recognize and adapt to this. McKnight and Stewart identified four strategies:

Reduce exposure by limiting the amount, time, and place of travel.

Reduce situational demands by using help from passengers (e.g., navigational assistance), or through use of appropriate vehicle types, sizes, accessories, and special aids to driving.

Maintain physiological competence (health) through exercise, rest, medicine, and diet.

Avoid conditions that cause deterioration in performance—e.g., fatigue, alcohol, and drugs.

Remedial licensing, they noted, can be handled by incorporating it into the renewal process. (However, in the case of a driver reported to the department for possibly hazardous driving, handling may need to be more expeditious than this.) Licensees in the upper age ranges may be provided a manual and administered a test focusing upon those competencies identified as being pertinent to their age group. The material can be integrated into a special version of the renewal manual and test, or administered as a supplement.

Automated testing for psychophysical screening to identify drivers who have diminished competency was strongly recommended by McKnight and Stewart. (The NPSRI test battery has been described in Part 3.) Automation, they felt, would enable use of a wide range of test stimuli, rapid change from one test situation to another in order to assess different competencies, and use of testing sequences that change as a function of ongoing test performance (adaptive testing) in order to achieve maximum efficiency and minimum testing time. The technology is now available, as the authors wrote, to automate the testing of knowledge, vision, perception, and a broad range of psychophysical functions.

The two assessment plans outlined above, both focusing on older drivers, are different from many that were proposed in the past in that they can be incorporated into the regular renewal process, as contrasted with reexamination programs that apply only to drivers whose abilities have been called into question.

The Idea of Tiered Vision Testing

Not a fully-developed assessment plan but a thoughtful paper, written by Shinar and Schieber (1991), addressed visual requirements for licensing older drivers, and introduced the idea of tiered vision testing. Tiering was thought to be one of two alternative methods for effectively monitoring and controlling visually impaired drivers who cannot necessarily be assumed to restrict themselves appropriately.[6] The first tier, in their view, would consist of standard tests and emerging techniques administered at licensing stations. Those who failed this first tier would be referred to a centralized testing center or private practitioner for a comprehensive clinical evaluation which would include additional measures such as motion detection and effective field of view. The authors wrote that their first alternative is already operating in a rudimentary way. In California this would be through the DL62 process[7]. Shinar and Schieber, however, questioned the cost-effectiveness of "periodic gross vision screening at the state licensing stations" (p. 515), given that in California extremely large-scale studies (on renewal by mail) had found no traffic-safety effect of renewal testing (e.g., Kelsey, Janke, Peck, & Ratz, 1985). That finding, however, was interpreted by the California researchers as an indication that renewal testing, as it was then, was inadequate. This was one of the chief motives spurring development of an improved assessment system.

Maryland Model Screening Program

Perhaps the most developed functional capacity screening system is the "Model Driver Screening and Evaluation Program" funded by NHTSA in 1996, and conducted by researchers from the Scientex Corporation who are now affiliated with TransAnalytics LLC (Staplin, Lococo, Gish, & Decina, 2003; also see Staplin & Hunt, 2004). In its major effort, the "Maryland Pilot Older Driver Study," a battery of functional tests was developed and administered in Maryland Motor Vehicle Administration (MVA) sites and in the community. Screening data were collected and analyzed for three separate samples of drivers aged at least 55. These data represented 1,876 drivers who visited MVA offices for license renewal or other transactions, 366 drivers referred by various sources to the MVA for medical evaluation because of suspected driving-related

[6] The second alternative, apparently preferred by Shinar and Schieber, would involve requiring older drivers to present a certificate attesting to their good vision from a licensed vision specialist. They wrote, "The inclusion of state-specified vision tests would then become part of a standard evaluation. This approach would ensure better screening of elderly drivers and provide them with professional help to improve their vision" [p. 515].

[7] The DL-62 process is one of referral, by way of driver license form 62, to a vision specialist for applicants who fail the DMV screening standard for visual acuity. Upon coming back to DMV with the specialist's report and, if prescribed, new corrective lenses, the applicants' acuity is retested.

impairments, and 266 drivers in an affluent residential community for seniors who used the services of a mobile MVA office that made periodic visits to their facility.

Analyses were done to relate drivers' test performance, representing their functional status at the time of testing, to prior and subsequent traffic crashes and moving violations as gleaned from state records. The odds of incurring a crash or committing a moving violation within the time frame of one year before testing to an average of two years afterward were calculated. The odds ratio for drivers who failed a particular screening test, as opposed to those who passed it, served to indicate the usefulness of the test in a licensing context.

Tests that were best able to predict undesirable road safety outcomes included:

- Motor-Free Visual Perception Test/Visual Closure Subtest. This is a test of visuospatial abilities in which subjects are shown a pattern lacking some elements, and are asked to indicate what the pattern would be if complete. According to Staplin et al. (2003), the test measures the ability to visualize whole objects or patterns when there are missing elements and only partial information is available. Within the battery used, performance on this test showed the strongest relationships to safety outcomes, both crashes and traffic convictions.

- Trail-Making, Part B (Trails B). This was significantly related both to crashes and to moving violations. It is based on a test with a long history as a valuable neuropsychological instrument. The original paper-and-pencil test, due to Reitan (1955, 1958), required the person being examined to search for and connect randomly arranged numbers 1-13 and letters A-L in order but in alternating sequence, resulting in a 1-A, 2-B,…pattern. Speed is measured as the dependent variable. Trails B calls on an assortment of perceptual/cognitive abilities, including complex conceptual tracking, directed visual search, visuomotor coordination, and short-term memory. In the Maryland study, a PC-based version called "Dynamic Trails" was used in the battery. Dynamic Trails is a PC-based test that preserves the basic task described above, but the letters and numbers are presented upon the moving image of a freeway-driving scene, to introduce distraction. Both speed and errors were measured.

- Useful Field of View Subtest 2. This component of the PC-based Useful Field of View test yields a combined measurement of information processing speed and divided attention. Staplin et al. noted that differences in the *size* of the "useful field of view" were

not measured. In contrast, Useful Field of View Subtest 1 (PRT) was used in the present 3-Tier study, as it was in the Novato pilot study (Janke, 2001). This first component of the computer-based Useful Field of View test yields only a measurement of information processing speed. See the Methods section for a description of the measurement of PRT.

In addition to the above, other measures showing significant promise were Delayed Recall, Rapid Pace Walk, and Head/Neck Rotation, measuring respectively working memory, strength and mobility of the legs, and flexibility of the neck and upper torso.

Monash University (Australia) Project

Stage 1 of this project was to develop a model license re-assessment program for older drivers (see Fildes et al., 2000). In stage 2 of the project (Fildes, et al., 2004), the first study evaluated the stage 1 model procedure in an Australian licensing environment, and a second study evaluated the effectiveness of four candidate-screening tests in predicting performance on a standardized road test as an indicator of potential crash risk. The discussion here will focus on the second study of stage 2. The goal was to identify effective licensing tools for "older and functionally-disabled drivers," using the screening tests to provide two thresholds. The lower one would identify drivers who could be considered unsafe, and would require a case review to consider such countermeasures as restrictions, temporary suspension, retraining, or rehabilitation. The upper threshold would identify drivers who could be considered safe. The area between the two thresholds would represent drivers who were of indeterminate safety and who, therefore, would be required to undergo another level of assessment. The tests studied were:

- Gross Impairments Screening Battery of General Physical and Mental Abilities (GRIMPS), developed by staff of Scientex Corporation (later TransAnalytics, LLC). It is composed of 11 subtests measuring abilities thought to be necessary for safe driving and at risk of decline in advanced age. The measures included in the GRIMPS battery, several of which have been mentioned above, were rapid-pace walk, foot-tapping, overhead arm reach, head/neck/upper body rotation, Motor-Free Visual Perception test (Visual Closure subtest involving selecting the most probable completed versions of incomplete stimuli), cued recall, delayed recall, scan test (categorizing examinees' scanning patterns as systematic [normal], erratic, and neglectful), Parts A and B of the Trail Making Test, and visual acuity (high and low contrast).

- CALTEST. According to the report, two of these tests were taken from the battery developed for California's cooperative venture with NHTSA in the mid-1990s. However, it should be noted that the California studies, unlike the Monash study, used only the first UFOV subtest (PRT). The tests included:

  - Autotrails (an automated version of Trail Making Part A, or Trails A, developed by Frank Schieber (Heimstra Human Factors Laboratories, University of South Dakota). This is described below in the Methods section, because it was considered for the updated 3-Tier system that is the subject of this report. Involving visual search and attention, Autotrails requires examinees to touch, in numerical order, each of 14 randomly arranged numbered circles superimposed on a (stationary) traffic scene. The number of errors and time to completion were recorded.

  - Visual Awareness' UFOV or Useful Field of View test (Ball & Owsley, 1991; Owsley, McGwin, & Ball, 1998). The Monash investigators used the last two components of this three-part PC-based test: divided attention and selective attention. The selective attention task is the same as the divided attention task with the addition of distracters.

  - HPT or Hazard Perception Test (Congdon, 1999). The task here was an adaptation of a test, developed by VicRoads in Australia, requiring examinees to assess potentially hazardous video situations. It was never used in California. The adaptation contained six subtests, video sequences of traffic scenes selected from the full set of HPT items. Unlike the scoring system on the original test, the number of correct responses was defined as the number correct on either the first or second trial.

- DriveABLE (DriveABLE Inc., 1997). As used in the Monash project, DriveABLE included six computer-based tasks. These yielded measures of motor speed, useful field of view, judgment of gap size, attention shifting, executive functions, and component driving abilities (videos of traffic situations about which examinees were required to make judgments). Because the battery is proprietary, in place of scores for the individual tests the experimenters were furnished a confidence rating for each examinee indicating his or her probability of road-test failure (i.e., failure of the DriveABLE standard road test).

- Elemental Driving Simulator (EDS, Life Science Associates, New York). This test, as its name implies, was presented on a computer-based driving simulator. With the examinee seated at a computer and responding by means of steering wheel/turn signal and accelerator controls, six scores were derived. These reflected steering control, reaction speed, field of vision, adjustment to changed circumstances, self-control (number of errors on the most difficult task, a contingent differential response), and consistency (the difference between mean and median response time).

These tests tapped the realms of visual abilities, cognitive abilities, and other bodily abilities thought to be relevant to driving safely, any of which may decline in the course of aging.

The study was conducted in two steps. In the first, the (volunteer) participants, all of whom were near their 80th birthday or older, completed one of the four screening batteries. This yielded almost 400 valid assessments. The EDS was discarded, in part because of unreliability, and in step 2 a further 560 elderly participants were assessed on the three remaining screening tests. Participants' performance on a standard driving test—the New Zealand road test required of drivers 80 or older—was used as a measure of safety risk. Analyses showed that there were significant relationships between performance on this test and the following ones:

- GRIMPS (overall score, rapid pace walk, foot tap, delayed recall, Trails B, and visual acuity (high contrast and low contrast).

- CALTEST (Autotrails, UFOV Selective Attention).

- DriveABLE.

The authors recommended implementation of the reassessment model and a much larger field trial of the more promising screening batteries with a prospective evaluation of the association between test results and crashes. This would both establish the predictive accuracy of a selected test or tests, and highlight any need for further test refinement.

AGILE

AGILE, which stands (in English) for "**AG**ed people **I**ntegration, mobility, safety and quality of **L**ife **E**nhancement through driving," is a project, conducted within the European Union, which seeks to "develop a new set of training, information, counseling and driving ability assessment

and support tools for the elderly, evaluating their full range of physical, cognitive, behavioral and interaction abilities . . . ." (Breker, et al., 2003, p.2). To this end, participants in the project have written a series of reports (AGILE Deliverables) that are posted here: http://www.agile.iao.fraunhofer.de/deliverables.html. One of these, AGILE Deliverable 2.1 (Middleton, et al., 2003), addresses the variability in procedures for assessing fitness to drive found in a survey of EU countries. AGILE urges that there be a pan-European driving-assessment process, containing a standardized set of tests and aimed particularly at elderly drivers (age undefined), who would often enter the system on medical grounds. They have found a lack of standardization in procedure across sampled countries, with no agreed-upon criteria for invoking the assessment process, no agreement on the specific medical conditions that would require assessment, and little knowledge regarding guidelines and standards relating to specific driving-relevant functional defects. AGILE Deliverable 5.2 (Arno and Boets, 2004) describes in detail their proposed three-tier assessment system:

> …the assessment primarily aims at evaluating the cognitive functional status of the elderly driver. When cognitive decline is detected, the assessment further focuses on the detection of possible compensation mechanisms. (p. 6)

> The overall AGILE assessment procedure involves a medical pre-screening [by a general practitioner, physical therapist, or occupational therapist] to identify early age-related conditions (e.g. dementia) with implications for functioning. When a medical condition with possible implications for driving is diagnosed, an evaluation of functional skills is proposed via paper and pencil as well as computerised tests (screening). When scores are below specified thresholds, referral for further in-depth assessment should be recommended at specialised driving assessment centers, where trained psychologists can assess specific functional deficits through neuropsychological assessment. Any symptom indicating a functional deficit considered important for safe driving has then to be further evaluated by means of a behind-the-wheel test, which can be performed in a driving simulator and/or on the road in real traffic conditions. Assessment should not focus on driving skills only but on safe driving behaviour. The on-the-road assessment should indeed allow to evaluate whether age-related cognitive decline is - at least partly - compensated by better awareness of risks or improvement in hazard perception, which are skills developed through experience. (p. 18)

California DMV Projects Culminating in the Present 3-Tier Assessment System

Two separate California DMV projects led up to the present 3-Tier assessment system. One of these projects was a cooperative venture, starting in 1993, between the California Department of Motor Vehicles (DMV) and the National Highway Traffic Safety Administration (NHTSA). Its aim was to identify functions important to test, and suitable tests, for a tiered licensing-agency assessment of older drivers. The goal was not to develop a complete, integrated assessment system like the recommended 3-Tier system of the present study, but the idea of 3 tiers of testing arose very early. Page iv of the Executive Summary of the first report of the NHTSA-DMV project (Janke, 1994) states that the report "offers suggestions for a three-tier assessment system which might be used by licensing agencies to (1) identify drivers with possibly driving-related impairments (first tier), (2) assess those identified further, to estimate the degree to which any impairments would be likely to affect driving (second tier), and (3) test their on-road driving performance in a standardized manner (third tier)."

Janke (1994) thus identified, similar to other authors (e.g., Shinar & Schieber, 1991), the usefulness of an assessment system containing three testing tiers that have a progressively increasing relationship to driving. Her 1994 report also identified common aging-related medical conditions and their effect on driving, described existing driving and non-driving assessment tools (ATs) for measuring functional abilities judged necessary for safe driving, and discussed elderly driver-licensing programs and licensing provisions in selected states. From the important driving functions and ATs studied for the literature review, promising ATs were selected and piloted in a DMV field office (the Santa Teresa office in San Jose). A preliminary report came out of this (Janke & Eberhard, 1998) that also described independent work at that site by the Scientex Corporation, which studied intersection negotiation using as subjects the same older drivers (Staplin, Gish, Decina, Lococo, & McKnight, 1998). A second study to identify suitable 3-Tier ATs was conducted in Novato's (Marin County, California) Buck Center for Research in Aging; participants were a group of elderly volunteers. The Santa Teresa and Buck Center studies are described in Janke & Hersch (1997) and Janke (2001). These two studies, for the most part, piloted different ATs, using road test performance as the principal criterion measure, and recommended their use as is, their further development, or their abandonment. The ATs studied and recommended here to be part of the final 3-Tier assessment system were among the most promising survivors of the Santa Teresa and Buck Center studies.

The ATs chosen here are to be administered by field-office staff, under field-office conditions, within a necessarily limited amount of time. In these circumstances too much complexity can be

a drawback. While a simulator test, for example, showed great promise in Santa Teresa when administered only by the second author, Janke and Hersch (1997) warned that:

> 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-limited persons, and in particular [administering] the specific test being used, would do much to assure valid results. (p. 193)

The other project that led up to the present 3-Tier assessment system is Hennessy's (1995) research into visual and perceptual ATs, conducted as a component of DMV's driver competency enhancement program which called for an enhanced vision-test system. ATs studied were the Pelli-Robson chart-based contrast sensitivity test, the Smith-Kettlewell Low-Luminance (SKILL) card, the Berkeley Glare Tester, standard and attentional visual field using a modified Synemed perimeter, and the Visual Attention Analyzer version of the Useful Field of View test (UFOV, including all three modules, the first being what we call here, perceptual response time [PRT]). Using prior crashes rather than road-test performance as a criterion, and self-reported levels of different forms of self-restriction as moderating variables, Hennessy found that the most promising ATs were the Pelli-Robson chart and PRT. These ATs—which were also studied, respectively, at Santa Teresa and Buck Center as part of the agreement with NHTSA—are a large part of the recommended 3-Tier system. Note that the two projects found the same ATs useful in spite of the fact that they used very different criterion measures.

Ecological Perspective on Driving

Ecology is concerned with the nature of the *relationships* and the *interactions* between organisms and their environment (the physical and biological factors affecting them and affected by them). Taking an ecological perspective on driving means first keeping in mind that in

driving and in preparing for driving, drivers continuously actively adjust—in accordance with their *perception of their* driving-relevant abilities and limitations:

- The demands of the driving environment/conditions—for example, by avoiding nighttime driving or by restricting driving to familiar and well-practiced routes.

- The demands of the driving task—for example, by slowing down or making three right turns rather than making a left turn.

In other words, *drivers are actively and continuously compensating* (e.g., Powers, 1973; Ranney, 1994) in maintaining their safe mobility.

Compensating

In regards to the importance of researchers keeping in mind drivers' *continuously* compensating, observations made by Näätänen and Summala's (1976) over 33 years ago still remain generally relevant.

> A profound misunderstanding of the basic nature of the driver's task by many workers in the field has led research in fruitless directions: little attention has, for example, been paid to the driver's ability to compensate for changes in the degree of difficulty of traffic situations by modifying his efforts (attention, vigilance).…Driving indeed should not be understood as involving a forced-pace task in which the driver principally has only a responsive role in his interaction with the traffic situation; instead his active role and initiative most [of the] time on the road should be given sufficient notice. (pp. 36-37)

Compensating is universal. Drivers of all ages and states of health *continuously* adjust their driving both in response to and in anticipation of challenges to maintaining their safe mobility. When youthful and relatively inexperienced drivers fail to detect a hazard in a timely manner—commonly because of inadequate visual search or immaturity-based excessive speed—they often are able to compensate by using their quick reflexes to brake or steer. When experienced drivers *notice* a decrement in any of their driving-relevant abilities (noticing the decrement, at least at some level, is the necessary first step), they commonly minimize challenges to maintaining their safe mobility by avoiding problematic driving environments/conditions like nighttime driving, freeway merging, or unfamiliar areas. Based on Michon's (1985) hierarchical conceptualization of driving as concurrent activity at three different time scales of change (strategic,

tactical/maneuvering, and vehicle control), Ranney (1994) illustrated the "continuously-adjusting" nature of compensating:

> … changes in trip plans, such as the avoidance of rush-hour or nighttime driving by older drivers (Planek & Fowler, 1971), are examples of strategic-level compensations. Adjustments to safety margins, such as the rejection of a higher percentage of gaps during on-road merging by older drivers (Wolffelaar, Rothengatter, & Brouwer, 1987), or during conditions of poor visibility, are maneuver-level compensations. Momentary adjustments to steering and acceleration in response to slippery roads are examples of compensation at the vehicle-control level. (p. 743)

Lundberg (2003) offers additional common ways of compensating and related schemes for classifying these different ways of compensating.

From an ecological perspective, compensating is not something the driver either does or does not do**;** compensating is always or continuously "done," though with *varying degrees of adequacy and consistency* (Bäckman & Dixon, 1992; Hennessy, 1995). Please note that the varying degrees of adequacy and consistency in compensating are ***frequently changing attributes of a driver's driving rather than fixed/stable attributes of the driver*.**

Constraints on Consistently and Adequately Compensating

Lacking in awareness or understanding of a driving-relevant limitation(s), lacking in knowledge of ways of fully compensating for a limitation, and passively accepting a driving-relevant limitation as inescapably caused by aging are some of the factors detailed in the next major section (p. 35) that *variably constrain* drivers from consistently and adequately compensating (and from improving their driving-relevant abilities as well). In viewing driving from an ecological perspective, these constraints amount to ***"barriers" to maintaining safe mobility;*** some barriers are higher than others.

"Lowering" Barriers to Safe Mobility

In addition to viewing most of the safe-mobility interventions listed in the Overview (referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting [conditional licensure] and so on, see pp. 4-5) as different ways available to DMV for aiding/regulating functionally-limited drivers'

compensating, these interventions may also usefully be viewed as mechanisms for "lowering" barriers to safe mobility. That is to say, they are mechanisms for lowering barriers to consistently and adequately compensating. For example, in the case of a driver lacking awareness and understanding of a newly-identified driving-relevant limitation and lacking knowledge of ways of fully compensating, a DVD-based education intervention might be used to lower these two barriers to consistently and adequately compensating. A barrier need not be eliminated; it just needs to be lowered enough to where it's just another bump in the *road to being driving fit* (consistently small level of risk for making a critical driving error; Table 1, p. 8).

Driver-Centered "Compensation"

Researchers sometimes pose as an empirical question, "whether" older drivers compensate for their driving-relevant "deficiencies." Sometimes researchers simply assert that older drivers do compensate for their driving-relevant "deficiencies." For example, McKnight (2003) states:

> …older drivers tend to compensate for their deficiencies by driving more slowly and more carefully than they once did and by avoiding the situations that present the greatest threat. As a result, they do not pose a substantially greater threat to the public than any other age group. (p. 30)

Four years later Loughran, Seabury and Zakaras (2007) echoed McKnight's assertions:

> There is also evidence, however, that older individuals compensate for their impairment by changing their driving behavior… To identify the appropriate policy response to older drivers, such self-regulation must be taken into account. (p. 2)

> Because they are aware of their own limitations and adjust their driving patterns in response, older drivers pose only a slightly increased risk to other drivers. (p. 14)

The above assertions are based on a *driver-centered* conceptualization of "compensation" versus a *driving-centered* conceptualization of "compensating." When one's focus is on regulating the *driver* rather than the driver's *driving*, "compensation" is *not* viewed as an ongoing driving process as it is in a *driving-centered* conceptualization of "compensating". Instead, *driver*-centered "compensation" is viewed as a *possible* fixed/stable *attribute* of the driver. "Compensation" is viewed as neutralizing a driving-relevant deficiency(s). There is no sense of

"compensation" varying in its adequacy and consistency as it surely does[8], let alone differently for different drivers. Furthermore, attributing or not attributing *driver-centered* "compensation" to *all* older drivers entails making two kinds of logical errors: an amalgamation error (the aggregating of two or more functionally disparate groups) and an ecological fallacy (attributing a characteristic of the aggregate at large, typically the mean, to one or more of the individuals making up the aggregate). These logical errors are examined in a later section of the Introduction and Rationale: Follow-Up to Age-Based *Driver-Centered* Questions & Answers: Two Kinds of Logical Errors.

Thinking of "compensation" as a *possible* fixed/stable *attribute* of the driver, and that if possessed would neutralize a "physical defect," would also seem to be the basis of routinely implementing California Vehicle Code section 12804.9 (a) (3) (quoted immediately below) by administering an *office-based* road test.

> CVC §12804.9 (a) (3) A physical defect of the applicant that, in the opinion of the department, is compensated for to ensure safe driving ability, shall not prevent the issuance of a license to the applicant.

As indicated in the Overview, in the case of a driver having been identified as having a "physical defect," a fully *driving-centered* DMV, in contrast to a traditional *driver-centered* DMV, would *first* identify and initiate relevant safe-mobility interventions. Later the *driving-centered* DMV would make a driving-based determination of whether the level of risk for making a critical driving error (see next subsection) is consistently small in that driver's *customary* driving environments/conditions and for that driver's customary driving practices.[9] Relevant safe-mobility interventions would include, if feasible, providing a functionally-limited driver with specific ways of compensating for their limitations.

Critical Driving Error

Failing to consistently and adequately compensate for the effects of a driving-relevant functional limitation can result in the driver making a critical driving error (CDE). A CDE is defined here as an action or inaction which has a high probability of precipitating an *adverse driving event* if

[8] This may be due to a variety of factors, such as fatigue and distractions, which are described in the next major section: Barriers to Maintaining Safe Mobility.

[9] For example, can the driver keep from making a critical driving error or a large number of important, but less critical errors, on a content-valid road test (this would include infrequent though important regular destinations)?

the consequences of the CDE are *not* attenuated by such factors as a lack of conflicting traffic. Adverse driving events include the following negative outcomes: forcing other road users to take evasive action in order to avoid a crash, actually colliding with them, or nearly colliding with them (cf. Marottoli, 1997).

Driving Wellness

When it comes to driving, maintaining safe mobility is first a matter of preserving a high degree of driving wellness. "Driving wellness" is a phrase due to Emerman and Finn (2001); it was designed to focus attention on preserving and proactively improving driving-relevant functional abilities. A driver assessed as "driving well" would be a driver deemed free from driving-relevant functional limitations. The degree of driving wellness will vary in accordance with the *number, kinds, and severity* of driving-relevant functional limitations. In an internet-based health-promotion module funded by a collaborative agreement between the American Society on Aging and the Centers for Disease Control and Prevention and called a "Road Map to Driving Wellness," its authors, Nancy Ceridwyn & Sandra Maldague (2002-06), describe a variety of ways that drivers may preserve (maintain) and/or improve their driving wellness. For example:

- *Actively working at keeping physically fit* [See Marottoli et al. (2007) for documentation of a physical conditioning program that aids in maintaining safe mobility].

- *Getting regular physical examinations to assess and possibly improve visual, cognitive, and physical functioning.*

- *Abiding by the recommendations made by the driver's doctor.*

- *Periodically reviewing the state's Driver Handbook to refresh one's knowledge of safe driving practices and the laws and rules of the road.*

The Older Drivers Project has developed driving-wellness tools for physician use in "optimizing the driver through health care" and published them in the *Physician's Guide to Assessing and Counseling Older Drivers* (Wang & Carr, 2004; Wang, Kosinski, Schwartzberg & Shanklin, 2003).

Driving Fitness

The level of risk for making a CDE is termed here as the *degree* of "driving fitness." The *degree* of driving fitness is contingent on ***how well the driver manages***—by regularly searching/scanning for hazards, slowing down or speeding up, and so on—**the different *ongoing everyday challenges to maintaining a low level of risk for making a CDE*** (cf. Fuller, 2005) . As indicated in Figure 1 (discussed below), these everyday challenges derive from the *combined effects* of four factors:

- Ongoing changes in the demands of the driver's customary driving tasks.
- Ongoing changes in the demands of the driver's customary driving environments/conditions.
- The driver's driving-relevant limitations.
- The driver's driving-relevant abilities—especially proficiency (consistency and adequacy) in compensating for the effects of any driving-relevant limitations that the driver may have acquired.

Therefore, the level of risk for making a CDE is not an attribute of the driver as is driving wellness. The degree of driving fitness is not some thing that could ever be measured in a DMV or doctor's office. Instead, like the varying degree of adequacy and consistency in compensating, the degree of driving fitness is another ***frequently changing attribute of a driver's driving rather than a fixed attribute of the driver*.** Just as a driver may not be assessed as always adequately compensating or not, a driver may not be assessed as having a high degree of driving fitness or not. However, a driver may be assessed as "***driving fit***." This would be a driver whose level of risk for making a real-world CDE is expected to be consistently small in that driver's *customary* driving environments/conditions and for that driver's customary driving practices. For example, the driver did not make a structured-CDE (see Appendix G for examples) during the course of a content-valid road test (this would include infrequent though important regular destinations).

How and Why the Driver *Competently* Manages

Just as the safe-mobility interventions listed in the Overview (referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting [conditional licensure] and so on, pp. 4-5) may be viewed as different ways that DMV may "lower" barriers to drivers' consistently and adequately compensating (p. 23), they may also usefully be viewed as mechanisms available to DMV for aiding functionally-limited drivers in *competently managing* their everyday driving challenges and thereby maintaining a low level of risk for making a real-world CDE. This is because "compensating for the effects of limitations" (other than not driving) and "managing everyday driving challenges" refer to different levels in the hierarchy of concurrent processes making up driving. "Compensating for the effects of limitations" is embedded in "managing everyday driving challenges" which in turn is embedded in "maintaining safe mobility." Regardless of the reference level, going down a level in this hierarchy answers "***how?***" to regulate at a given level by in part using the next lower level; going up a level answers "***why?***" regulate at a given level (Powers, 1973). In addition to maintaining a low-CDE risk (driving safely) by regularly searching/scanning for hazards, slowing down or speeding up (Fuller et al., 2006), and so on, *consistently* and *adequately* "compensating for the effects of limitations" (for example, focusing one's attention exclusively on the drive task at hand) is also ***how*** a best-corrected functionally-limited driver may in part *competently* "manage everyday driving challenges." ***Why*** *competently* "manage everyday driving challenges?" It is a "lower level" means of "maintaining safe mobility." In addition to functionally-limited drivers *regularly* achieving their travel objectives by avoiding nighttime driving, restricting driving to familiar routes, and so on, *competently* "managing everyday challenges" (maintaining a low-CDE risk) is also ***how*** a functionally-limited driver "maintains their safe mobility." Maintaining a low-CDE risk, that is, driving safely, is integral to "maintaining safe mobility."

Driving Wellness Versus Driving Fitness

A driver's *degree* of driving wellness is a driving-relevant description or assessment of the driver made *irrespective* of the driver's customary driving environments/conditions and *irrespective* of his or her customary driving practices. It includes aspects of functional health that have potential relevance for driving, as well as such cognitive acquisitions as knowledge of safe driving practices and knowledge of the laws and rules of the road. Assessing a driver's contrast sensitivity (the amount of contrast a driver needs to quickly detect objects that are important to safe driving, like other cars and pedestrians), for example, is a necessary *part* of assessing the

driver's degree of driving wellness, since good contrast sensitivity is critical to noticing potential road hazards under numerous everyday low-contrast viewing conditions such as the light car in the fog, a dark car in the shade, and faded lane-boundary markings. However, this does not mean that a driver assessed in a DMV field office as having *severely* limited contrast sensitivity should be expected necessarily to be at an elevated risk for making a CDE. Nor does it mean that a driver assessed as having *only* a *marginal* decrement in contrast sensitivity (and who has no other decrements in driving wellness) should be expected *not* to be at an elevated risk for making a CDE. There is potentially a great difference between a driver's expected risk for making a CDE, given their driving-relevant limitations, and a driver's actual risk for making a CDE (Hakamies-Blomqvist, 1994; Näätänen & Summala, 1976; Ranney, 1994; Shinar & Schieber, 1991). As already indicated, this is because even though a driver's level of risk for making a CDE is a function of his or her degree of driving wellness, the degree of driving fitness is ***not determined*** by the degree of driving wellness. Figure 1 schematically summarizes the nature of the relationship between the degree of driving wellness and the degree of driving fitness**,** as well as the nature of the relationship between the latter and the probability of an adverse driving event. Both of these relationships may be strongly moderated. A moderated relationship is one in which the nature of the relationship between factors A and B *depends* on the value of another factor(s), C, the moderating factor (Jaccard, Turrisi & Wan, 1990). In Figure 1, the arrows pointing to another arrow indicate a "moderated relationship" (Jaccard, Turrisi & Wan, 1990). Figure 1 indicates how the driving fitness-diminishing effect of a decrement(s) in driving wellness may be moderated in two fundamentally different ways:

- The driving fitness-diminishing effect of a decrement(s) in driving wellness *depends on* the driver's proficiency in compensating for that limitation. Consistently compensating adequately can greatly ***attenuate*** the fitness-diminishing effect of even a *severe* decrement(s) in driving wellness (Hennessy, 1995; Soderstrom and Joyce, 2008). For example, in the case of drivers assessed as having *severely* limited contrast sensitivity, said drivers may still drive safely if they consistently keep from driving in low contrast viewing conditions such as dusk or dawn, residential streets at night, and when it is foggy or raining. Factors that may in turn moderate the driver's consistency and adequacy in compensating are detailed in the next major section: Barriers to Maintaining Safe Mobility.

- The driving fitness-diminishing effect of a decrement(s) in driving wellness also *depends on* everyday changes in the demands of the driver's driving tasks and driving environments/conditions. If left unchecked by compensating, *everyday* changes in the

demands of a driver's driving tasks and/or driving environments/conditions can greatly ***exacerbate*** the fitness-diminishing effect of even *a single marginal* decrement in driving wellness. For example, in the case of a driver assessed as having *only* a *marginal* decrement in contrast sensitivity (with no other decrements in driving wellness) said driver may suddenly and, perhaps only for a moment, drive very unsafely (high level of risk for making a CDE). S/he could fail to notice in a timely manner a darkly clothed pedestrian walking on the black asphalt inside the upcoming crosswalk when it is dusk and the lines marking the crosswalk are greatly faded. The everyday convergence of such factors can result in a kind of momentary "perfect storm."

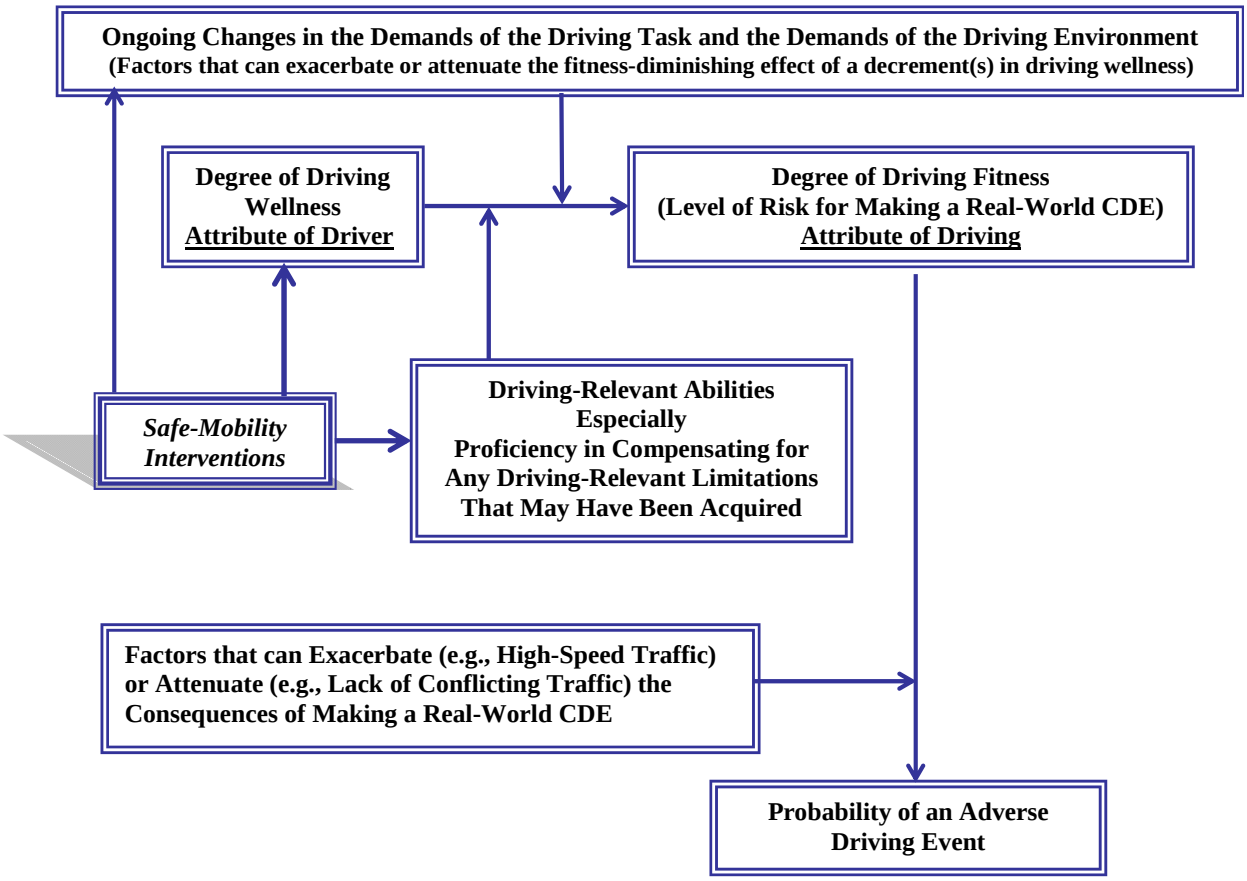

Figure 1. Ecological perspective on the nature of the relationship between the degree of driving wellness and the degree of driving fitness**,** and the nature of the relationship between the latter and the probability of an adverse driving event. Adverse events include crashes and forcing other road users to take evasive action. The arrows pointing to other arrows indicate a "moderated relationship," where the nature of the relationship between factors A and B depends on the value of another factor(s), C, the moderating factor(s). Factors that may constrain the proficiency of compensating for the effects of limitations are detailed in the text. Also represented are the effects of safe-mobility interventions—mechanisms available to DMV for aiding drivers in improving their driving wellness and in adequately and consistently compensating. Please note that this figure is not intended to be a comprehensive representation, but rather a broad overview.

Driving Fit

Determining whether a driver is "driving fit" (consistently small level of risk for making a real-world CDE, see p. 26) requires an assessment of the driver, with whatever driving-relevant abilities and limitations that he or she may have acquired, *made relative to* his or her:

- Customary driving tasks.
- Customary driving environment(s)/driving conditions.
- Customary driving practices (especially compensating practices).

Please note:

- What is "customary" can be changed either by the driver, for example, by getting behind-the-wheel training in compensating for limitations, or by the DMV, for example, by restricting the driver from freeway driving.
- Only a driver's driving, not the driver per se, may be defensibly characterized as "safe" or "unsafe".

Unlike measuring driving wellness in the DMV office, determining whether a functionally-limited driver is driving fit *necessarily requires on-road assessment* with at least some individualization of the assessment procedures.[10] This is consistent with Baldock's (2008) "Best practice criteria in practical driving tests of medically referred drivers." It may even require, as Baldock (2008) and Wheatley and DiStefano (2008) both note, the services of a certified driving-rehabilitation specialist (DRS).

> …meeting the needs of particular drivers with complex medical, disability, and aging-related driving concerns is currently best addressed by an individual assessment [on-road testing] procedure with a DRS who considers their particular health and lifestyle needs, has

[10] In the event of a DMV office-based structured road test, the driver may be given the opportunity to decline a driving task(s) or driving environment(s)/condition(s) that they rarely if ever encounter, for example, merging on and off a freeway. If a portion of road test is declined and the road test is passed (the driver does not make a structured-CDE [Appendix G]), then the driver would be restricted accordingly, for example, "no freeway driving." In the event of a home-based on-road assessment, the driver specifies the driving routes. If the road test is passed, then the driver would be restricted to driving on the tested routes.

> a detailed understanding of how impairment may impact upon driver performance, and can develop a customized driver rehabilitation program. What may be described as weakness in terms of [road] test consistency may thus also be viewed as one of the strengths of this customized assessment approach. However, a balance needs to be struck between considering the needs of individual drivers (within jurisdiction systems for accommodating drivers with health and medical conditions) and offering a consistent, reliable, and equitable assessment and rehabilitation procedure (Wheatley & DiStefano, 2008, p. 324).

Crash Record Cannot Be Used *Alone* as a Reliable Indicator of a Driver's Degree of Driving Fitness

The driver-centered objective of identifying unsafe/high-risk/at-risk/problem drivers is commonly, and perhaps typically, pursued using a correlational/risk-factor methodology as a means of evaluating prospective ATs (e.g., Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Owsley, 1997; Owsley & McGwin, 1999). This methodology tends to rely on specificity and sensitivity measures and the corresponding odds ratios as a means of developing cut scores for these tools (e.g., Browner, Newman, & Cummings, 1988; Staplin, Lococo, Gish & Decina, 2003). Implicit in this driver-centered approach is the working assumption that**,** if a functional ability is truly critical for an individual's safe driving, then one should be able to account for variation in driving performance by variation in that functional ability. The criterion measure in such studies is almost always crash record which, on the one hand, is widely considered to be the best *indicator* of an *individual's* diminished driving safety but, on the other hand, is often questioned in this role (e.g., see Schieber's [1994] discussion of the "tyranny of the accident criterion"[11] and Ball & Owsley, 1991). In terms of Figure 1 (p. 30), even though crash record would have to be a function of [12] the "probability of an adverse driving event" which in turn is a function of the "degree of driving fitness" (itself, as discussed on pp. 27-29, a function of the "degree of driving wellness"), crash record is ***not determined*** by the "degree of driving fitness." This is due to the factors (see Figure 1) that regularly *moderate* the consequences of a driver making a real-world CDE. Consequently, a clean driver record cannot be used *alone* as a

[11] Schieber (1994; p. 30) notes: "Accidents are caused by many factors as well as the interactions among those factors. These combinations of causative influences rarely repeat themselves; and, in fact, it has often been claimed that 'no two accidents are alike.' As such, the size of statistical main effects relating accident variance in a large population to *any* factor will be small (see Shinar and Schieber (1991) for a commentary on accident-based driving research). It has become clear that advances in driving research, especially in the domain of older drivers, will accrue only to the extent that we free ourselves from the 'tyranny of the accident criterion' and focus upon performance-based driving criteria."

[12] In the sense of "depends on."

reliable indicator of whether that driver's level of risk for making a real-world CDE is ***currently*** consistently small. Everyday factors such as a lack of conflicting traffic, and especially, other driver's defensive maneuvering can greatly attenuate the adverse consequences of a driver making a real-world CDE. Furthermore, for at least two reasons, having crashed one or more times in the past cannot be used *alone* as a reliable indicator of whether that driver's level of risk for making a real-world CDE is ***currently*** *not* consistently small. First, one, or perhaps more crashes, could have been due to either a perfect storm (convergence) of everyday factors or a single unforeseeable critical factor[13] that would have overwhelmed even a driver who was deemed free from driving-relevant functional limitations. And secondly, in terms of Figure 1, DMV-initiated "safe-mobility interventions" (referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting [conditional licensure], and so on, pp. 4-5) and/or the driver (acting in response to having crashed) could have, since crashing, improved the "degree of driving wellness," improved proficiency in compensating, reduced the demands of their driving tasks, and/or reduced the demands of their driving environment(s)/driving conditions. Thus, neither a clean record nor a crash history can be used *alone* as a reliable indicator of whether a particular driver's level of risk for making a real-world CDE is or is not ***currently*** consistently small.

Barriers to Maintaining Safe Mobility

Historical Backdrop

As noted earlier in the discussion of an ecological perspective on driving, a driver may be constrained, that is, greatly hindered, by a variety of factors from either improving their functioning or adequately and consistently compensating for their driving-relevant limitations. Limitation-naivety is one of the most troublesome of these factors. Baldock (2008) notes that:

> …insight into their driving abilities and the reasons for their referral…is likely to be an essential ability for appropriate monitoring of one's driving performance, for self-regulation, and for adherence to license conditions.

[13] For example, the intoxicated driver who crosses the center line.

Appreciating this particular constraint and others as "barriers" to safe mobility, and as barriers they may be "lowered," dates back at least to 1936 when the DMV was evaluating a battery of "special" tests. These tests included an assessment of brake-reaction time, a steering test (measuring eye-hand coordination), a speed-estimation test (measuring the ability to time moving objects and estimate relative speeds), and various visual ability tests such as glare resistance and peripheral vision (Fletcher, 1939a). In a seminal two-part report published in the August and September 1939 issues of the *California Highway Patrolman*, Edwin Fletcher, the California Examiner in Charge of Research, made several perceptive driving-centered observations relevant to a DMV lowering barriers to safe mobility:

> …numerous road tests given to both "good" and "poor" drivers with restricted fields showed that the "good driver" knowingly or unknowingly compensated for his restriction and the "poor" drivers did not. Knowing his weakness and doing something about it was the secret of the "good driver". (Fletcher, 1939a, p. 60)

> In order to properly evaluate the eligibility of the applicant, it is necessary to know what type of driving he intends to do and how well he is equipped to do that type of driving. It is in such work as this the special tests will prove invaluable. (Fletcher, 1939b, pp. 49-50)

> In the past, an applicant either qualified or did not qualify for regular driving privileges. Even if the applicant intended to do only a limited type of driving, he was required to pass the tests for regular driving privileges, because the examiner had no way of evaluating limited driving privileges. Through the use of special tests**,** however, many restricted licenses have been issued, granting limited privileges to persons capable of driving safely only under limited conditions. The accuracy of selection can be gauged by the fact that during the three years that this policy has been in effect, none of the specially licensed drivers has been reported in any traffic difficulties. (Fletcher, 1939b, p. 50)

> In addition to driver selection, the special tests are a valued means of improving the driver, through revealing his driving limitations. Showing a driver how to compensate for his limitations not only improves his "avoidance ability" but creates a more cooperative attitude. Such an approach has resulted in effectively improving the accident or violation record of tested drivers. Aiding a driver through successful re-education is far more satisfactory than endeavoring to discipline him by summarily stripping him of all driving privileges and then putting him under surveillance to make sure that he ceases driving. (Fletcher, 1939b, p. 65)

Fletcher even specified two mechanisms for how not recognizing or valuing the importance of driving safely can act as a barrier to maintaining safe mobility:

> …On the other hand, an individual may posses a high degree of skill in all the responses required in driving and be an unsafe driver because he extends himself beyond the safe limits of his ability or because he does not utilize his ability to the degree required. (Fletcher, 1939b, p. 14)

The 3-Tier assessment system described in the present report is entirely consistent with Fletcher's "special testing" program which appears to have concluded in 1938 when data collection was completed for the evaluation study. Perhaps related to the beginning of World War II, a change in departmental administration, or later, to the swollen tide of postwar drivers in California, the special tests do not appear ever to have been implemented statewide.

Abiding and Transient Factors

In addition to limitation-naivety, compensating for driving-relevant functional limitations also varies in its adequacy and consistency due to a variety of other abiding and transient factors. For example, a case in which compensating cannot be expected to be consistently adequate would be that of a driver with undiagnosed glaucoma (which typically restricts the visual field) and a very stiff neck. Compensating for the visual field restriction would involve frequently turning the head, but the stiff neck would restrict head movement and at the same time could be excessively painful. This combination of limitations is a constraint on the driver's compensating for the effects of glaucoma, and equally a constraint on the driver's compensating for the effects of a very stiff neck. Immediately below is a list of general constraints based mostly on Hennessy (2002).

Barriers to Maintaining Safe Mobility: Factors That Variably Constrain Consistently and Adequately Compensating for Functional Limitations:

- *Number and criticality of driving-relevant functional limitations.*
  - The more limitations a driver has and the more critical each is to safe driving, the more challenging adequately compensating will be for all of them.

- A greater number of limitations increases the probability of finding combinations of limitations for which compensatory methods are mutually incompatible.

- "Decisions about driving for older individuals often are difficult because of the presence of multiple chronic conditions and the use of multiple medications. In fact, the interactions between age, medical conditions, and medications make predictions about medical fitness-to-drive using medical guidelines or screening tools next to impossible. In these cases, referral for an objective driving assessment can be helpful" (Dobbs & Carr 2005, p. 10).

- *Severity of driving-relevant functional limitations.*

  - If limitations are severe enough they may not be compatible with driving safely under any circumstances. In the case of drivers renewing their driver license at DMV, severities this great are uncommon[14].

- Extent to which the driver is not fully aware of their driving-relevant functional limitations and how these limitations could affect driving safely or, in other words, limitation-naivety.

- *Extent to which the driver fails to acknowledge a known decrement in their driving wellness as possibly a problem for driving safely or, in other words, denial.*

  - In terms of readiness to make an effort to compensate for a driving-relevant functional limitation, the lowest possible level of readiness, which Prochaska, DiClemente, & Norcross (1992) call the precontemplation stage of change, is: "Resistance to recognizing or modifying a problem."

[14] Before such a driver could renew, the driver would almost certainly be referred to the DMV for a reexamination by a physician, law enforcement, or a family member. Priority reexamination cases are reported by law enforcement pursuant to CVC §21061 (drivers referred by law enforcement for committing a traffic violation and giving evidence to the officer of a chronic incapacity to drive safely). Medical cases are reported pursuant to HS §103900 (This law provides for mandatory physician reporting of every patient aged at least 14 whom a physician has diagnosed as having a disorder characterized by lapses of consciousness. Reports of these cases are sent to DMV. The latter group includes many medical conditions, and the reporting law is explicitly written to include Alzheimer's disease and other dementias severe enough to be likely to limit a person's ability to safely operate a motor vehicle.) Such a driver may decide to stop driving as a result of the reexamination referral or before, due to taking responsibility for their severe driving-relevant limitations.

- Extent to which the driver is not fully aware of specific driving conditions or traffic situations that will be made more challenging by their driving-relevant limitations.

- Extent to which the driver is not fully aware of ways of compensating for their driving-relevant limitations.

  - For instance, making three right turns to avoid turning left.

- Feasibility of possible ways of compensating in specific situations.

  - For instance, a one-way street may make it impossible to make three right turns to avoid turning left.

- *Extent to which the driver is unfamiliar with the route.*

  - In a particular situation, it may be unclear which possible ways of compensating are feasible and which are not. To continue the above example, at a unfamiliar intersection the driver may not be able to tell that making three right turns to avoid turning left is not possible due to a one-way street.

  - Coping with an unfamiliar route can overwhelm drivers whose attentional resources are already reduced by cognitive limitations. Marottoli (2008b) offers the following relevant scenario: "'Anyway,' Mr. Wagner continued, 'it was one of those times when I was trying to figure out where we were. I thought I was paying close attention to the road, but somehow I ended up with this minor, but particularly annoying, fender bender. Luckily no one got hurt.'"

- *Extent to which the driver attaches relatively low importance to compensating for the crash potentiating effects of the limitation(s) that the driver has acquired.*

  - Complacency and indifference toward road traffic injuries was identified as the number one key characteristic of the traffic safety culture in the United States in 2007 (Hedlund, 2007).

- *Necessity of driving regardless of known constraints.*

  - For example, there may be a need to carry out essential activities in a timely manner—as in getting to a medical appointment on time—that keeps drivers from avoiding heavy traffic.

- *Intermittent exacerbating environmental conditions.*

  - These may be internal or external distractions, like a sudden, heavy downpour, a fly buzzing around the driver's face, or other kinds of unexpected hazards that could overwhelm a driver, whose attentional resources are already strained, and cause a CDE.

- *Intermittent exacerbating driver conditions.*

  - These may include fatigue, stress, acute physical disturbances, effects of over-the-counter or prescribed medications, and alcohol or illicit drug effects.

  - In Research Report Number 11**,** published by the American Automobile Association in 1939, Earl Allgaier cited this factor as one of the primary reasons why one should *not* expect to find a high correlation between test performance and crashes, noting that:

    > …visual acuity at the time of the accident may not be the same as when tested because such factors as fatigue, health, attention and a host of others may have altered that particular trait. Even within the few minutes while the test is being given the visual acuity of a person will vary. (Allgaier, 1939, page 7)

- *Distraction from attention-demanding technologies.*

  - These need not only be emergent technologies like route guidance systems and real-time Internet services, which have an obvious potential to overload the attentional resources of many drivers. There can be distractions from older technologies as well—such as cell phones, tuning the radio, or finding the right setting for air conditioning**—**that can overload drivers whose attentional resources are restricted by inexperience, cognitive limitations, or other factors.

- *Distractions from other people—either inside, or observable from, the vehicle.*

- *Distractions internal to the driver—mind wandering, lost in thought, and so on.*

The above long list indicates why drivers commonly fail in compensating consistently and adequately for their driving-relevant functional limitations. As noted earlier, these are the factors that moderate the driver's consistency and adequacy in compensating. They are the constraints which amount to *barriers* to safe mobility. There are undoubtedly more; another barrier that might be added to the list is the possibly harmful effect of habit. A driver who has practiced careless driving habits over an extended period of time may find it very difficult, once functional limitations appear, to modify ingrained careless-driving habits in order to compensate consistently and adequately in specific circumstances.

An Overriding Barrier to Maintaining Safe Mobility—*Expecting a Gradual Decline in Functioning with Advancing Age*

Among drivers, physicians and researchers, expecting a gradual decline in *all* driving-relevant functional abilities with advancing age makes for a tall barrier to preserving driving wellness and to consistently and adequately compensating for limitations.

Among Drivers

Many older drivers believe attainment of a specific chronological age *in itself* is a sufficient condition for driving unsafely. Kelsey and Janke (2005) asked drivers age 70 or more who had some, though not many, incidents on their driving records: "Which of the following are signs of diminished capacity for driving safely?" Any number of the three listed possible answers could have been checked:

- Being over the age of 65 (formerly conceived by the authors to be a throwaway distractor).

- Being unable to concentrate.

- Being unable to read ordinary road signs.

Over 85% of respondents in all surveyed groups marked the first alternative, which was the favorite in terms of choice. Being unable to concentrate was felt to be nearly as bad, but inability to read road signs was chosen by relatively few. Expecting a gradual decline with aging often results in elders failing to seek help from health professionals for driving-relevant functional limitations that could, in fact, be corrected, controlled, or at least slowed in their progression. According to Sarkisian, Hays, Berry, and Mangione (2002), geriatricians and gerontologists have documented that older adults frequently attribute their health problems to "old age," which in turn can result in neglect that only worsens the problems. They note that:

> Attributing health conditions to aging has also been associated with greater acceptance of illness symptoms, delays in seeking treatment, less use of preventive health measures, and increased mortality. (Sarkisian et al., 2002, p. 534)

In regards to drivers expecting a gradual and universal decline, Tuokko and Hunter (2002) note that:

> Reviews of the literature, in fact, show that little data support the assumption that older drivers are, per se, unsafe drivers. That is, it is unclear that the effects of age alone adversely impact on driving performance. (p. 83)

Effectively extending the safe driving years of functionally-limited licensed drivers will require that the following *three myths* be debunked among all drivers, *especially the older ones* (Hennessy 2006), as well as *among DMV Field Operations staff:*

- Older drivers are a functionally-unitary group.
  (In the next section we discuss heterogeneity as a hallmark of older populations.)

- "Old age" causes driving-relevant functional limitations.

- "Older" can be used as a sign of diminished capacity for driving safely.

Among Physicians

Problems that arise in old age frequently have numerous subtle physiological causes and may not be medically recognized as "diseases." Physicians themselves may frequently attribute such problems to aging alone, and therefore suggest no remedy.[15] In regards to suggesting no remedy, Marottoli et al. (2007) make the following pertinent observations:

> This study demonstrated that it is possible to maintain or enhance driving performance among older drivers using a safe, well-tolerated physical conditioning program. The availability of such an intervention may change the content and tenor of clinician-patient discussions on this topic from a negative interaction regarding the need to limit or stop driving to a more positive one of possible interventions to prolong safe driving by maintaining or enhancing driving ability. Hopefully, this would increase the likelihood of this important issue being addressed. (p. 594)

Among Researchers

Expecting a gradual decline in *all* driving-relevant functional abilities with advancing age is one of the bases for researchers posing such *age-based* driver-centered questions as:

- Are older drivers a problem?
- Do older drivers pose a threat to the health and safety of other road users (e.g., Langford et al., 2008a; Langford et al., 2008b)?

Posing these questions implies a mistaken interpretation of aging-*associated* "declines" in visual, mental, or physical abilities as aging-*determined* (Rowe & Kahn, 1987; Tuokko & Hunter, 2002). In the descriptive phrase "older driver," the adjective "older" is often mistaken to stand for something (age) that *causes* driving-relevant functional limitations, which in turn are *assumed* to cause CDEs. These questions do not make sense—they are based on incorrect assumptions. "… *old age itself is not a disease* [emphasis added] and as such should not cause health problems…." (Sarkisian, Liu, Ensrud, Stone, & Mangione, 2001). Unfortunately, in

[15] The history of Alzheimer's disease is instructive in this way (Janke, 1994; http://www.medicinenet.com/dementia/article.htm). Dementia in an old person was previously called "senile dementia" and thought to be a condition that unavoidably comes with aging, for which there was no treatment. What was called Alzheimer's disease was considered a "pre-senile dementia"—that is, a dementia that came on before old age. Later the two were recognized as the same disease, a disease that is aging-*associated* but is not to be expected in every aged brain.

posing these age-based *driver-centered* questions and in purportedly carrying out research to answer them, researchers, *and their editors,* necessarily contribute to drivers expecting a gradual decline in all their driving-relevant functional abilities with advancing age. Therefore, researchers and their editors contribute to older drivers' failing to seek treatment and accepting rather than compensating for their driving-relevant functional limitations. For example, in the 2005 Public Policy & Aging Report on Older Drivers, the editor wrote:

> The question of when and if older people should cease driving is both a very private and a very public one. For older people and their families, the need or requirement to give up driving is a painful one. Among the public at large, widespread concern exists about the dangers associated with drivers of advanced age. *Conceptually, the solution to the older driver question lies in a combination of valid determination of when driving cessation must begin* [emphasis added] and the provision of reliable transportation alternatives to those individuals. (Hudson, 2005, p. 2)

In the same volume, Dobbs and Carr (2005; see also Dobbs, 2008) disagree with their editor's premise:

> It is unlikely that the increase in crash rates of older drivers, in comparison to middle-age drivers, is caused by changes associated with normal aging. Rather, the increased crash rates are most likely due to age-associated medical illnesses and the medications used to treat those conditions. As such, it is important that any focus of evaluations for declines in driving competence resulting in an unacceptable crash risk is directed to medical conditions and medications.…Importantly the shift in conceptualization from the older driver to the medically at-risk driver avoids the political backlash of having labeled seniors inappropriately. (Dobbs & Carr, 2005, p. 7)

A researcher who poses age-based driver-centered questions is logically drawn to focus on *average* age-related losses. Such a researcher may not even plot the frequency distributions that underlie the reported mean values (a lack found not only in Hennessy [1995] but also in a plethora of other studies), and thereby largely neglect the substantial heterogeneity of older drivers (Waller, 1991). Ball and Owsley (1991) expressed one possible adverse consequence of focusing on the average:

> In most aging research the average performance of one group (younger) is compared with the average performance of another group (older). Given that the performance of older

> individuals varies to a much greater extent than that of younger individuals, a few debilitated individuals in the older group can significantly alter the group mean. As a result, **some researchers have erroneously concluded that there is widespread, gradual age-related deterioration on most visual, cognitive, and motor functions [emphasis added]**, even though a substantial number of older individuals have experienced no (or only minimal) age-related declines. (p. 584)

The Transportation and Aging Interest Group of the Gerontological Society of America, even more pointedly, has recently written about aging in relation to driving (Dickerson et al., 2007, p. 579):

> As older drivers have come under increased scrutiny, it has become apparent that it is not age, per se, that leads to problems with driving. Rather, declines in driving-related abilities are primarily the result of medical conditions (such as Alzheimer's disease and Parkinson's disease), other health problems, or the medications used to treat those conditions (Dobbs & Carr, 2005). Although these medical conditions can occur at any age, they are more likely to occur as one becomes older. At the same time, not all drivers experience these declines in the same way or even at all. … Based on these insights, two complementary but interdependent goals have emerged with respect to older drivers: ***to help those who are able to drive safely continue to do so*** [emphasis added]; and to identify and provide community support to those who are no longer able to drive. (Molnar, Eby, & Dobbs, 2005)

These insights and goals have been incorporated into AARP's *Promising Approaches for Promoting Lifelong Community Mobility* (Molnar et al., 2007).

Follow-up to Age-Based *Driver-Centered* Questions & Answers— Two Kinds of Logical Errors

Logical Errors

In posing and answering age-based *driver-centered* questions, the drivers comprising any age-based grouping are treated as though they are all functionally unitary. Treating older drivers, teenage drivers, the drivers who use bioptic telescopic lenses, or the drivers making up any outwardly-identifiable group that is perceived as a problem as though they are all functionally

unitary, and therefore, all equally lacking in the qualities necessary for safe driving is a common way of streamlining our thinking. Unfortunately, such streamlined thinking is predicated on an **ecological fallacy**—erroneously assuming that all members of the aggregate exhibit the characteristics of the aggregate at large (Robinson, 1950; typically the mean)—which in the case of age-based grouping is itself based in multiple **amalgamation errors**—aggregating two or more functionally disparate groups (cf. Gould's [1996] exposition). The following example, based on Hennessy (2004), illustrates the making of these two logical errors:

> I've just completed a large scale study in which I measured the best-corrected visual acuity of people sitting in California ophthalmologists' waiting rooms. Their mean visual acuity works out to be 20/60. As I expected would be the case, the people populating ophthalmologists' waiting rooms fail to meet the California DMV 20/40 visual acuity screening standard.
>
> With my expectation confirmed, I did no further analyses, and therefore, did not discover that fully one-half of the people that I sampled in California ophthalmologists' waiting rooms had a best corrected visual acuity of 20/20—the designated drivers who will drive the patients home. The other half—the patients—all had a best-corrected visual acuity of 20/100. None of the people sampled in ophthalmologists' waiting rooms were even close to having the overall 20/60 average visual acuity.

Lumping together the functionally disparate designated drivers and the patients is an obvious amalgamation error—in this example, the 20/60 mean visual acuity of people sitting in ophthalmologists' waiting rooms is clearly what Gould (1996, p. 35) has called an "artifact produced by amalgamating two entirely different subpopulations." Attributing the 20/60 mean for the aggregate to *all* the people sitting in ophthalmologists' waiting rooms is clearly erroneously assuming that all the members of the aggregate exhibit the characteristics of the aggregate at large—an ecological fallacy.

Adverse Consequences of Lumping Together All the Older Drivers

Lumping together all older drivers and treating them as though they are *equally lacking* in the *qualities necessary for safe driving* is as much a case of an ecological fallacy (based in multiple amalgamation errors) as is the one in the above illustration. As alluded to above, variability is a hallmark of older drivers; researchers have found that as we age, we become increasingly different from one another in our visual, mental, and physical abilities. The concept of

"differential aging" has been used to highlight the heterogeneity observed in older populations, to summarize the varieties of aging phenomena, and to point to individual differences in intra-individual change (Smith & Gerstorf, 2004). Calculating a mean test performance value or a traffic collision mean for a group of older drivers, which typically involves amalgamating elders who have, to use the words of Ball and Owsley (1991), "experienced no (or only minimal) age-related declines" with "debilitated" elders—whatever their relative frequency may be—is a fundamental, and unfortunately, common amalgamation error. As indicated earlier, a common ecological fallacy following from this amalgamation error is erroneously concluding that with aging there is an inevitable gradual decline in *all* driving-relevant functional abilities. It is this fallacious reasoning that drives misguided age-based driver-centered questions as well as misguided age-based licensing policies.

Screening Drivers for Constraints on Consistently and Adequately Compensating

Given the many barriers to safe mobility (pp. 35-39), *fully* achieving the goal of extending functionally-limited drivers' safe driving years while at the same time improving road safety will require the development of a formal means of screening drivers for the specific factors (barriers) that constrain them from adequately and consistently compensating. For example, this may include a computer-based Driving Information Survey (see Appendix A). After identifying a driver's specific barriers, focused work can *begin* on lowering these barriers by systematically applying *relevant* safe-mobility interventions. Interventions will be directly linked to constraints on compensating rather than drivers' limitations per se. These future work processes will require *developing* and *training* DMV staff in regularly using a sophisticated conditional licensing program—probably computer-based. Developing and using such a conditional licensing program will require the DMV to partner with driving-knowledgeable physicians (Wang, et al., 2003), driving-rehabilitation specialists (Baldock, 2008; Wheatley & DiStefano 2008), and possibly others.

Better Assessing Driving Wellness —Driving-Centered Assessment

Fundamental Driving-Centered Question

This study addresses the following fundamental driving-centered question:

> How can the DMV better *identify* and *assess* licensed drivers of any age who have acquired a driving-relevant functional limitation(s) (decrement(s) in driving wellness) so that the DMV, together with physicians, driving-rehabilitation specialists, and others can aid such drivers, if feasible, in driving safely by referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting (conditional licensure), and so on? (see pp. 4-5 & p. 25)

Assessing driving wellness has always been a *driver*-centered concept. An approach to assessment that is fully *driver*-centered is without regard for how the driver might interact with his or her customary driving environments/conditions; it is without regard for when, where, why, and how the driver actually drives. As indicated above, when measuring a decrement in driving wellness one does not typically take into account the interaction of the driver with his or her everyday driving environments/conditions. *But this need not be the case*. In keeping with an ecological perspective, we develop an approach to assessing driving wellness that is *driving*-centered**.**

Theoretical Backdrop to DMV Making a *Driving-Centered* Assessment of Driving Wellness

McKnight (2003) asserted that "it is the small number of older drivers with severe deficits who tend to be involved in accidents" (p. 28). But from an ecological perspective, the *driver*-centered assumption that the most functionally-limited drivers will be the most crash-involved is highly questionable (see pp. 27-29) unless the deficits are so severe that the "driver" does not meet absolute standards (see footnote #5, p. 6), and so, will be unlikely even to attempt driving.

When functional limitations are great, licensed drivers are probably *least* constrained from adequately and consistently compensating for their limitations. Unless the functional limitations of these drivers have affected their judgment, as in many cases of moderately advanced dementia, they are more aware of their functional limitations, more knowledgeable of ways in which their limitations can affect their driving, better at recognizing the types of driving

conditions that are made more challenging for them by their limitations, and more knowledgeable of ways of compensating. Generally, drivers whose functional limitations are great compensate by restricting themselves to *familiar and well-practiced routes* near home. They likely avoid a wide variety of driving tasks, conditions, and situations which experience has taught them pose excessive challenges to their driving-relevant abilities or simply make them uncomfortable (e.g., Hennessy, 1995; Owsley, Stalvey, & Wells, 2001; Owsley, Stalvey, & Phillips, 2003). *This avoiding and self-restricting has the effect of reducing the quantity of their driving which in itself also reduces their level of exposure to crash risk.* As a group, extremely functionally-limited drivers are expected to *generally* have a relatively high "degree of driving fitness" (consistently small level of risk for making a real-world CDE) *together with* their low "degree of driving wellness." Thus, the *proportion* of drivers crashing among the extremely functionally limited is expected to be *low*[16].

On the other hand, the proportion of drivers crashing is predicted to be at its highest among those who have only one marginally-limited driving-relevant functional ability. Such drivers will be called ***somewhat* functionally limited**. With the onset of the first decrement in driving wellness, commonly a reduction in contrast sensitivity, *this decrement will likely "substantially" diminish driving fitness on an intermittent basis* as illustrated earlier with the crosswalk example (p. 29). Somewhat functionally-limited drivers will generally be *highly* constrained from compensating for their *intermittent fitness-diminishing limitation* due to a lack of awareness of it. Consequently, they will not be aware of its impact on their driving or what can be done to compensate for it. Some evidence for this was noted in a study evaluating renewal by mail (RBM) for drivers who lacked clean driving records and were under age 70 (Janke, 1989). According to this author:

> It could . . . be argued that drivers in an age range—say, the forties—at which visual and possibly other bodily functions *begin* to decline significantly, are most harmed by being excused from renewal testing. ***Such drivers may be impaired to some degree and not yet be aware of their impairment*** [emphasis added]. There is some evidence to support this view. (p. 8)

[16] As will be seen on pages 50 & 57-57, this prediction is an integral part of the criteria that will need to be satisfied in validating a way for the DMV to make a driving-centered assessment of driving wellness. In stating and evaluating these criteria, crash record is used as a criterion/outcome variable, not as an indicator of an *individual's* driving fitness. Therefore, this moderator-based prediction for extremely functionally-limited licensed drivers *as a group* does not contradict our earlier statement (p. 33) that "neither a clean record nor a crash history can be used *alone* as a reliable indicator of whether a particular driver's level of risk for making a real-world CDE is or is not *currently* consistently small."

The evidence referred to above came both from Janke's 1989 RBM study and from an earlier study of two RBM programs for clean-record drivers (Kelsey, Janke, Peck, & Ratz, 1985). Kelsey et al. found that the *largest **increase** in subsequent crashes attributable to each of the two RBM programs* was for drivers aged 30 to 50. Janke (1989) found that middle age drivers with prior crashes or traffic convictions on their records, when offered RBM, had 8.5% more subsequent crashes than their randomly selected controls, who were similarly RBM-eligible and of the same age, but were not given the opportunity to renew by mail. This was not true for the other age groups, where functional limitation is *much less common*—in the younger drivers, and where it can be *more serious, long-standing, and apparent*— in many of the older drivers.

If the crash rate for the somewhat functionally limited, *as a group*, proves to be *higher* than that for the extremely functionally limited, as hypothesized, then the somewhat functionally-limited *drivers' intermittent substantially-diminished driving fitness* (intermittent high level of risk for making a CDE) would be another reason *not* to expect a *linear* (straight line) relationship between measures of driving-relevant functional ability and crash involvement. Shinar & Schieber (1991) listed seven reasons—including compensating—to expect at most a weak linear relationship. From an ecological perspective, one would expect to find a stronger and more positive linear (straight line) relationship between measures of functional limitation and crash involvement **when extremely functionally-limited drivers are *excluded* from the analysis,** leaving only those with no driving-relevant limitations and those who are at most only *somewhat* functionally limited. Data summarized in this report are consistent with this expectation.

In contrast to the situation for crashes, it was hypothesized that an *opposite* result would be found in the case of DMV office-based structured road tests. Structured road tests are commonly given in geographic areas that are unfamiliar to many examinees. Therefore, many examinees cannot anticipate the locations and types of potential hazards that are typically encountered on the test routes. Furthermore, a structured road test is what Näätänen and Summala (1976) term a "forced-pace task." As these authors note, the tested driver is forced into a "responding role in his interaction with the traffic environment rather than a more active one in which many situations are 'created' by the driver" (p. 114). In taking a structured road test, the driver must obey the instructions of an examiner and cannot modify the driving task to make it less challenging. For example, if told to change lanes in preparation for a left turn at a particular intersection, the driver must change lanes and soon afterward make the turn. However, given the driving task demands involved, the driver might greatly prefer to drive past that point and then make a protected U-turn or three right turns in order to go in the direction indicated. This consistently high constraining of compensating on a structured road test is represented in

Figure 2 by the box marked with dashed lines. Due to consistently high constraints on adequately compensating for driving-relevant limitations during a structured road test, the driver can only weakly moderate the relationship between his or her degree of driving wellness and his or her level of risk for making a critical driving error. Consequently, most drivers who are *extremely* functionally limited will likely fail a structured road test by making a structured-CDE (see Appendix G for examples). On the other hand, due to following three reasons, most of the drivers who are only *somewhat* functionally limited are expected to pass a DMV office-based structured road test:

- The low to moderate driving-task demands.
- The low to moderate demands of the driving environments/conditions typically encountered on a road test. For example, there is ordinarily no road testing in heavy traffic, at night, or in inclement weather.
- "Perfect storms[17]" are not represented on a DMV office-based structured road test.

Data summarized in this report are consistent with these expectations.

[17] The convergence of factors that might intermittently substantially diminish a somewhat functionally-limited driver's driving fitness.

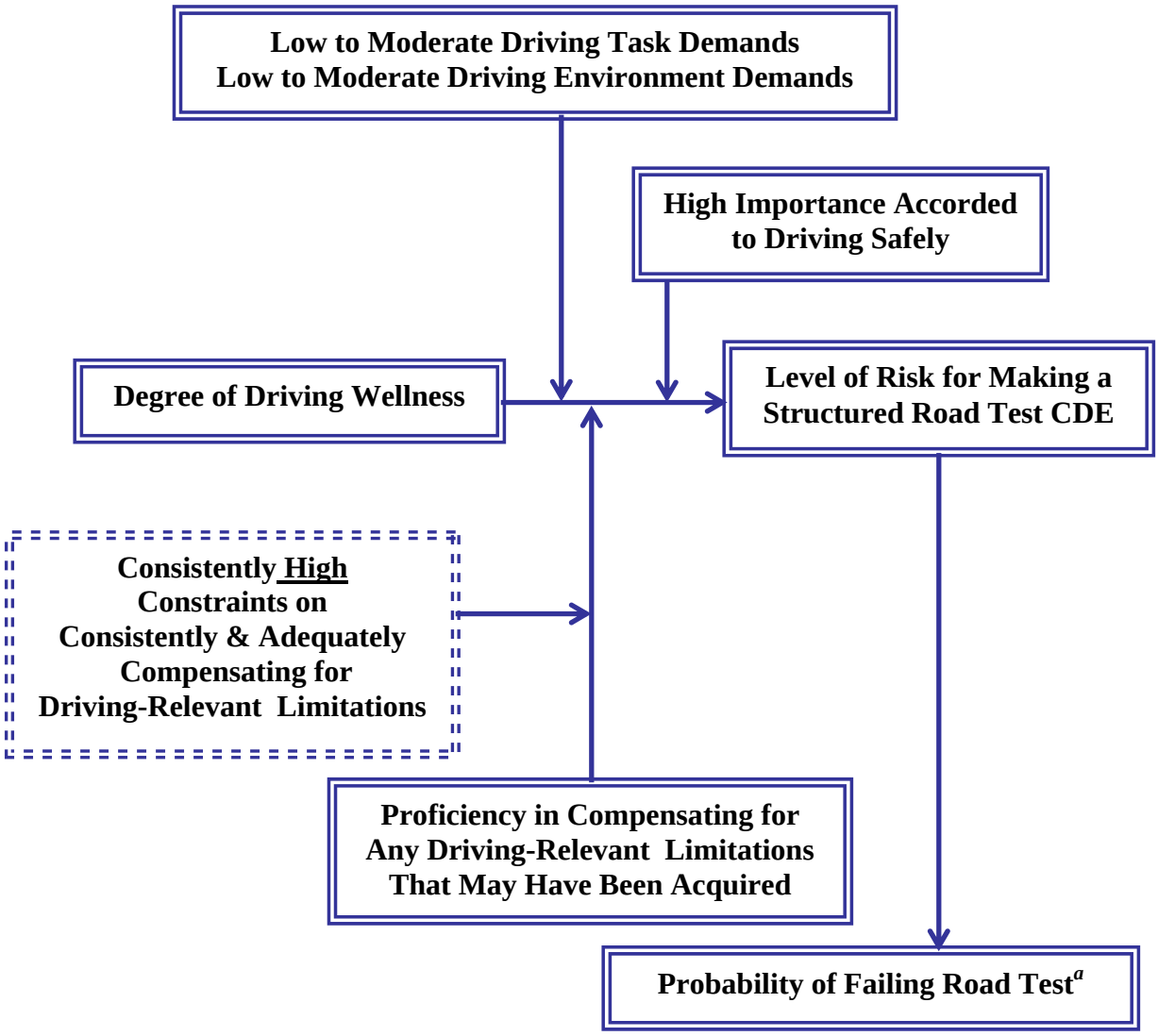

Figure 2. Ecological perspective on the nature of the relationship between the driver's degree of driving wellness and the level of risk for making a structured-CDE on a structured road test. (See Appendix G for examples of structured-CDEs.) The consistently high constraining of compensating on a structured road test is represented by the box marked with dashed lines. Compare with Figure 1.

[a] The road-test examiner generally prevents a CDE from resulting in an adverse driving event other than failing the test.

DMV Making a Driving-Centered Assessment of Driving Wellness

If the driving-centered expectations outlined above are empirically confirmed, then it follows that one way for the DMV to make a driving-centered assessment of driving wellness would be

to sort drivers into three approximately *functionally-unitary* categories. These approximately functionally-unitary categories and their definitions would be:

- Driving Well—free from driving-relevant functional limitations.

- Somewhat Functionally Limited—one marginally-limited driving-relevant functional ability.

- Extremely Functionally Limited—two or more marginally-limited driving-relevant functional abilities and/or one or more severely functionally-limited driving-relevant functional abilities.

The drivers in the three categories are approximately *functionally unitary* with respect to their level of driving-relevant limitation(s) and their level of awareness of their limitation(s) in the case of the latter two categories.

As indicated in Table 1 (p. 8) the **primary objective of identifying somewhat functionally-limited drivers**, since they are hypothesized *as a group* to have the highest crash rate due to limitation-naivety, is to educate them about (1) their specific limitation, (2) the types of driving conditions that are made more challenging for them by their limitation, and (3) ways of compensating for their respective limitations that cannot be corrected or remediated. Such an education intervention may take various forms, for example, a DVD-based presentation and/or behind-the-wheel refresher training.

The **primary objective of identifying extremely functionally-limited drivers** is to follow-up the initiation of relevant safe-mobility interventions with an *on-road assessment of whether they are driving fit.* These drivers should be given a choice between the DMV's SDPE (DMV *office-based* supplemental driving performance evaluation—meant to evaluate the driving abilities of experienced drivers who have acquired a driving-relevant limitation since their initial licensure) and a content-valid ADPE (area driving performance evaluation—the department's customized road test administered in a limited and familiar area around the driver's home). The ADPE is mainly, although not exclusively, administered to severely functionally-limited drivers whose compensating strategies likely already include restricting themselves to familiar and well practiced routes and taking only necessary trips close to their home. By road testing extremely functionally-limited drivers when and where they customarily drive (this would include

infrequent though important regular destinations), one can estimate whether they can consistently and adequately compensate for their limitations and, therefore, truly estimate whether their level of risk for making a critical driving error can be expected to be consistently small in their *customary* driving environments/conditions and for their customary driving practices. Requiring extremely functionally-limited drivers *who have already restricted themselves to familiar and well-practiced routes* to take the office-based SDPE, which is generally given in an area that is unfamiliar to the examinee, would *not* be a driving-centered estimate of whether such a driver is driving fit. The SDPE would *not* be appropriate for them—it would *not* be content valid.

Before administering an ADPE, the examiner would meet with the driver and determine the times, places (routes or areas), and conditions for a *content-valid* ADPE. As noted above, a content-valid ADPE must include infrequent though important regular destinations. With the implementation of a 3-Tier Assessment System, during this initial meeting with the driver and immediately after the ADPE, the examiner would be charged with initiating relevant safe-mobility interventions (referring for physician-based evaluation and treatment, educating about driving-relevant limitation[s], recommending behind-the-wheel training, restricting [conditional licensure] and so on, see pp. 4-5 & p. 24). [18] Repeating a *failed* content-valid ADPE would be contingent on the applicant demonstrating or providing DMV with certification of s*uccessful* completion of the relevant interventions identified by the examiner (see description of Brainin's [1980] model licensing system on pp. 10-11). In order to be licensed, extremely functionally-limited drivers would be required to demonstrate that they can *reliably* negotiate the routes or areas specified for the ADPE during the specified times and under the specified conditions without making any of the SDPE structured-CDEs[19] (Appendix G). As will be seen in Table 13 (p. 105), the passing criterion, "without making any of the SDPE structured-CDEs," is consistent with failure of the SDPE which is almost always due to a structured-CDE. Drivers passing a content-valid ADPE would have their driving restricted appropriately to the specific times, places, and conditions under which they have demonstrated an acceptable level of driving fitness. Just as with the SDPE, in ADPE-based licensing there would be **no attempt to balance a driver's mobility needs with road/public safety** (cf. Arno & Boets, 2004, pgs. 7 & 41; Staplin & Hunt, 2004, p. 69)[20]. As noted earlier (p. 26), maintaining a low level of risk for

[18] As indicated earlier, in initiating a safe-mobility intervention a DMV may or may not involve itself in actually administering the intervention.

[19] Making a large number of important, but *not* technically-critical driving errors, would also indicate that the driver *cannot reliably* negotiate the routes or areas specified for the ADPE during the specified times and under the specified conditions without making any of the SDPE structured-CDEs.

making a real-world CDE, that is, driving safely, is integral to maintaining safe mobility. If functional limitations worsen (e.g., as indicated by DMV assessment results on future renewals or as reported by a physician before the end of the prescribed renewal term), and the driver continues to meet absolute standards for licensure (see footnote #5, p. 6), subsequent ADPEs would be necessary and the window of approved driving times, places, and conditions would diminish until, ideally, both the driver and DMV together realize that driving safely is no longer feasible. This is consistent with the U. S. Department of Transportation's (1997) statement that:

> It is in the national interest to keep people operating their personal vehicles as late in years as possible for quality of life reasons; yet we do not want that operation to unnecessarily endanger the individual or the public. (p. ix)

Operationalizing "Driving Well," "Somewhat Functionally Limited," and "Extremely Functionally Limited"

"Driving well," "somewhat functionally limited," and "extremely functionally limited" are constructs that, in order to be useful, must be translated into valid operationalizations. That is to say, practical—operational—working definitions need to be developed and then validated. The logic and steps followed in operationalizing these three constructs are summarized below. The next section presents the logic followed, in the present study, in validating them.

Consistent with the general agreement of the International Older Driver Consensus Conference on Assessment, Remediation and Counseling for Transportation Alternatives (Stephens, et al., 2005), it was deemed necessary to separately assess each of the three primary driving-wellness domains in order to operationalize the three constructs. These domains are driving-relevant visual ability, mental ability (includes knowledge of safe driving practices and knowledge of the laws and rules of the road), and physical ability. The phrase "physical ability" refers here to those locomotor/manipulative abilities necessary for operating vehicle controls. Assessment of these three driving-wellness domains must be operationally feasible. Here, the judgment of

[20] This is not to deny that in operationalizing 3-Tier there would be no subtle prioritizing of mobility over safety or vice-versa. For example, even though repeating a *failed* content-valid ADPE could be made contingent on the applicant demonstrating or providing DMV with certification of s*uccessful* completion of relevant interventions, one might ask: Should an applicant be limited in how many attempts they are permitted to pass an ADPE? Is so, how many? The answers to these questions will be influenced by a prioritizing of mobility over safety or vice-versa.

operational feasibility includes a consideration of the time and effort involved in administering a new AT and the time and effort involved in training DMV staff to administer the new AT.

Based on a literature review (Janke, 1994) and pilot studies in DMV field offices (Hennessy, 1995; Janke & Hersch, 1997, Janke & Eberhard, 1998; and Janke, 2001), a final selection of possible ATs was made. Three chart-based tests of contrast sensitivity were available and judged useful for measuring visual ability. A simple rote memory task (measured by recall from long-term memory) was used to assess what may be termed "rote-memory failure"; rote memory in this case was measured by recall of birth date and social security number (SSN). (Another memory task, the DMV written knowledge test, assesses rote memory by the less-demanding measure of recognition rather than recall.) Partly because declining rote memory and judgment are common in the moderate to severe stages of Alzheimer's disease, another task was explored that involved both memory and judgment. In this memory/judgment task, a diagram of an intersection with signs such as "no left turn" and "do not enter" and the question, "If you stopped at this intersection at X (marked on diagram) and saw these signs, what could you do?" was used to prospectively screen for the degree and kind of memory and judgment needed in driving. Additionally, unobtrusive structured observations of physical (locomotory, manipulatory) functioning were used for assessing the adequacy of the driver's ability to use foot- and hand-operated vehicle controls. These were similar to functional ability scales used by other authors and in other states (e.g., Janke & Hersch, 1997; Florida, Utah, Wisconsin). Finally, ways used in this study for measuring driving-relevant attentional/cognitive abilities included computer-based tests of visual information processing and visual search.

The department's current Snellen test of visual acuity, one test of contrast sensitivity, all of the structured observations for physical limitations, and a brief cognitive screen were originally slated for Tier 1 of the prospective 3-Tier driving-centered assessment system. Tier 1 was envisioned as being rather brief and very easily administered. An AT that would seemingly have fit naturally on Tier 1 but had to be slated for Tier 2 was the department's current written knowledge test of safe-driving practices and the laws and rules of the road. This is because a departmental decision was made to automate the knowledge test; thereafter, it more naturally fit with the computer-based AT(s) that was projected to be in Tier 2. In an operational system, driver-license-renewal candidates successful on Tier 1 would merely go on to take the knowledge test on Tier 2. Licensure is contingent on the driver's *passing* the knowledge test; if necessary, the knowledge test may be taken up to three times on one application. Driver-license-renewal candidates who were unsuccessful on Tier 1 would take the selected computer-based test(s) of attentional/cognitive abilities on Tier 2. Drivers who were successful on Tier 1, but

failed the knowledge test two or more times before passing it, would also be required to take the selected Tier 2 computer-based AT(s).

As indicated in the previous sections, determining whether a driver-license-renewal candidate should be further assessed on the road and determining whether safe-mobility interventions should be initiated depends on the driver's degree of driving wellness, as inferred from AT performance. In order to make a *driving-centered* assessment of driving wellness, two cut scores were developed for ATs that yielded a range of scores as opposed to pass vs. fail. Two cut scores were necessary because, for each measured ability, "extremely functionally limited" needed to be distinguished from "somewhat functionally limited" which in turn needed to be distinguished from "driving well" (see Methods).

Staplin et al. (2003) also called for the development of two cut scores for driver ATs that yield a range of scores. However, these researchers' driver-centered rationale for developing two cut scores is just the opposite of the driving-centered view presented above. They offered the following reasoning for identifying what they term a "prevention threshold" and an "intervention threshold":

> Individuals having the highest priority for further evaluation are those who not only score below the "prevention threshold," but also fail to perform at or above the lower cutpoint, or "intervention threshold." This cutpoint connotes a more advanced stage of decline on one or more functional measures, where immediate diagnostic testing is necessary for the protection of both the individual and the general public, and the risk of driving impairment is high. (Volume I, p. 35)

Thus Staplin and his co-authors, despite their use of a crash criterion, recommend further evaluation for the most seriously limited as having a higher priority than evaluation of the moderately limited. Their recommendation is inconsistent with the findings of this study on crashes (detailed below).

The Snellen and knowledge tests were not included in this process because licensure is contingent on passing, or at least performing acceptably, on both. Drivers failing the department's Snellen test are referred to their vision specialist of choice, who in most cases is able to correct the driver's acuity to an acceptable level; if not, a road test can determine whether the person should be licensed to drive.

Since only a subset of the different possible ATs were intended for inclusion in the final 3-Tier system—for example, only one of the three chart-based tests of contrast sensitivity studied—different logical combinations of the ATs were quantitatively compared with one another in such a way that the most useful combinations were revealed. So-called "false negatives" and "false positives" were minimized by maximizing sensitivity and specificity (see Results and Discussion).

The final selection of a combination of ATs included a consideration of the ATs' time and cost to DMV staff and customers, field-office operational feasibility, resistance to learning effects, and their face validity. In order for an AT to be operationally feasible, it had to be acceptable "on its face" (looks like it is relevant to driving safely) to both customers and staff. In general, if new DMV ATs are not considered to be relevant to driving safely, they will be challenged by customers and will tend to be poorly administered by staff. In the present study, face validity was assessed by asking study participants and staff the following four questions about test acceptability:

- In your opinion, is this a good test?
- Were the instructions easy to understand?
- Do you think that this test would help DMV predict which people might have trouble driving?
- Do you think it would be fair to give drivers this kind if test to see if they should get restrictions on their license?

The answer choices for each question were "Definitely No," "Probably No," "Probably Yes," and "Definitely Yes."

Validating the Three Operationalizations for Making a Driving-Centered Assessment of Driving Wellness

Validating the three operationalizations will be defined as evaluating the extent to which the constructs of driving well, somewhat functionally limited, and extremely functionally limited

were successfully translated into operationalizations that are useful for making a driving-centered assessment of driving wellness. Specifically, the validity of the three operationalizations was evaluated using a technique called outcome pattern matching (e.g., Trochim, 1985, 1989). In outcome pattern matching, one assesses the extent to which an obtained outcome pattern matches an expected outcome pattern. As discussed above, we hypothesized opposite outcome patterns for performance on a structured road test and real-world adverse-driving events (here, crashes). *The observance of such opposite patterns would serve to validate the three operationalizations, according to pattern-matching logic. Hypothesizing opposite outcomes as a function of limitation severity yields a pattern which "if corroborated, provide[s] a stronger basis for valid inference"* (Trochim, 1989; p. 355).

The hypothesized *opposite-outcome model* yielded four key comparisons. Together, these four comparisons serve to evaluate the extent to which the obtained outcome pattern matches the expected outcome pattern. In the following statements of the four comparisons, the model components are rendered as four hypotheses.

- Compared to driver-license-renewal candidates assessed as extremely functionally limited, renewal candidates assessed as driving well are substantially *less likely* to make a structured-CDE on an office-based structured road test (for examples of structured-CDEs see Appendix G).

- Compared to driver-license-renewal candidates assessed as extremely functionally limited, renewal candidates assessed as somewhat functionally limited are substantially *less likely* to make a structured-CDE on an office-based structured road test.

- Compared to driver-license-renewal candidates assessed as driving well, renewal candidates assessed as extremely functionally limited are *no more likely* to have been crash-involved in the prior three years.

- Compared to driver-license-renewal candidates assessed as extremely functionally limited, renewal candidates assessed as somewhat functionally limited are substantially *more likely* to have been crash-involved in the prior three years.

Two Null Hypotheses

The two study null hypotheses are: Functional categorization of driver-license-renewal candidates as "driving well," "somewhat functionally limited," or "extremely functionally limited" on the basis of their 3-Tier AT performance on Tiers 1 and 2 is not associated with, nor predictive of, either (1) SDPE failure or (2) real-world crash involvement.

Recommendations

This report concludes with detailed recommendations for statewide implementation of a 3-Tier driving-centered assessment system. As noted above, the first two tiers (non-driving ATs) assess drivers' degree of driving wellness, while the third tier (content-valid road test) estimates drivers' adequacy and consistency in compensating for any driving-relevant functional limitations that may have been identified on the first two tiers.

METHODS

The Methods are divided into 11 major sections:

- Data Collection Phases & Locations.
- Assessors.
- Non-Driving Assessment Tools (ATs).
- Participant Selection and Processing.
- Tier 1 Assessment Procedures.
- Tier 2 Assessment and Retention Procedures.
- Tier 3 Assessment Procedures.
- Operationalizing: Plan for Developing Two Cut Scores for the ATs that Yield a Range of Scores.
- Operationalizing: Scoring Procedures and Combining the Results of the Novel ATs.
- Comparing Alternative AT Combinations.
- Validating: Statistical Analyses of Outcome Pattern Matching.
- Study Limitations.

Data Collection Phases and Locations

Driving-centered assessment of driving wellness was conducted in two phases, each phase involving two different southern California Department of Motor Vehicles (DMV) field offices.

(The public goes to field offices in order to apply for driver licenses, register vehicles, etc., when their transactions cannot be accomplished by mail or online or when they simply prefer to.)

First-phase offices were Santa Monica and Costa Mesa, and second-phase offices were Van Nuys and Pasadena. These offices are all fairly large, with Santa Monica, Costa Mesa, and Van Nuys conducting 150,000 to 275,000 transactions per year, and Pasadena conducting more than 275,000 transactions per year. Data collection ran from July 16 through December 31, 2001 for the first phase and from February 11 through July 31, 2002 for the second phase.

Assessors

Three Motor Vehicle Field Representatives (MVFRs), working within the study offices and administering non-driving tests, and two Licensing/Registration Examiners (LREs), administering the road test, were chosen to serve as the study assessors. In preparation for administering study tests, the MVFRs were given 3 consecutive days of onsite training by the first author and on-site assistants. The LREs had already been trained in, and had frequently administered, the road test used in this study, DMV's Supplemental Driving Performance Evaluation (SDPE). Nevertheless, the DMV Training Branch provided them with 5 days of off-site refresher training to enhance their scoring reliability. In addition, the first author gave each study LRE 3 consecutive hours of on-site training in processing study participants and recording their data.

The MVFRs and LREs assigned to the 3-Tier study served throughout the duration of the study activities at their particular field office. They were recommended by their management on the basis of their experience, professional demeanor, enthusiasm for the study, excellence in public relations, and commitment to public safety.

Non-Driving ATs

Two non-driving ATs have long been used at DMV for licensing and relicensing drivers: the Snellen test and the knowledge test.

Snellen Test

The Snellen test is a modified Snellen "wall" chart which is typically hung from the ceiling. It contains five lines of 20/40 letters and is used to screen for best-corrected high-contrast 20/40 visual acuity in both eyes together and in each eye separately. Depending upon space constraints, the DMV uses Snellen charts designed to be viewed at a distance of 10, 15, or 20 feet (3.048, 4.572, or 6.096 m). In the past, customers failing the Snellen chart then took an Optec 1000 Checkerboard Slide test, but as a consequence of later research (Hennessy & Waters, 1998) which indicated that successful guessing and cheating on the Optec 1000 test could be minimized with a Snellen letter slide, Snellen failure is now followed by assessment using a Snellen letter slide. This slide allows testing at four different acuity levels and is presented in a Stereo Optical Optec 1000DMV-CA viewer at optical infinity and under optimal lighting conditions. Failure of this Snellen slide test following failure of the Snellen wall-chart test equates to failure of the department's vision screening process.

Among states in the US, acuity is the visual function most commonly screened for licensure. As pointed out by Owsley, Stalvey and Wells (2001), this seems paradoxical given that research generally does not support the conclusion that acuity tests can effectively identify "high-risk drivers." This apparent paradox has been recognized for many years, following the seminal work of Burg (1967). In an unpublished paper, Janke (1986) pointed out that the licensing/relicensing process, which in California includes renewal acuity testing, has already affected the *range* of visual skills possessed by drivers on California highways. This is not only because some people cannot pass the acuity requirement for driving and others are discouraged from trying, but also because the process alters still others. These individuals may, for example, be influenced to get corrective lenses or cataract surgery. Other reasons for the apparent paradox mentioned in the 1986 paper include drivers not needing in many situations to see clearly to avoid a crash and many drivers with extreme acuity loss choosing not to drive.

Knowledge Test

The knowledge test (often referred to by DMV staff as the "law test") is almost always given in written form as a multiple-choice test on safe-driving practices and traffic laws; it contains 18 questions for renewal-license applicants (36 questions for original applicants). DMV administers the knowledge test at the end of the renewal process; by that time a photograph of the true applicant has been taken and can be compared with the person submitting an answer sheet, to deter fraud. If a DMV customer is required to take a road test, it comes directly after, and is

usually contingent on, the customer passing the knowledge test. However, the 3-Tier study protocol specified that, for study purposes only, the written knowledge test was always to be given *after* the SDPE. Written instructions to study staff were as follows:

> In order to minimize getting biased data it was determined that the Law test needs to be always administered after the SDPE. Here's why. If the Law test is given before the SDPE we run the very real risk of chilling the study participant's performance on the SDPE due to poor performance on the written test. It would not matter whether the customer was given their law test score. We have all experienced thinking that we did poorly on a test before finding out how well we really did. We also risk the LREs being naturally negatively biased against a study applicant that did poorly on the written test. Both of these sources of possible bias apply to both renewals and road-test referrals.

Please note here, consistent with assessing non-3-Tier driver-license-renewal candidates, renewal-study participants were told that they were *not* required to pass the SDPE in order to renew their license—they were required to pass the knowledge test.

Results for the knowledge test were analyzed and appear in the Results and Discussion Section.

Experimental Non-Driving ATs

Non-driving ATs in the present study included the Pelli-Robson chart (Pelli, Robson, & Wilkins, 1988), which tests contrast sensitivity (Tier 1 service-counter AT); two other tests of contrast sensitivity, FACT and SKILL, which are described briefly below (Tier 2 testing-room AT); the automated measurement of Perceptual Response Time or Processing Speed, which is the first module of the UFOV or Useful Field of View test (Owsley, Ball, Sloane, Roenker, & Bruni, 1991) and is here called PRT (Tier 2 testing-room AT); and Auto-Trails, an automated modification of Reitan's (1958) Trail Making test, Part A, which was developed by Dr. Frank Schieber of the University of South Dakota (Tier 2 testing-room AT). Auto-Trails was given twice, once in a forward and once in a backward direction. Study participants were also required to complete a Driving Information Survey (summarized below and shown in Appendix A).

In addition to the non-driving ATs mentioned above, the study MVFR used an observation checklist to make a series of unobtrusive structured observations beginning with the customer's approach to the service counter, and also administered a brief cognitive screen (see Appendices

B, C and D for a detailed description of these Tier 1 service-counter ATs). The following possible structured observations were on the checklist and marked by the MVFR if applicable:

- Unable to walk if not aided.
- Full or partial loss of use of leg or foot.
- Obvious and excessive shaking of lower body.
- Obvious and excessive stiffness of lower body.
- Failure to follow directions.
- Someone is assisting customer in completing forms and/or answering questions.
- When asked, customer did not recall birth date.
- When asked, customer did not recall social security number.
- Failed to indicate correct solution of intersection problem (described below).
- On intersection problem, did not respond within 1 minute.
- Full or partial loss of use of arm or hand.
- Obvious and excessive shaking of upper body.
- Obvious and excessive stiffness of upper body.
- Other impairment.

A word should be said about the items on the checklist that involved questioning the customer. The MVFR, while still holding a customer's paperwork, told him or her "I need to verify some of your driver-record information." This was followed by "What is your birth date?" and "What is your social security number?", information that appeared on the MVFR's computer monitor. Study participants did not know in advance that they would be required to complete these simple

rote-memory tasks, which precluded any rehearsal—though presumably no rehearsal would have been needed for birth date, since none of the study participants missed it. If recalling the SSN is eventually part of an operational 3-Tier process, applicants will become increasingly aware of the task, likely leading to rehearsal. In the future, rehearsal effects can and should be evaluated.

Customers were next shown a sheet that contained a diagram of an intersection containing an X at the entry point and signs such as "no left turn" and "do not enter" (Fitten et al., 1995, Appendix D**).** To introduce it, the MVFR announced, "This is a new question that we are trying out for the written test. If you stopped at this intersection at X and saw these signs, what could you do?" As the customer looked at the diagram, the MVFR started timing his or her oral response; possible answers were presented to the customer in written form using a multiple-choice format. Both an incorrect answer and a response latency of more than a minute were considered failures. The rationale for this question was discussed earlier on p. 54.

One AT that was very promising in a study described by Janke (2001) was used briefly in the present study but could not be retained because intermittent equipment problems made it unreliable. This was a PC-based version of Doron Precision Systems' Critical Cue Recognition test (Cue III). It will not be referred to further.

The following ATs, all evaluated in the present study, will be described in more detail:

Pelli-Robson Chart-Based Test of Contrast Sensitivity

The Pelli-Robson chart-based test of contrast sensitivity (Pelli, Robson, & Wilkins, 1988) presents rows of triplets of letters. These letters are all the same size (i.e., the same spatial frequency) and, since the triplets progressively become a lighter gray, their contrast with the white background decreases going down and toward the right of the chart. While the complete chart contains 48 letters (8 rows, 16 triplets), only 36 letters (6 rows, 12 triplets) were used in the present study. The top line was eliminated because its high contrast made it too similar to a standard visual acuity test, while the bottom line was eliminated because its low level of contrast made it too difficult for most observers. The letters in the full chart range from 90% letter-to-background contrast, at the upper left of the complete chart, to 0.5% letter-to-background contrast at its lower right. In the reduced chart used for this study, the contrast ranged from 50% at the upper left to approximately 1% at the lower right. Since contrast sensitivity equals 1 divided by contrast [or the reciprocal of contrast], an examinee who can read letters of 50% contrast, but cannot read letters of contrast less than this, has a contrast sensitivity of 2 (1 divided

by 0.5). Because Pelli-Robson contrast sensitivity is expressed as the logarithm to the base 10 of contrast sensitivity, this equals a Pelli-Robson score of 0.30. The lower-right contrast of slightly less than 1% in the present study has a log contrast sensitivity, or Pelli-Robson score, of 1.95 (log to the base 10 of 1 divided by .01).

Study participants viewed the chart binocularly (i.e., with both eyes together) while wearing their eyeglasses or whatever visual aids they normally use for distance correction. Testing was performed at a distance of 6 feet (1.83 m) under "normal" field office illumination. The light reflected from the charts hung in the four different study offices ranged from 21 to 116 candelas per square meter (a measure of chart brightness). The Pelli-Robson contrast sensitivity testing protocol calls for 85 candelas per square meter, but Zhang, Pelli, and Robson (1989) demonstrated that scores are roughly the same over a range from 7 to 514 candelas per square meter. With respect to examinee distance from the chart, they also showed that scores are roughly the same from 0.8 feet to 13 feet (.244 m to 3.96 m).

Pelli, Robson, and Wilkins (1988) made the following instructive point about Pelli-Robson testing protocol:

> While detailed assessment of the visual defect in any particular subject will require the subject's whole contrast-sensitivity function to be measured, it should be possible to determine if a subject's vision is abnormal by making only two measurements. One measurement is required to reveal the existence of reduced acuity at high contrast [such a reduction would limit one's ability to read road signs and house numbers] and a second to reveal a contrast-sensitivity loss at intermediate spatial frequencies [such a loss would limit one's ability to notice large nearby objects such as other vehicles and pedestrians]. It should be possible to provide the first of these measurements using a standard high-contrast acuity chart and the second using a variable-contrast letter chart with letters of appropriate size. (p. 191)

Since DMV does not try to make a detailed assessment of visual limitation, but only attempts to determine whether a driver's vision is good enough to permit safe driving, and since the DMV-required Snellen test already provides an indication of any reduced acuity at high contrast, only one more measurement—to indicate any contrast sensitivity loss at intermediate spatial frequencies—should arguably be necessary. The Pelli-Robson chart can provide that measurement. Based on real-world recognition performance while driving, Wood & Owens

(2005) empirically confirmed the effectiveness of such a DMV approach to assessing visual functioning[21].

In the present study, testing on the Pelli-Robson chart was continued until the customer incorrectly read, or failed to read, all three letters in a triplet. Reading one or two letters correctly in a triplet allowed the participant to continue. Guessing was encouraged, and there was no time pressure.

There has been much research on the Pelli-Robson test. It performed very well in distinguishing road-test referrals (generally functionally-limited older drivers) from volunteers (generally limitation-free older drivers) in a previous 3-Tier pilot study conducted in a DMV field office (Janke & Hersch, 1997). Hennessy (1995) found poor Pelli-Robson test performance to have positive crash-predictive value for 26- to 39-year-old drivers, and also for those aged 70 or more when the drivers with reduced contrast sensitivity reported never avoiding heavy traffic. In outside research, the Pelli-Robson chart was found to be the most discriminating measure for crash prediction in a group of insurance policyholders aged 50 or more (Brown, Greaney, Mitchel, & Lee, 1993).

Functional Acuity Contrast Test (FACT)

Two tests of contrast sensitivity that were not included in the two original 3-Tier pilot studies reported by Janke and Hersch were tested in the present study to determine whether they were better for screening purposes than the Pelli-Robson. One was the Functional Acuity Contrast Test or FACT (Vision Sciences Research Corporation) developed by Dr. Arthur Ginsburg (Ginsburg, 1995). The FACT consists of five rows of nine "test patches" of parallel lines which are viewed at a distance of 10 feet (3.048 m). The contrast of each patch decreases progressively from left to right within each row. The study participant's task was to indicate whether the parallel lines were vertical, tilted to the right, or tilted to the left. They were encouraged to guess if necessary, and testing was continued until the participant responded incorrectly or reached the

[21] "Real-world recognition performance of all age groups was significantly degraded under low light conditions [which were low contrast conditions as well], and this impairment was greater for the older participants. These changes in drivers' recognition performance were more strongly predicted by contrast sensitivity than visual acuity measured under standard photopic conditions. Interestingly, contrast sensitivity was highly correlated with visual acuity measured under low-luminance conditions. Further analyses showed that recognition performance while driving is better predicted by combinations of two tests: either 1) photopic visual acuity and photopic contrast sensitivity, or 2) photopic and mesopic visual acuity."

end of the row. The last correct response for each row determined the contrast sensitivity score. Participants viewed the FACT binocularly with their usual distance correction in place. As with the Pelli-Robson chart, testing was performed under 'normal' field office illumination. The light reflected from the FACT charts hung in the four different study offices ranged from 46 to 94 candelas per square meter. (As will be explained below, the FACT was given in a separate testing room, so the range of illumination levels was smaller than in the main part of the office, where the Pelli-Robson chart was located.)

Smith-Kettlewell Institute Low Luminance (SKILL) Card

The other novel contrast sensitivity test used in the present study was the Smith-Kettlewell Institute Low Luminance (SKILL) Card, developed at the Smith-Kettlewell Eye Research Institute in San Francisco (as described by Haegerstrom-Portnoy, Brabyn, Schneck, & Jampolsky, 1997). SKILL is a test of low-luminance, low-contrast acuity. It consists of a standard high-contrast (black on white) near-vision acuity chart on one side of a card containing 16 rows of 5 letters each (the "light chart"), while on the other side of the card (the "dark chart") there is a similar display in which the letters are gray on a dark background. A prototype SKILL card was included in the test battery studied by Hennessy (1995). Unlike the Pelli-Robson and FACT tests, which had been described to study participants as "fog charts," the SKILL card was introduced to participants as follows: "This card measures your ability to see in low light and low-contrast conditions, which is like driving through a residential area at night."

The SKILL card is small enough to be held in the hand, but for the present study participants were seated 16 inches away from it. They started with the light chart. Again there was no time pressure, and guessing was encouraged. Participants were asked to start with the first letter in the first row and name each of the letters. They viewed the chart binocularly with their usual near-vision correction in place. Testing was continued until they incorrectly read, or failed to read, three of the five letters on a line; the participant's score was number of correct responses, which could be as great as 80. This procedure was repeated for the dark chart. Testing was performed under "normal" field office illumination, with the light reflecting back from the light charts ranging from 90 to 189 candelas per square meter. The manufacturer calls for 150 candelas per square meter.

PC-Based Perceptual Response Time (PRT)

Another AT used here was PC-based measurement of perceptual response time (PRT). PRT was considered a leading candidate for the second (automated) tier of the 3-Tier system and is the first component of the three-part Useful Field Of View or UFOV test (Owsley et al., 1991). It was described to study participants as a perceptual response test that measures information processing speed. Although originally developed for use on the company's Visual Attention Analyzer, Visual Awareness, Inc. has developed a PC-based version that can be used with a touch-screen monitor. This first UFOV module deals only with processing speed for stimuli in the central part of the field, requiring the examinee to touch the monitor to identify a preceding silhouette—flashed at most a half-second—as representing either a car or a truck. The task was not designed to challenge visual acuity. It is very rare for examinees to have such poor acuity that they cannot make the discrimination because of it, and in such cases the test is aborted.

While taking the test, participants were seated so that their eyes were between 18 and 24 inches from the touch-screen monitor. Instructions were given on the screen and then these participants were familiarized with the car and truck silhouettes and given up to five practice trials on the task, using a relatively long stimulus presentation time. Following this the test proper began; as usual, examinees were told to make their best guess. In PRT, the speed of the examinee's motor response in touching a later-presented exemplar of the correct silhouette is irrelevant. What is timed (by the computer) is the duration at which the car or truck stimulus is initially flashed. This duration could range from 16 to 500 ms. The briefest stimulus duration at which a participant can identify the car/truck correctly 75% of the time in an iterative process is his or her score. Because PRT uses an adaptive testing method in which stimulus duration depends on the test-taker's level of performance, the number of stimulus presentations is not fixed. The average time to administer this AT is about 5 minutes.

Evidence for PRT's potential value as a 3-Tier AT comes from Hennessy (1995), using the Visual Attention Analyzer. For driver license renewal applicants who were 25-years-old or more and who failed the DMV's 20/40 visual acuity screening standard, Hennessy (1995) found poor PRT to have substantial positive crash-predictive value when the driver with reduced PRT reported any of the following: often or always driving at night, never avoiding sunrise/sunset, never avoiding heavy traffic, never avoiding rain/fog, or never avoiding driving alone.

The second and third UFOV modules (divided and selective attention) were not considered for use in the present study (nor in the 3-Tier pilot at the Buck Center [Janke, 2001]), in part because

Hennessy (1995) had previously found that the crash predictive values of the divided attention module, and the UFOV total loss scores (all three modules combined), were no better than using PRT alone.

Schieber's Auto-Trails

Schieber's Auto-Trails, also considered for the second tier of the 3-Tier system, was described to study participants as a test of visual search. As noted above, it is an automated version of Part A of the Trail Making test (Reitan, 1955; 1958). In the present study it was composed of two separate subparts. In Auto-Trails, randomly arranged numerals 1 to 14 are displayed on a computer touch-screen against the background of a traffic scene as observed through the windshield of a car. Participants seated before the monitor saw a practice screen with a particular configuration of numbers. The MVFR explained the task—to touch the numbers on the screen in numerical order—and if necessary demonstrated it, telling participants to touch the screen to begin practice and to work as fast and as accurately as they could. After up to two practice trials, the ascending series of the test began with a different number configuration.

In the ascending series (first subpart), the study participant's task was to touch the numbers 1 (start) through 14 (end) in numerical order as rapidly and accurately as possible, with error detection and timing accomplished by the computer. Those who asked what to do if they made a mistake were told by the MVFR to touch the number they had intended to touch and go on from there. After participants had completed the ascending series they were shown a new number configuration (second subpart) involving a descending series from 14 (start) through 1 (end); no practice was offered for this task. However, the MVFR was trained to observe whether the participant was touching the numbers in descending order. If not, the test was stopped and the task was explained again before starting a new descending test. Going backwards from 14 to 1 required a shift of response set, and it was hypothesized by the authors, on the basis of work on attention shifting (e.g., Hart, Kwentus, Wade & Taylor, 1988), that people with cognitive limitations, especially, would be slower on the descending series than on the ascending one because of interference from the previous task, despite whatever generalized practice effect might be expected to improve performance. The score for both series used in the present study was total time corrected for the number of screen touches. This correction was meant to prevent participants from registering extremely fast times spuriously when they had not touched all of the numbers.

Driving Information Survey

When experimental non-driving assessment was over, each participant completed a Driving Information Survey (Appendix A) initially obtained from Dr. Cynthia Owsley and later used by Hennessy (1995), and by Janke and Hersch (1997), in driver assessment studies. Survey questions dealt, first, with how much and what type of driving the respondent customarily did. Following these questions there were nine more questions that asked respondents about the extent they avoided specific driving situations (e.g., darkness, congested traffic, unfamiliar areas; see Appendix A). Answers could range on a four-point scale from "never" to "always."

Participant Selection and Processing

None of the participants in the present 3-Tier study was a volunteer. See Appendix E for DMV's legal authority to make study participation mandatory. Volunteers in studies of driving performance, old or young, have been found to be more active drivers and less likely to avoid challenging driving situations than non-volunteers; therefore, they are not representative of the general population of licensed drivers (Zhou and Lyles, 1997). Some people who presented themselves at a driver-licensing window in the present study were excluded from participation in this study, but that was for reasons listed below. ***All study participants were evaluated with all of the ATs.*** There were three groups of customers who participated:

- Renewal applicants (here called **Renewals**).
- DMV Driver Safety road-test referrals (here called **Road Test Referrals**).
- Field office low-vision referrals, who were required to have had completed a Report of Vision Examination, DMV's form DL62, (here called **Visual Acuity Referrals**).

This last group of people was composed of:

- Applicants who were unable to pass DMV acuity screening on their first attempt, were then referred to a vision specialist for examination and vision correction if possible, and were still unable to pass DMV's acuity screen when they returned with a DL62 form completed by the specialist.

- Applicants whose vision condition was one in which DMV does not issue a full-term driver license even if the applicant passes the acuity screen. (Cataract is probably the most common such condition.) The limited license term for these drivers is based on the vision specialist's diagnosis or confirmation of a potentially progressive condition and, to some extent, their estimate of "how soon your patient's vision should be reevaluated."

The group of Road Test Referrals contained drivers referred occasionally by the field office for reasons other than vision test failure, but usually by an outside source—generally physicians or other health care professionals because of a medical condition, or law enforcement officials because of an egregious traffic error, or having been involved in a collision because of such an error. Drivers are referred to Driver Safety (DS), the branch of DMV that accumulates and adjudicates evidence bearing on the driving safety of individuals and determines, among other things, the extent of assessment needed and what actions, if any, to take against their driving privilege.

Not all Renewals were eligible for participation in the study, as indicated above. Some were excluded from participation based on the following criteria:

- The excluded driver was age-eligible and record-eligible to renew by mail. (Renewal by mail is frequently shortened to RBM.) Most drivers whose prior 2-year driving records are relatively good (not necessarily perfect) are eligible for RBM. However, drivers of age 70 or more at license expiration, or those who have accumulated more than one violation or collision responsibility point during the 2 years immediately before their licenses expire are not eligible. (A complete list of California's exclusionary criteria for RBM appears in Appendix F.) Current law allows, at most, two consecutive RBMs—although, after one in-person renewal, drivers who qualify may again renew by mail in future years. Thus, otherwise qualifying drivers must return to a field office for their third renewal (in 15 years, since the license term in California is 5 years). Even with a field office renewal, however, those who continue to qualify are excused from otherwise mandatory knowledge testing and need only pass the visual acuity screen to be relicensed. These applicants, like those actually renewing by mail, were excluded from the study. Drivers who came to a field office to renew despite being eligible for RBM (often wanting a new photo license) were also excused from 3-Tier assessment. The renewal applicants studied here, then, consisted of people younger than 70 whose flawed records made them ineligible for RBM, and people aged 70 or more at the expiration of their current licenses.

- The excluded driver, applying for renewal, failed DMV's visual acuity test and was referred to a vision specialist of his or her choice for examination, possible remediation, and completion of a comprehensive report form (the DL62) to be returned to the field office at a later date. When he or she brought the form back, the person's acuity was retested. Such drivers could not become study participants until the completed DL62 had been returned and repeat acuity testing at DMV on a subsequent visit had either been passed or failed. If passed, the person would participate as a member of the Renewal group. If failed, the person would participate as a member of the Visual Acuity Referral group; current policy requires such a driver to be assessed on the road to check adequacy of compensating for their visual defect.

- The excluded driver could not speak or could not read English.

- The excluded driver was accompanied by young children.

The above are the study exclusion criteria for drivers seeking to renew their licenses. Study Road Test Referrals and Visual Acuity Referrals were required to take a road test and possibly other tests in any case, so in general the only things that would lead to their not being selected as study participants were inability to speak or read English.

The identification and processing of study participants was the responsibility of two of the three study MVFRs, with the third serving as backup in case one of the other two was unavailable. Renewal applicants appearing at DMV field offices either have an appointment for their transaction or have simply walked in without an appointment, hoping for timely service. Therefore, one of the on-duty MVFRs was assigned to an appointment window and the other to a walk-in window.

Tier 1 Assessment Procedures

Staff whose job it was to schedule appointments for road tests had been asked to schedule at least one Road Test Referral (Driver Safety referral) driving test each morning and each afternoon. MVFRs were told to identify and include both of these daily referral customers in the study, unless there was a language barrier as indicated above. Field office staff were also directed to

send only license-renewal applicants (rather than customers desiring to register a vehicle, for instance) to the walk-in windows.

The Pelli-Robson contrast sensitivity chart (see above) was hung 6 ft (1.83 m) back from the public side of the service counter next to each of the study MVFR windows.

If the Tier 2 testing room was available and the customer was a renewal applicant, items 1-4 on the structured observation checklist (Appendix C), dealing with lower body functioning, were completed as the customer approached the window. The eligibility of the customer to be a study participant was determined following the criteria given above. If ineligible, the MVFR processed that customer in DMV's usual manner.

While still holding an eligible customer's paperwork, the MVFR asked the birth date and social security number questions (structured observation items 7A and 7B). If the customer asked why these questions were being asked, MVFRs answered that they were piloting a new screening procedure. Customers were required to give their answers from memory, since their paperwork was being held by the MVFR.

Next, the MVFR completed items 5 and 6 on the observation checklist, which asked whether the customer failed to follow directions or needed help from a third person in carrying out their transaction. These, like items 7A and 7B, which deal specifically with rote memory, are associated with cognitive functioning. As a further cognitive exercise, the customer was given a diagram containing the intersection problem (see above), told that it was a new question the department was trying out for the knowledge test, and asked what the right answer might be.

The MVFR completed the remaining items on the checklist, and then administered standard DMV visual acuity testing, using the department's modification of the Snellen letter chart on which all lines are 20/40. Customers who failed this test (that is, could not correctly identify four out of five letters in a row) were tested, as described above, on a slide of Snellen letters in an Optec 1000 viewer.

As noted above, the supplementary Snellen slide for those who fail the Snellen chart is now a standard DMV procedure, introduced and evaluated by Hennessy and Waters (1998). While not a replica of the Snellen chart, the slide is close to it in containing letters at four different sizes, 20/40, 20/50, 20/70, and 20/100. Failure to meet the 20/40 screening standard on the Optec 1000 after failing the chart test results in a DL62 referral to a vision specialist, and customers given

such a referral could not immediately proceed with study participation—though, as indicated, they could participate if they returned for retesting with a completed DL62.

Acuity testing was followed by the Pelli-Robson contrast sensitivity test, represented to participants as a "fog chart." This AT is described above; since its letters become progressively lighter from top to bottom, they resemble objects seen through fog. After they took this test, participants were told by the MVFR that the test was a new one that DMV was trying out, so their opinion of it was valuable. Then they were verbally asked the four acceptability questions listed in the Introduction and Rationale. This was true for all of the new study ATs, except for the non-test ATs: the unobtrusive structured observations of upper and lower body functioning, etc. Test acceptability data were also collected from DMV staff, who served as "practice participants" during the training of the study examiners.

This concluded Tier 1 assessment. The next subsection describes the Tier 2 procedures for *retaining* study participants. The procedures for retaining study participants following Tier 1 varied depending on the participant's status, since Road Test Referrals had no option but to undergo assessment, but it was possible that Renewals might refuse. It was considered that Renewals might be especially likely to refuse if they perceived their performance on Tier 1 to have been good enough for licensure. Therefore details of renewal applicant retention procedures were made dependent upon whether the applicant had "passed" or "failed" Tier 1. (Recall that all of the study participants were evaluated with all of the ATs.) Tier 1 was considered to have been "failed" and the MVFR so notified the applicant if:

- Any structured observation of a "problem" was recorded on the data collection form (DCF). These might include loss of a limb, failure to recall one's social security number, and so forth.

- Failed DMV visual acuity screening (both Snellen chart and Snellen slide) together with presentation of a completed DL62, indicating that the applicant had recently consulted with a vision specialist.

- Failed to read any letter correctly on the last two lines of the reduced Pelli-Robson chart[22].

[22] Recall that the top and bottom lines of the original chart had been removed.

Tier 2 Assessment and Retention Procedures

The ATs used in Tier 2 and the way they were scored has been described above. For every participant, Tier 2 test order was as follows: (1) FACT, (2) SKILL, (3) PRT, (4) Auto-Trails. After each new test was administered, the customer responded to the four test-acceptability questions listed in the Introduction and Rationale and in Appendix H-1. At the conclusion of Tier 2 assessment the participant completed the Driving Information Survey describe above and in Appendix A.

Road Test Referrals

These participants were told that before taking the road test they needed to complete some additional "eye tests" and some computer-based tests. They were told that the added testing was a new procedure DMV was evaluating and that, because of this, any customer's performance on the new eye tests and computerized tests could not affect their driving privilege. If participants asked, they were told that the "new tests" (i.e., Tier 2 ATs) would take about 30 minutes, while the road test (Tier 3, the SDPE) would also take about 30 minutes. MVFRs were told that if there was extreme resistance to taking the non-driving Tier 2 ATs, that requirement would be quietly waived. However, Road Test Referrals could not avoid taking the Tier 3 road test described in the next subsection—which in their case, and also in the case of field office Visual Acuity Referrals, *could* affect the driving privilege.

Renewal Tier 1 "Passes"

Participants who were renewal applicants and had "passed" Tier 1 according to our preliminary criteria might, it was thought, have objections to continued testing. The study MVFRs were trained to represent study participation as mandatory as is authorized by state law (CVC 12804.8b, see Appendix E). Moreover they were instructed to approach all customers with the full expectation that they would do as the MVFR directed. The MVFR was trained to tell the customer that DMV was evaluating new tests, and "before going statewide, we need to find out how well performance on these new tests predicts performance on a road test." Renewal Tier 1 "Passes" were also told that they had been randomly selected for participation in the study, that all test results would be confidential and could not affect the driving privilege, and finally, that

DMV would reimburse the customer for their renewal fee ($15 at the time; $24 now). The customer was then asked to accompany the MVFR to the Tier 2 testing room.

If there was resistance, MVFRs were given a choice of arguments they could use. They could say that this was an opportunity for the customer to have input into improving DMV testing procedures. Or they could remind customers that they had been randomly selected, and that in order for the study to be valid, everyone randomly selected to participate would have to take all of the study tests. The customer was also given a chance to look at Section 12804.8 in the California Vehicle Code, in order to verify what he or she had been told. However, if resistance remained uncompromising to an extreme, the study-testing requirement was quietly waived (and no reimbursement was offered).

Renewal Tier 1 "Fails"

If the customer was a renewal applicant who had failed Tier 1 (this would include all field office Visual Acuity Referrals who had failed the follow-up DMV acuity screen even after professional help), this failure in itself was expected to make the task of persuasion easier. The MVFR was instructed to inform customers of their failing performance, and say that because they had failed Tier 1, they might have a condition that impaired their ability to drive safely. "This means that we need to do some follow-up testing, including a road test."

The MVFR would explain, as always, that "this is a new procedure that DMV is still evaluating," and because of this the person's test results on Tier 2 would not affect their driving privilege. As with Renewal Tier 1 "Passes", reference could be made to Vehicle Code Section 12804.8(c) (seen in Appendix E) in case of reluctance. Customers were then asked to accompany the MVFR to the Tier 2 testing room. No reimbursement was offered.

Tier 3 Procedure

The third tier of the assessment system was the Supplemental Driving Performance Evaluation, or SDPE. As indicated, it was administered to all study participants by field office examiners who had been especially selected, and given refresher training, for the study. The test is a DMV task force creation broadly based on California's Driving Performance Evaluation, or DPE, used mainly for novice license applicants. (The DPE itself was based on a 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, and construct validated by Romanowicz and Hagge [1995].) The DPE primarily measures the constructs of visual search, speed control, and directional control.

The SDPE is a longer test than the DPE and, beyond the constructs mentioned above, is meant to evaluate the driving abilities of experienced drivers who have acquired a driving-relevant limitation since their initial licensure. It shares features with the Modified DPE (MDPE) used by Janke and Hersch (1997) in their study of older-driver assessment. The MDPE, an experimental test developed before the SDPE was in existence, was used only in the two studies described by Janke and Hersch, and Janke (2001).

The SDPE includes the DPE elements and the following additional elements:

- Freeway Driving – Near the end of the SDPE the driver is required to merge onto and exit from at least one-quarter mile of freeway driving. At least twice before beginning the SDPE, the driver is asked, "Do you drive on the freeway?" If at any time the driver indicates that she or he does not drive on the freeway or does not wish to be tested on the freeway, the freeway element is waived; if the driver then passes the remainder of the SDPE, she or he is restricted from freeway driving as advised earlier by the examiner. Items scored on the freeway segment of the SDPE include, checking for traffic, speed, spacing, and lane position.

- Multiple Directions – At three different locations on the SDPE route, the examiner gives the driver two sets of driving directions—e.g., at the next light, turn left then change lanes to the right. Two items are scored. The first is whether added cues were needed in order for the driver to understand the task. The second is whether the driver either did not follow the instructions properly and complete the task safely, or did not acknowledge a driving error and correct it immediately without creating a hazard.

- Concentration – At two locations on the SDPE route where there is no immediate hazard to deal with, the examiner engages the driver in conversation. This conversation is meant to be innocuous, but to include questions that call for a brief answer by the driver. What is scored (as a concentration error) is whether or not the driver commits any driving errors while conversing.

- Destination Trip (Way-Finding) – This is typically the last exercise on the SDPE. It involves returning to the field office without assistance from the examiner after being directed along a short route past it (2-3 blocks). The driver, in returning to the office, is expected to retrace the exact route used to drive away from it. What is scored is whether the driver, using the identical route, can find the field office without help. This task is different in the SDPE from the similar task used by Janke and Hersch (1997), who included it in the MDPE. In that earlier study the examiner could give a directional cue if needed to start the driver off, and there was no requirement to retrace the route exactly. The task was used to measure confusion about what the task was, not sense of direction. Under those circumstances there was an association of task failure with cognitive impairment.

Operationalizing: Plan for Developing Two Cut Scores for the ATs that Yield a Range of Scores

As noted in the Introduction and Rationale (p. 55), in order to operationalize "Driving Well," "Somewhat Functionally Limited," and "Extremely Functionally Limited," two cut scores had to be developed for ATs that yield continuous results. As reported in the Results and Discussion section (p. 98), some drivers become marginally limited and some extremely or severely limited with aging, but others remain relatively limitation-free for a very long time. The frequency distributions for the different measured functional abilities *change shape* with aging rather than simply shifting to the right. This general finding is illustrated in Figure 3.

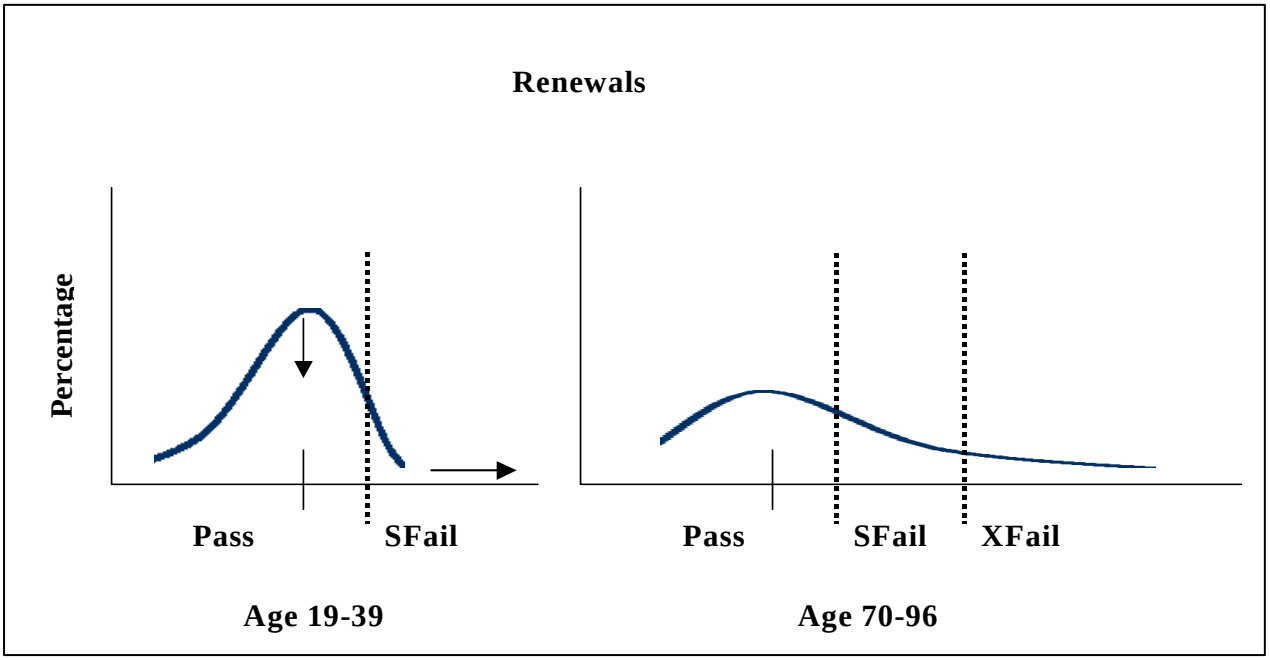

Figure 3. Generally observed changes in the shape of the Renewals' frequency distribution of driving-relevant functional ability with aging. The two arrows indicate the general direction of change with aging. The dotted vertical lines represent the conceptualization of cut scores for operationalizing "Driving Well," a Pass, and "Extremely Functionally Limited," an XFail. Together these two cut scores demarcate "Somewhat Functionally Limited," an SFail—marginally limited.

Study participants were divided into three age groups: young (19-39), middle-aged (40-69), and elderly (70-96). The choice of 70 as the age separating middle-aged and elderly was less arbitrary, from the point of view of DMV, than the other dividing point. This is because, as explained above, drivers of 70 or more must be assessed in a field office in order to renew their licenses, while younger people who qualify may renew by mail. Assuming that the percentage of driving-well people in the two younger age groups is likely to be greater than in the 70- to 96-year-old age group, and assuming that the percentage of driving-well people in the 70- to 96-year-old Renewal group is likely to be greater than in the Road Test Referral group of the same age, the *Pass* cut score (see Figure 3) for a specific continuous AT may be *selected* by comparing the pass rates of the 70- to 96-year–old Renewals and Road Test Referrals.

The following two specific *target criteria* were developed and used to evaluate plausible *Pass* cut scores:

- Less than 50% (in fact, the fewer the better) of the 70- to 96-year-old Road Test Referrals should pass any of the ATs selected for this study that yield continuous results.

    - Rationale: As noted above, the vast majority of Road Test Referrals come from physicians or other health care professionals because of a medical condition, or from law enforcement because of an egregious traffic error that might be due to failing to compensate for a visual, mental, or physical limitation(s). Therefore, most of them, at least 50%, likely are at least somewhat functionally limited.

- More than 50% of the 70- to 96-year-old Renewals should pass any of the ATs selected for this study that yield continuous results.

    - Rationale: None of the Renewals (by definition) have been referred for a road test. Therefore, as indicated in Figure 3, most of them, at least 50%, likely do not have even one marginally-limited driving-relevant functional ability.

This method of *selecting* a Pass cut score based on a researcher's judgments about different groups of test takers is generally described in Livingston and Zieky (1982). The method for *validating* these cut scores was described in the Introduction and Rationale.

Tables 2 and 3 illustrate the application of these criteria to the computer-based test of perceptual response time and the chart-based test of contrast sensitivity finally recommended for inclusion in the 3-Tier driving-centered assessment system. Table 2 shows for three plausible Pass cut scores the obtained PRT values that correspond to the above target criteria. Table 3 shows the same for the reduced Pelli-Robson chart used in the present study. The plausible Pelli-Robson Pass cut scores, > = 27, > = 30, and > = 33 letters correct, correspond to > = 1.5, > = 1.65, and > = 1.8 log contrast sensitivity. Recall that the Pelli-Robson chart is organized into triplets of letters of the same log contrast sensitivity. Based on the above Pass cut score target criteria, the best of the plausible Pass cut scores for the two tests are bolded and underlined. Note that for both tests, as posited, the proportion of Renewals scoring the same or better than a specific plausible Pass cut score was always greater than that for the corresponding group of Road Test Referrals. The same posited relationship for the two younger age groups compared to the 70-96 year-olds was also obtained for both tests.

Table 2

Obtained Values for Evaluating Three Plausible
Pass Cut Scores for the PRT

PRT – milliseconds		Pass rate	
Plausible pass cut score	Age group	Renewals	Road Test Referrals
<=20	19-39	97.0%	88.7%
	40-69	91.2%	64.9%
	70-96	48.0%	31.1%
<=23	19-39	98.5%	96.8%
	40-69	93.0%	79.8%
	70-96	65.8%	48.0%
<=26	19-39	98.5%	96.8%
	40-69	93.0%	82.5%
	70-96	73.0%	56.8%

Table 3

Obtained Values for Evaluating Three Plausible
Pass Cut scores for the Pelli-Robson Contrast Sensitivity Test

Pelli-Robson chart - letters correct		Pass rate	
Plausible pass cut score	Age group	Renewals	Road Test Referrals
>=27	19-39	100.0%	98.4%
	40-69	100.0%	94.0%
	70-96	78.1%	58.9%
>=30	19-39	97.1%	88.7%
	40-69	89.5%	73.5%
	70-96	45.8%	19.9%
>=33	19-39	75.7%	61.3%
	40-69	61.4%	44.4%
	70-96	8.4%	2.0%

The XFail cut score should demarcate the lower boundary of a marginally-limited driver and the upper boundary of an extremely-limited driver (see Figure 3). The tail(s) of a frequency distribution contain its extreme values. Therefore, the XFail cut score was *selected* by inspecting the study *sample,* and estimating the beginning of the "inferior/XFail" "tail" of the AT distribution in the 70- to 96-year-old renewal *population*. Even though this method is necessarily somewhat arbitrary, which plausible XFail cut score is finally selected will make very little difference in terms of the percentage of drivers identified as XFailed, since by definition of "tail" the frequency of drivers is relatively very low at any given point in the tail of the distribution. Figure 4 illustrates the *selection* of an XFail cut score for PRT. The beginning of the tail of the PRT distribution in the 70- to 96-year-old Renewal *sample* was estimated to be at the point 43. Note that it would have made very little difference, in terms of who would have been identified as an XFail, if 43 or 50 had been selected as the XFail cut score.

Figure 5 illustrates the *selection* of an XFail cut score for the Pelli-Robson contrast sensitivity test. The selected XFail cut score of 23 letters correct, with scores less than or equal to 23 being an XFail, can be converted to a log contrast sensitivity of 1.30 or worse. Making a log contrast sensitivity of 1.30 or worse an XFail is consistent with Ball et al. (1998), who defined a Pelli-Robson score of 1.35 or worse as impaired, and with Owsley, Stalvey, Wells, Sloane, and McGwin (2001), who defined a Pelli-Robson score of 1.25 or worse in the worse eye as a "serious contrast sensitivity deficit." [Note that in measuring contrast sensitivity for clinical use, it is now standard practice to give credit (.05 log units) for each letter read correctly on the Pelli-Robson chart (Cynthia Owsley, personal communication, 10/5/04)]. This agreement with other researchers' independent judgments of severely limited contrast sensitivity lends support to this study's method of selecting an XFail cut score.

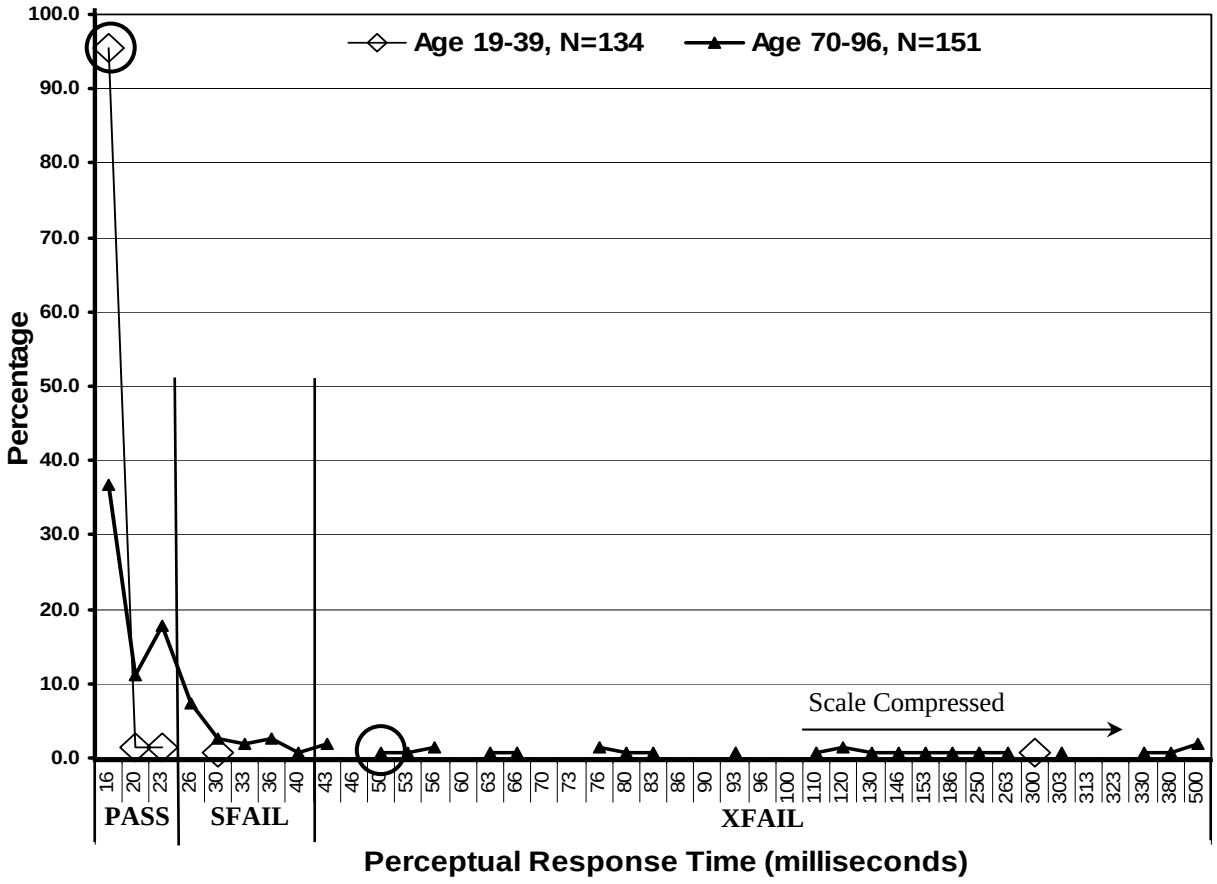

Figure 4. Distributions of Perceptual Response Time for the Youngest and Oldest Sampled Renewals. The circled values are the distributions' means. The frequency distribution of scores for the oldest age group is greatly positively skewed; the mean is considerably to the right of the group's mode and is here defined as an XFail.

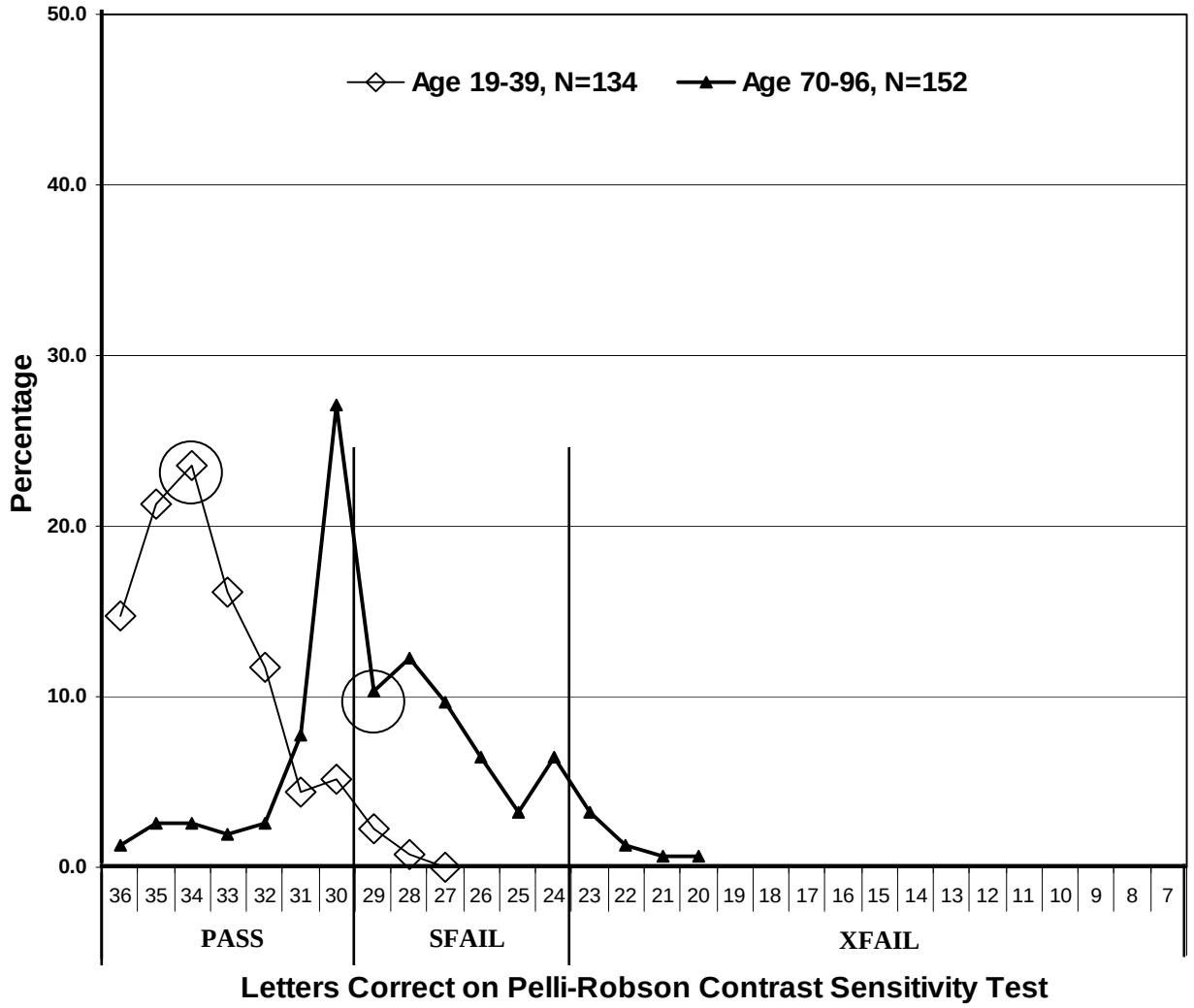

Figure 5. Distributions[23] of Pelli-Robson Letters Correct for the Youngest and Oldest Sampled Renewals. The circled values are the distributions' means. Note that on the abscissa the numbers of correct responses are in descending order, so that the curve to the left indicates superior performance.

[23] Since the Pelli-Robson chart presents letters in same-contrast triplets and "jumps" to a lesser amount of contrast from one triplet to the next, the reduction in contrast is stepwise rather than continuous. Thus it is to be expected that, ignoring chance factors, the mode for any group might occur at the end of a triplet. That was roughly the case here. The mode for the youngest group (34 letters) was close to the end of the next-to-last triplet on the reduced chart (letter 33), while the mode (30 letters) for the oldest group was exactly at the end of its triplet (letter 30), a difference of only about one level of contrast on the Pelli-Robson chart.

Operationalizing: Scoring Procedures and Combining the Results of the Novel ATs

After selecting prospective 3-Tier ATs based on past studies (pp. 54 & 60-69) and rejecting those that are judged to be too costly or otherwise infeasible in a DMV field office (p. 56), the next steps in operationalizing (developing a working definition of) "Driving Well," "Somewhat Functionally Limited," and "Extremely Functionally Limited" involve specifying scoring procedures for all of the ATs, specifying cut scores for all of the ATs (reported in the Results and Discussion, Table 12, p. 103) and specifying a way of combining the results of the ATs.

As indicated in the Introduction and Rationale (p. 55), the Snellen and knowledge-test results were not combined with the results of the new ATs since licensure is contingent on passing, or at least performing acceptably, on both.

Assessing Physical Limitation

The results of the seven pass-or-fail unobtrusive structured observations of physical functioning (Appendix B, Items 1-4 and 9-11) were combined as follows into one measure, called "Physical Limitation." The Physical Limitation score is the sum of the scores for lower and upper body functioning. Lower body was scored 1 if the driver failed one or more of the four lower body structured observations (Items 1-4 in Appendix C); otherwise, it was scored 0. Similarly, upper body was scored 1 if the driver failed one or more of the three upper body structured observations (Items 9-11 in Appendix C); otherwise, it was scored 0. Thus, if either upper or lower body showed functional limitation, but not both, the total Physical Limitation score was 1—an SFail. If both upper and lower body showed functional limitation, then the score was 2—an XFail.

AT Scoring Procedures

Table 4 summarizes the scoring procedures for the novel ATs. Failure of the structured observations numbered 5, 6, 7A, and 12 (failure to follow directions, requiring help from a third party, failure to recall birth date, and other impairment; see Appendix B) was extremely rare in the Renewal sample (less than 2% for Renewals aged 70-96, and approximately zero for the younger age groups) so they are not included in Table 4.

Combining Tier 1 ATs

Each of the logically plausible combinations of Tier 1 ATs consisted of a physical, mental, and visual component, for example, respectively, the Physical Limitation Score, the Recall SSN score, and the Pelli-Robson score. Each component was assigned a value of 0 if Passed, 1 if SFailed, or 2 if XFailed. These three values were then added together to get the participants' total scores for the Tier 1 combination under consideration. The participant was assigned a value of 2 for a Tier 1 total that equaled 2 or more. These Tier 1 scores for different combinations of ATs translate to a:

- Tier 1 Pass if the total equals 0.
- Tier 1 SFail if the total equals 1.
- Tier 1 XFail if the total equals 2.

As discussed in the Introduction and Rationale, a combination of different kinds of limitations may be a formidable constraint on the driver's compensating consistently and adequately.

Tier 2 AT

Since the knowledge test was not evaluated in combination with other ATs, Tier 2 consisted solely of PRT. Auto-Trails was not used because it proved to be too strongly susceptible to learning effects (see Results and Discussion).

Table 4

Scoring Procedures for the Novel Assessment Tools

Novel ATs	Scoring procedure
Physical limitation	Physical Limitation had three scoring categories: 0, 1 and 2.
Recall SSN	SSN was recalled without error (0) or the participant either could not remember it at all or made an error (1).
Intersection problem	The intersection problem was either answered correctly in less than a minute (0), or it was not (1).
Pelli-Robson chart	Number of letters correctly identified on the Pelli-Robson contrast sensitivity test.
SKILL dark side	Number of letters correct on the dark side of the SKILL card.
SKILL light-dark	Number of letters correct on the light side of the SKILL card minus the number of letters correct on the dark.
FACT rows 1& 2	Number correct on the first and second lines of the FACT chart.
PRT	Perceptual response time in milliseconds.

Comparing Alternative AT Combinations

In order to compare alternative logically-plausible combinations of the ATs for operationalizing "driving well", "somewhat functionally limited," and "extremely functionally limited," their pass/fail screening characteristics vis-à-vis SDPE performance were quantified and compared. For each plausible AT combination, the AT fail rate, the relative risk of failing the SDPE, the proportion of SDPE Passes who passed AT (specificity), and the proportion of SDPE Fails who failed AT (sensitivity) are reported. Also, the odds ratio for failing the SDPE is reported in Appendix I. For comparison purposes, the values of these pass/fail screening characteristics were also computed for each AT by itself. Table 5 defines the counts (A, B, C, and D) for calculating the pass/fail screening characteristics vis-à-vis SDPE performance. For example,

"A" is the number of drivers who passed the AT and also passed the SDPE. The values of A, B, C, and D for the various ATs are shown in Appendix I.

Table 5

Counts (A, B, C, and D) for Calculating Pass/Fail
Screening Characteristics vis-à-vis SDPE Performance

Assessment tool or combination of assessment tools (AT)	SDPE pass	SDPE fail	
AT pass	A	B "false negative"	A+B
AT fail	C "false positive"	D	C+D
	A+C	B+D	A+B+C+D

The following is a detailed definition of each of the pass/fail screening characteristics used in this study:

- AT fail rate is the total number failing the AT (C+D) divided by the grand total (A+B+C+D).

- Relative risk of failing SDPE—the estimated risk of failing the SDPE if the AT is failed [D/(C+D)], divided by the estimated risk of failing the SDPE if the AT is passed [B/(A+B)]. The relative risk of failing the SDPE is a measure of association between AT failure and SDPE failure. It is a conservative estimate of how much more likely it is that drivers will fail the SDPE if the AT is failed than if the AT is passed.

- Proportion of SDPE Passes who passed AT, also termed *AT specificity*, is simply A/(A+C). It is indicative of how good the AT is at identifying drivers who *need not* be road-tested.

- Proportion of SDPE Fails who failed AT, also termed *AT sensitivity*, is simply D/(B+D). It is indicative of how good the AT is at identifying drivers who *should be* road-tested

- Odds ratio for failing SDPE is the odds of failing the SDPE when the AT was failed, (D/C), divided by the odds of failing the SDPE when the AT was passed, (B/A). The odds ratio is a measure of association between AT failure and SDPE failure. It is indicative of how much more likely it is that drivers will fail the SDPE if the AT is failed than if the AT is passed.

So-called "false negatives" (B) and "false positives" (C) (Table 5) were minimized by maximizing sensitivity and specificity.

The precision or reliability of the above estimates of AT efficacy was indicated by reporting the 95% confidence intervals (CI) as calculated by the Statistical Package for the Social Sciences (SPSS Version 11.5).[24]

As defined in Table 6, the results of Tier 1 and Tier 2 assessments were combined in two different ways for two different purposes:

- Comparing the pass/fail screening characteristics of alternative logically plausible combinations of the ATs for operationalizing "driving well", "somewhat functionally limited," and "extremely functionally limited."

- Evaluating the four hypotheses comprising this study's opposite-outcome model (pp. 57-58).

[24] The lower and upper limits of 95% confidence intervals (CI) can be expected to bracket the true value of a specific AT's efficacy in 95% of all determinations.

Table 6

Prospective Tier 1 and Tier 2 Results Combined in Two Different Ways for Two Different Purposes

Two purposes	Tier 1 **Pass**, Tier 2 **Pass**	Tier 1 **Pass**, Tier 2 **SFail**	Tier1 **Pass**, Tier 2 **XFail**	Tier 1 **SFail**, Tier 2 **Pass**	Tier 1 **SFail**, Tier 2 **SFail**	Tier 1 **SFail**, Tier 2 **XFail**	Tier 1 **XFail**, Tier 2 **Any**
1. Comparing pass/fail screening characteristics of the alternative ATs	Screening pass				Screening fail		
2. Evaluating the four hypotheses comprising this study's opposite-outcome model	PP	N/A	N/A	SFail		XFail	

With respect to evaluating the two crash hypotheses (p. 58), participants who SFailed *both* Tiers 1 and 2 were grouped with participants who SFailed Tier 1, but passed Tier 2 to yield SFails for Tiers 1 and 2 combined. This was done because, compared to drivers who XFail on either Tiers 1 or 2, or both, drivers who SFail on *both* Tiers 1 and 2 are more likely to be similar to participants who SFailed Tier 1, but passed Tier 2, in terms of their likelihood of having little awareness of their functional limitations (see theoretical backdrop, pp. 46-49). For purposes of consistency and comparison with the crash hypotheses, the same SFail grouping for Tiers 1 and 2 combined was also made for evaluating the two SDPE hypotheses (p. 56).

Validating: Statistical Analyses of Outcome Pattern Matching

In order to evaluate the efficacy of the 3-Tier ATs, this study specifies two null hypotheses: "Functional categorization of driver-license-renewal candidates as 'driving well,' 'somewhat functionally limited,' or 'extremely functionally limited' on the basis of their 3-Tier AT performance on Tiers 1 and 2 is not associated with, nor predictive of, either (1) SDPE failure or (2) real-world crash involvement." If the probability is very small that the results obtained in the study are consistent with the two null hypotheses, then the two null hypotheses will be rejected.

P-values or 95% confidence intervals (CI) [25] will be presented with all effects as a means of further describing evidence for and against this paper's hypotheses.

- While smaller *p*-values provide greater confidence for rejecting the null hypothesis of no effect, they nonetheless need to be interpreted in the context of other available evidence rather than using a fixed decision rule (e.g., Christensen, 2005; Cohen, 1990, 1994; Fisher, 1956; Hubbard and Bayarri, 2003; Macdonald, 1997, 2002, and Nakagawa 2004.). Other available evidence includes the study's methodology, sample sizes, the estimated effect size, and how consistent the results are with what was hypothesized. Kline (2004) points out that:

    - Statistical significance says nothing directly about the size of an effect or whether it has theoretical, practical, or clinical import. Effect size magnitude, substantive significance, and whether a result replicates are what we really want (and need) to know. (p. 11)

- Starting on the flip side, Weinberg (2001) notes:

    - …the *P*-value is easy to misinterpret. (No, it is not the probability that a null hypothesis is true, nor is it the probability that we are making a certain error.) Mindless efforts to dichotomize results into significant vs. nonsignificant, based on some cutpoint, such as 0.05, get us into trouble: results were significant for males but not for females, and therefore? One of the most pernicious abuses of automated decision making occurs when clinical treatments are asserted to be equivalent, based on a nonsignificant *P*-value for the observed difference. (p. 288)

- In tables, effects with *p*-values of .05 or less will be bolded for ease of reading because these values are commonly though not universally accepted by researchers, as noted above, as indicating statistical significance.

Effects will be presented in the text as (1) raw data values, (2) difference values, and (3) ratios of values.

[25] A 95% CI that does not include the null value (e.g., 'zero' in the case of a difference between two means and 'one' in the case of a ratio such as relative risk) is equivalent to rejecting the null hypothesis at the .05 level.

Study Limitations

This study has limitations that may reduce the generalizability of its findings to all of the California DMV field offices. These include:

- The four study field offices are representative of a limited geographical area.
- The field office staff who participated in the study consisted of a select group of high performers not representative of all field office staff.
- The road-test routes were unique to the field offices that participated in the study.
- Random sampling from the entire population of renewal drivers was not possible. Therefore, the selected cut scores and study analyses were based on a convenience sample of modest size that may not have fully represented all of the factors affecting performance on the various ATs and the office-based road test. The selected cut scores may be "improved" with additional samples.
- Renewals were told that all Tier 2 test results and performance on the SDPE would be kept confidential and would not affect their driving privilege. This may have affected their performance on these tests. It is not known how representative the study results are of customer performance if the tests were employed as part of normal DMV licensing procedures.
- AT data and SDPE data was collected on the same day. Crash data was extracted from DMV records for the 3 years prior to study participation. Since functional status is subject to change, this may have affected the reported relationships between SDPE performance and crashes for drivers categorized as "Driving Well," "Somewhat Functionally Limited," and "Extremely Functionally Limited."

RESULTS AND DISCUSSION

The Results and Discussion are divided into four main parts:

I. Finalizing 3-Tier ATs

II. Outcome pattern matching

III. Exploring the positive correlation between knowledge-test errors and failing the SDPE

IV. Exploring the negative correlation between SSN recollection and having crashed

Part I: Finalizing 3-Tier ATs

Part I is divided into nine major sections:

- Participants.
- Erroneously Aggregating (Amalgamating) Older Drivers.
- Face Validity of Non-Driving ATs.
- AT Intercorrelations.
- Cut Scores for the novel ATs.
- Relationship between DMV Cataract Policy and Cut scores for Contrast Sensitivity Testing.
- SDPE Usually Failed Due To SDPE Structured-CDE.
- Pass/Fail Screening Characteristic Of Novel ATs Vis-à-Vis Performance on SDPE.
- Proposed Tiers 1 and 2 ATs for Making a Driving-Centered Assessment of Driving Wellness.

Participants

Table 7 shows the volumes of study participants in categories formed by their age and participant status (Renewal, Road Test Referral, Visual Acuity Referral), and the percentages of them who were male, failed the SDPE (taken by most of the study participants[26]), and experienced one or more on-road crashes during the 3 years prior to study participation. Age distributions (discussed below) are shown in Figures 6 and 7. Of the 730 drivers approached for study participation, only 5 (0.68%), all elderly, refused to participate. Four of them were Renewals aged 70- to 96-years-old and one, in the same age group, was a Road Test Referral.

The mean 1-year crash percentage of Renewals in this study (derived by taking one-third of the 3-year crash percentage shown in Table 7) can be compared with the annual crash rates per 100 drivers for the same age groups in the California driving population, as shown in Table 3 of Janke, et al. (2003). The annual crash rate can be converted into the approximate number of individuals having one or more crashes by applying the finding that 8 times as many drivers have one crash as have two or more (Gebers, 2003). Some comparisons are given below. There are many ways in which the numbers from these two studies are not strictly comparable (notably, the effect of renewal by mail) but, despite this, study crash percentages were not radically different from averages per 100 California drivers.

The 1-year crash percentage for the 19- to 39-year-old Renewals in this study, for example, was 9.6%, which is 25% to 88% higher than that reported by Janke et al. (2003) for all California drivers aged 19 (7.7%) and 35-39 (5.1%), respectively. The higher crash rate of the 19- to 39-year-old Renewals in this study relative to all California drivers of these ages may be partially explained by the different compositions of the two groups: no study Renewal was RBM eligible.

One of the main reasons for lack of RBM eligibility, especially at the youngest ages, is having incurred more than one negligent-operator point on the driver record (usually for traffic convictions, sometimes for crashes) during the preceding 2 years.

[26] Due to a lack of insurance, the brake lights did not work, or other related matters, an SDPE could not be administered to every study participant.

Table 7

Study participants

Age group	Participant	*N*	Male	Crashed	*N*[a]	Failed SDPE
19-39	Renewals	134	69.1%	28.8%	131	13.7%
	Road Test Referrals	62	64.5%	36.1%	59	28.3%
	Visual Acuity Referrals	0	N/A	N/A	0	N/A
40-69	Renewals	57	64.9%	10.9%	52	17.3%
	Road Test Referrals	114	59.0%	38.7%	114	25.9%
	Visual Acuity Referrals	3	N/A	N/A	3	N/A
70-96	Renewals	152	49.7%	19.7%	148	45.9%
	Road Test Referrals	148	60.3%	48.3%	144	63.1%
	Visual Acuity Referrals	55	41.1%	14.5%	52	40.0%
19-96	Participants	725			703	

[a] Due to a lack of insurance, the brake lights did not work, or other related matters, an SDPE could not be administered to every study participant.

Renewals aged 40-69 in this study had a 1-year crash rate similar to the one for drivers of that age shown in Janke et al. (2003); the oldest Renewals (70-96) in this study had a 1-year crash rate (6.6%) that was higher than the average population rate for that age bracket being roughly 27% to 61% higher than that reported by Janke et al. (2003) for all California drivers aged 70-74 (4.1%) and 85+ (5.2%). The relative crash rates of the three age groups in this study were essentially consistent with findings of Janke et al. and many other studies, which show that the youngest groups have the highest proportion, the oldest group the next highest, and the middle-aged group the lowest.

The following two figures, Figure 6 and Figure 7, show the age distributions of Renewals versus Road Test Referrals, and Renewals versus Visual Acuity Referrals, respectively, in the study sample. Elderly people predominate among both referral groups—especially Visual Acuity Referrals—and to a great extent because of RBM, as explained above, there are considerably fewer middle-aged Renewals than young or old ones. (Partly for this reason, many of the following figures contrast only the young and old groups.) The number of renewal applicants of a particular age found in a field office is, as indicated, influenced heavily by the department's

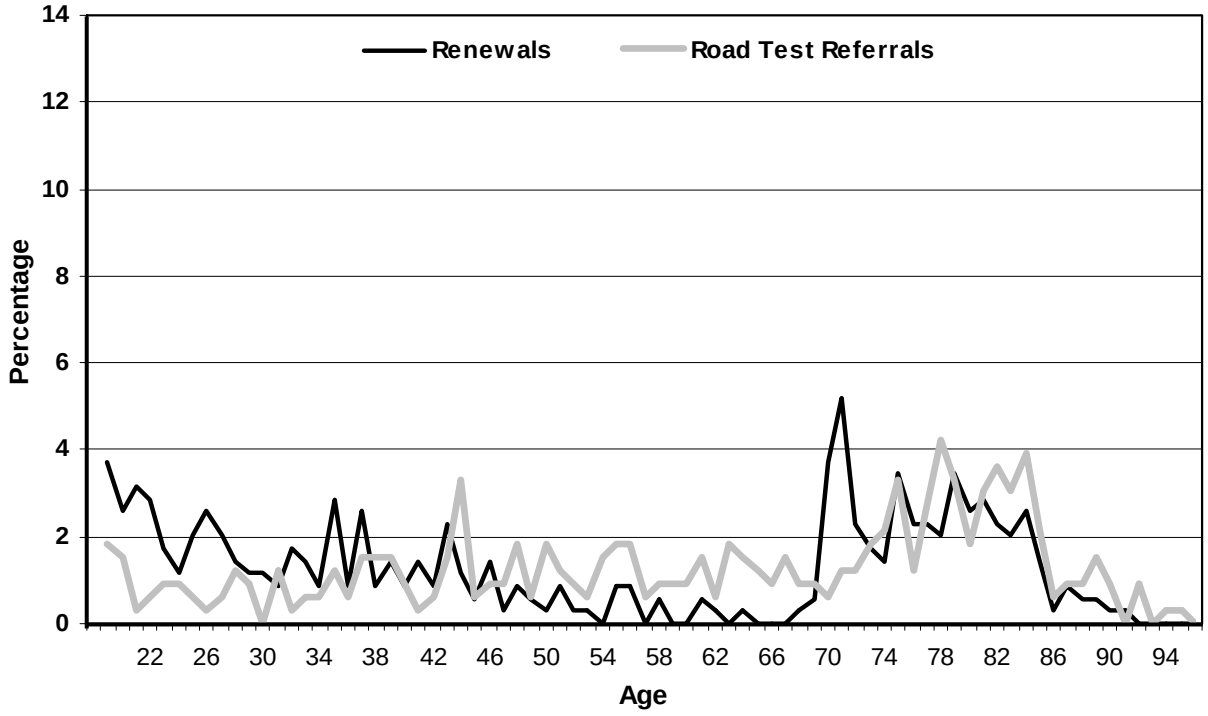

Figure 6. Age distributions of Renewals versus Road Test Referrals.

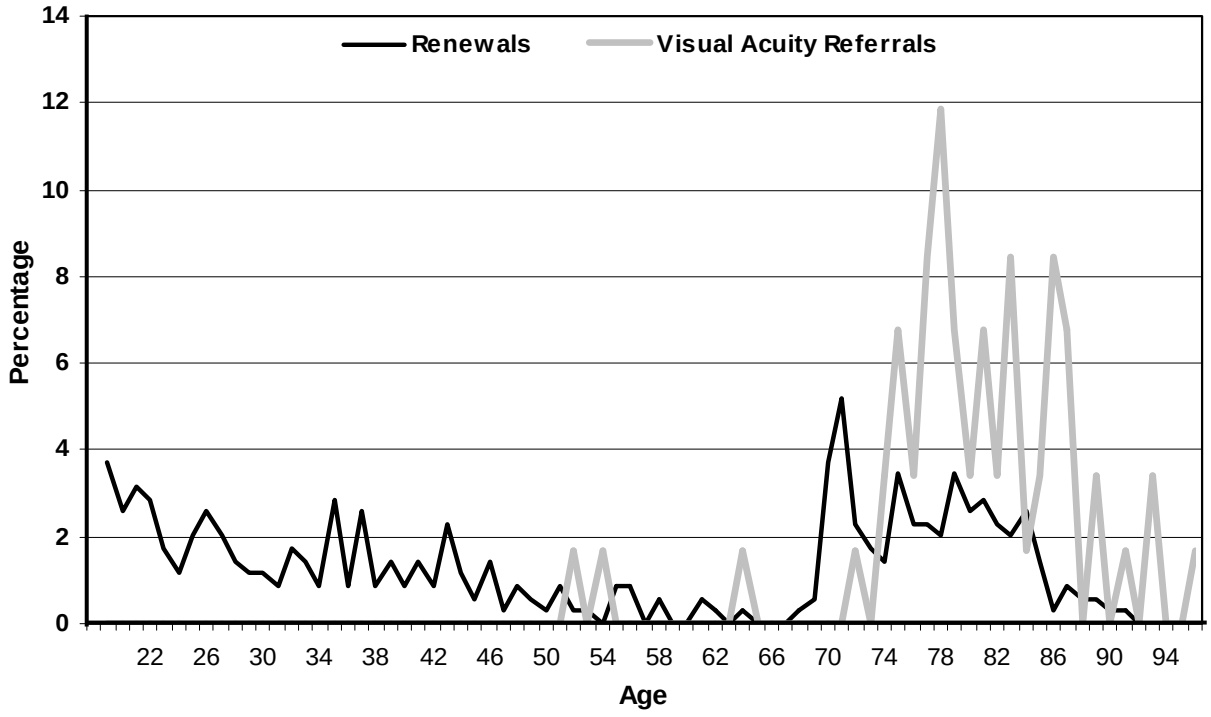

Figure 7. Age distributions of Renewals versus Visual Acuity Referrals.

RBM program. Young drivers will often not qualify for an RBM because of their driving records, while those aged 70 or more are not RBM eligible. On the other hand, the middle-aged group contains many drivers who do qualify and were therefore not available to participate in this study. Consistent with this is the predictable spike in the frequency curve for Renewals around age 72, perhaps the median age of people ineligible for RBM by virtue of age. (One might think the spike would be at age 70, but license expiration and the need to renew typically follow that age. If a person renews by mail at age 68, for example, there is generally no need to renew his or her license in a field office until it expires, when its owner has reached age 73.)

Erroneously Aggregating (Amalgamating) Older Drivers

The values of the Table 7 percentages reported for each of the three age groups are used to generally *describe* the three 3-Tier study samples, and can be helpful in ascertaining the representativeness of the study samples as was illustrated previously for crashes. In reporting these *descriptive* statistics the authors *do not assume* that the drivers in the three age groups in the three study samples are each functionally unitary, as discussed previously in the Introduction and Rationale (pp.43-44). For purposes of description and ascertaining the representativeness of the study samples, the drivers in the three age groups in the three study samples are not erroneously aggregated. As is explained in the next two paragraphs, this is not the case for the elder Renewals in Tables 8 and 9.

Table 8 shows, for the sampled Renewals in the three age groups, the means and standard deviations for the Tier-2 AT, PRT. If one's attention were to be predominantly focused on these means, one would note, consistent with expecting a gradual decline in *all* driving-relevant functional abilities with advancing age (see Introduction and Rationale, pp. 39-40), as age increases it takes more stimulus-presentation time, on average, for drivers to correctly identify a computer-projected silhouette as either a car or a truck. But that is *not* what happens, at least among older people healthy enough to be active drivers**.**

Table 8

Means and Standard Deviations for Sampled Renewals for the Three Age Groups on Perceptual Response Time

Perceptual response time (milliseconds)			
Age	*N*	Mean	Standard deviation
19-39	134	18.4	24.6
40-69	57	28.4	56.2
70-96	151[a]	48.8	86.0

[a] A PRT score is missing for one of the elderly Renewals.

Figure 4 (p. 83) shows the PRT frequency distributions for the youngest and oldest sampled Renewals. If PRT inevitably and gradually declines with age so that, everything else being equal, an older driver always performs worse (more slowly) than a younger one, then the 70- to 96-year-olds' distribution of scores should look something like the 19- to 39-year-olds' distribution, but shifted to the right far enough so that the two distributions do not overlap. Rather, what appears to be happening is that with increasing age there is an increasing proportion of drivers in the oldest group who are marginally limited in this respect—they may be suffering the onset of illness or injury—with some becoming extremely or severely limited. The other side of the coin is that with increasing age there is also a substantial proportion who remain functioning well enough for unconditional licensure, as far as their PRT performance is concerned. In fact, 37% of Renewals aged 70- to 96-years-old performed as well as the typical 19- to 39-year-old in scoring the shortest PRT achievable under the conditions of the test. Thus, with respect to Renewals' PRT, and between the age groupings studied here, *there is no inevitable gradual decline in functional ability*. **The overall observed decline in *mean* PRT with aging (Table 8) is an *artifact* produced by erroneously aggregating at least three functionally disparate populations: elderly Renewals who are PRT driving well, elderly Renewals who are severely functionally limited in how fast they can process visual information, and elderly Renewals who are marginally (somewhat) PRT-limited—which includes most of those who are experiencing the onset of illness or injury.** As discussed in the Introduction and Rationale, treating older drivers as though they are functionally unitary is no less an amalgamation error (cf. Gould, 1996) than lumping together in our contrived example the

20/100 patients with the 20/20 designated drivers. This common logical fallacy causes many researchers and others to lose sight of the substantial heterogeneity of older drivers.

Performance on another test, the Pelli-Robson test of contrast sensitivity, gives similar insights into erroneously aggregating older drivers. Table 9 shows the expected overall decline with aging in the mean number of letters read correctly on the Pelli-Robson test. In contrast, Figure 5 (p. 84) shows, for individuals in the youngest and oldest age groups, the number of letters identified correctly by each person on this test. While most of the elderly Renewals clearly had worse contrast sensitivity than the youngest ones, the modal difference was not great (see Figure 5 caption), and although 54.2% showed poor performance (defined as worse than the Pass cut score, see Methods), almost a fifth of the elderly Renewals (18.7%) were able to read letters in the last row of the reduced chart correctly. Thus, as was demonstrated for PRT, it appears that *there is no inevitable substantial decline associated with aging in Renewals' contrast sensitivity*.

Table 9

Means and Standard Deviations for Sampled Renewals for the Three Age Groups on Pelli-Robson Contrast Sensitivity

	Letters correct on Pelli-Robson Contrast Sensitivity test		
Age	*N*	Mean	Standard deviation
19-39	134	33.6	1.8
40-69	57	32.9	2.5
70-96	152	28.6	3.0

Face Validity of Non-Driving ATs

Appendix H lists and summarizes participants' and study staff's answers to the four test acceptability questions. Responses to the acceptability questions are only reported for the two novel AT tests (as opposed to the structured observations) that were finally recommended for inclusion in the 3-Tier system: the Pelli-Robson contrast sensitivity test and PRT. Acceptability questions were not asked about the visual acuity and knowledge tests that have been given for years to every license applicant. The Road Test Referrals' responses were very similar to the Renewals' responses. Visual Acuity Referrals' responses were very similar to those of Renewals on the PRT; however, as one might expect, the proportion of Visual Acuity Referrals (all of them

elderly) who answered "yes" to using the Pelli-Robson chart to "help DMV predict which people might have trouble driving" is somewhat smaller than that found for Renewals, about 75% compared to 90%. A similar drop was seen for the proportion of Visual Acuity Referrals indicating that "it would be fair to give drivers this kind of test to see if they should get restrictions on their licenses."

The response of Renewals was generally more favorable when asked whether the test was good and whether the instructions were easy to understand, than when asked whether it is useful to DMV in identifying people who "might have trouble driving," or is fair in making decisions about restrictions. For the test getting the highest ratings, the Pelli-Robson test, the pattern of responses was similar across all age groups. The percentage of favorable ratings (defined as definitely or probably yes) ranged from almost 90% to 100% over all four questions. The PRT, though still rated highly, had a somewhat smaller percentage of favorable ratings; these ranged from 70% to 100%. For this test, the ratings levels of the youngest and oldest participants were very similar to each other, and lower than the level of ratings for the middle-aged group. Nevertheless the pattern of ratings was similar, with more unfavorable answers given to the fairness question than to any other, regardless of participant age.

Like the participants, DMV staff (*N*=15: 19- to 39-year-olds and *N*=27: 40- to 69-year-olds) taking part in the study answered the same four questions. Percentages of favorable ratings were high overall. The Pelli-Robson test had favorable ratings over both age groups and across the four questions, ranging from about 85% to 100%. Ratings for the PRT were only slightly lower, ranging from about 74% to 100%, but the lower ratings appeared only in the younger staff group.

AT Intercorrelations

Tables 10 and 11 show, for Renewals and Road Test Referrals aged 70-96, intercorrelations between performance on the possible 3-Tier ATs, SDPE failure, and prior-3-year involvement in one or more crashes. The correlations for visual acuity referrals are not discussed here because of the small sample size. Correlation coefficients with a *p*-value less than .05 are bolded. Auto-Trails is not included because the test results were unstable, as discussed below. Only the oldest age group was used in determining intercorrelations, because AT performance of older drivers ranged from very poor to very good—unlike the generally good and much less variable AT performance of the younger participants. As mentioned in the table note, and for ease of interpretation, the number incorrect on the chart-based tests (number of letters or patches not correctly identified or not attempted) was used rather than the number correct.

Table 10

Pearson Correlation Coefficients Between Performance on Possible 3-Tier ATs, SDPE Failure, and 3-year Prior Involvement in One or More Crashes with the Corresponding *P*-values for **Renewals Aged 70- to 96-years-old (***N* = 152)

	SDPE Failure	Crashes	Snellen chart fail	Knowledge test errors	Physical limitation	Did not recall SSN	Failed intersection problem	Pelli-Robson letters incorrect	SKILL-dark letters incorrect	SKILL light-dark correct	FACT row 1 # incorrect	FACT row 2 # incorrect	PRT
SDPE fail	1.000	-.030 *p*=.718	.063 *p*=.451	**.382** ***p*=.000**	**.225** ***p*=.006**	.144 *p*=.080	.141 *p*=.087	.104 *p*=.208	.131 *p*=.112	.096 *p*=.248	**.207** ***p*=.012**	**.214** ***p*=.009**	**.295** ***p*=.000**
Crashed		1.000	-.090 *p*=.269	.089 *p*=.275	.040 *p*=.624	**-.177** ***p*=.028**	.089 *p*=.272	.117 *p*=.146	-.007 *p*=.933	-.018 *p*=.820	.109 *p*=.175	.098 *p*=.224	-.082 *p*=.312
Snellen chart fail			1.000	.043 *p*=.603	**.208** ***p*=.010**	.092 *p*=.256	**.198** ***p*=.014**	**.299** ***p*=.000**	**.351** ***p*=.000**	**.192** **.017**	.134 *p*=.097	**.320** ***p*=.000**	.134 *p*=.100
Knowledge test errors				1.000	.111 *p*=.170	.132 *p*=.103	.134 *p*=.100	.027 *p*=.739	.132 *p*=.103	-.021 *p*=.793	**.257** ***p*=.001**	**.200** ***p*=.013**	**.368** ***p*=.000**
Physical limitation					1.000	.056 *p*=.491	.028 *p*=.728	**.346** ***p*=.000**	**.240** ***p*=.003**	**.265** ***p*=.001**	**.322** ***p*=.000**	**.377** ***p*=.000**	**.218** ***p*=.007**
Did not recall SSN						1.000	**0.271** ***p*=.001**	.029 *p*=.717	-.036 *p*=.655	.011 *p*=.894	-.038 *p*=.640	-.026 *p*=.746	.022 *p*=.785
Failed intersection problem							1.000	.038 *p*=.635	-.043 *p*=.592	.064 *p*=.427	-.049 *p*=.545	.007 *p*=.929	.014 *p*=.867
Pelli-Robson letters incorrect								1.000	**.489** ***p*=.000**	**.395** ***p*=.000**	**0.568** ***p*=.000**	**.663** ***p*=.000**	.156 *p*=.056
SKILL-dark letters incorrect									1.000	**.653** ***p*=.000**	**0.395** ***p*=.000**	**0.499** ***p*=.000**	.152 *p*=.062
SKILL light-dark correct										1.000	**.318** ***p*=.000**	**0.393** ***p*=.000**	.095 *p*=.245
FACT row 1 # incorrect											1.000	**0.690** ***p*=.000**	**.405** ***p*=.000**
FACT row 2 # incorrect												1.000	**.269** ***p*=.001**
PRT													1.000

Note: To make it easier to interpret the correlation coefficients, the number incorrect on the chart-based tests (number of letters or patches not correctly identified or not attempted) was used rather than the number correct. Correlation coefficients with a *p*-value less than .05 are bolded.

Table 11

Pearson Correlation Coefficients Between Performance on Possible 3-Tier ATs, SDPE Failure, and 3-year Prior Involvement in One or More Crashes with the Corresponding *P*-values for **Road Test Referrals Aged 70- to 96-years-old** (*N* = 148)

	SDPE Failure	Crashes	Snellen chart fail	Knowledge test errors	Physical limitation	Did not recall SSN	Failed intersection problem	Pelli-Robson letters incorrect	SKILL-dark letters incorrect	SKILL light-dark correct	FACT row 1 # incorrect	FACT row 2 # incorrect	PRT
SDPE fail	1.000	-.095 *p*=.248	.148 *p*=.072	**.193** ***p*=.021**	.133 *p*=.105	.030 *p*=.716	.021 *p*=.796	.114 *p*=.165	.152 *p*=.064	.077 *p*=.353	.151 *p*=.067	0.161 *p*=.050	**.215** ***p*=.009**
Crashed		1.000	-.011 *p*=.890	.075 *p*=.375	-.021 *p*=.802	**-.212** ***p*=.009**	-.019 *p*=.812	-.084 *p*=.303	-.035 *p*=.668	-.030 *p*=.718	.024 *p*=.770	-.016 *p*=.844	-.044 *p*=.594
Snellen chart fail			1.000	.138 *p*=.100	.013 *p*=.875	.058 *p*=.479	.140 *p*=.086	**.317** ***p*=.000**	**.382** ***p*=.000**	**.351** ***p*=.000**	**.291** ***p*=.000**	**.394** ***p*=.000**	.120 *p*=.147
Knowledge test errors				1.000	.000 *p*=.997	**.166** ***p*=.047**	**.175** ***p*=.036**	.064 *p*=.449	.095 *p*=.256	.065 *p*=.441	.033 *p*=.693	.021 *p*=.799	.147 *p*=.081
Physical limitation					1.000	.064 *p*=.433	.057 *p*=.486	.103 *p*=.209	.112 *p*=.170	-.006 *p*=.942	0.189 *p*=.020	.103 *p*=.207	.103 *p*=.214
Did not recall SSN						1.000	**.195** ***p*=.016**	.022 *p*=.792	.049 *p*=.554	.033 *p*=.975	.064 *p*=.434	.001 *p*=.993	-.098 *p*=.236
Failed intersection problem							1.000	.020 *p*=.805	-.079 *p*=.338	-.018 *p*=.830	.036 *p*=.658	-.041 *p*=.620	.019 *p*=.814
Pelli-Robson letters incorrect								1.000	**.667** ***p*=.000**	**.554** ***p*=.000**	**.587** ***p*=.000**	**.605** ***p*=.000**	**.306** ***p*=.000**
SKILL-dark letters incorrect									1.000	**.785** ***p*=.000**	**.468** ***p*=.000**	**.575** ***p*=.000**	**.213** ***p*=.009**
SKILL light-dark correct										1.000	**.361** ***p*=.000**	**.491** ***p*=.000**	**.185** ***p*=.024**
FACT row 1 # incorrect											1.000	**.698** ***p*=.000**	**.231** ***p*=.005**
FACT row 2 # incorrect												1.000	**.200** ***p*=.015**
PRT													1.000

Note: To make it easier to interpret the correlation coefficients, the number incorrect on the chart-based tests (number of letters or patches not correctly identified or not attempted) was used rather than the number correct. Correlation coefficients with a *p*-value less than .05 are bolded.

For *both* the 70- to 96-year-old Renewals and Road Test Referrals, only scores for the knowledge test, FACT Row 2, and PRT are correlated—all positively—with failing the SDPE and only failing to recall SSN is correlated—*negatively*—with having crashed in the last 3 years[27]. The findings for knowledge-test errors are explored in depth in Table 23 (p. 126). The SSN finding may be consistent with study Hypothesis 4: compared to drivers assessed as extremely functionally limited, drivers assessed as somewhat functionally limited are substantially more likely to have been crash-involved in the last three years. The SSN findings are explored in Tables 19 (p. 113), 25, 26 (pp. 132 & 134).

The relatively high intercorrelations of performance among both the 70- to 96-year-old Renewals and Road Test Referrals on the Pelli-Robson chart, the SKILL card, and the FACT chart could be used to justify the use of any of these tests by the DMV as alternative means of measuring the same construct, contrast sensitivity.

Cut Scores for the Novel ATs

Table 12 contains the cut scores finally decided upon for the novel ATs (see Table 4 on p. 87 for scoring procedures). The cut scores for the ATs that yield continuous results were determined as described in the Methods.

Table 12

Cut Scores for the Novel Assessment Tools

Novel ATs	Pass	SFail	XFail
Physical limitation	0	1	2
Recall SSN	0	1	
Intersection problem	0	1	
Pelli–Robson letters correct	> = 30	< 30 & > = 24	< = 23
SKILL dark letters correct	> = 45	< 45 & > = 30	< = 29
SKILL light − dark	< = 28	> 28 & < = 36	> = 37
FACT row 1: patches correct	> = 8	< 8 & > = 6	< = 5
FACT row 2: patches correct	> = 8	< 8 & > = 6	< = 5
PRT	< = 23	> 23 & < = 40	> = 43

[27] Failing to recall SSN is associated with *not* having crashed in the last three years.

Relationship between DMV Cataract Policy and Cut Sores for Contrast Sensitivity Testing

As noted in the Methods section, even if a driver with an unoperated cataract passes the DMV 20/40 acuity screening standard after a DL62 referral, the DMV does not issue him or her a full-term license. Rather, the driver's license term is based on a vision specialist's identifying the condition as potentially progressive and is influenced by the specialist's estimate of when the driver's vision should be reevaluated, although DMV does not grant a limited license term of more than 2 years. Since cataract is a *progressive* clouding of the normally clear crystalline lens, and is one of the four most common sight-robbing conditions in older drivers (e.g., Jackson & Owsley, 2003), this policy can be considered reasonable. The policy is consistent with a cataract-affected driver—who may experience a kind of blurred or foggy contrast-poor vision due to light scattering within the lens—still attaining the 20/40 *high-contrast* acuity screening standard (e.g., Hess & Woo, 1978).

In the present study, 14 of the 59 Visual Acuity Referrals were able to pass the 20/40 acuity-screening standard when they returned from a vision specialist. Ten of these 14 drivers were diagnosed with cataract (sometimes in combination with another vision condition such as glaucoma). Using the cut scores described in Table 12, 8 of the 10 cataract-affected drivers failed the Pelli-Robson contrast sensitivity test, 5 failed FACT Row 1, and 6 failed FACT Row 2. Nine of the 10 drivers failed the dark side of the SKILL Card, and 7 failed the SKILL Card difference measure (light side score – dark side score). Based on the correlation coefficients reported in Tables 10 and 11, the Pelli-Robson chart, FACT, and SKILL are valid alternative methods of measuring contrast sensitivity (see Methods for a detailed description of these charts). The Pelli-Robson chart was finally selected over FACT as the preferred 3-Tier contrast sensitivity measure (see Recommendations); the finding that it was more sensitive than FACT in identifying participants with cataract supports the selection of the Pelli-Robson chart.

SDPE Usually Failed Due To SDPE Structured-Critical Driving Error (CDE)

Table 13 below shows the proportion of participants in the three age groups and three participant status groups (Renewals, Road Test Referrals, and Visual Acuity Referrals) who failed the SDPE by committing at least one structured-CDE. As shown in Appendix G, different kinds of SDPE structured-CDEs are operationally defined for the administration of the SDPE. The different kinds of structured-CDEs are listed separately on the left-hand side of the SDPE score sheet. Failure of the SDPE is almost always due to a SDPE structured-CDE. Although it is also possible to lose sufficient points to fail the test through committing 20 or more smaller errors,

only 4.2% of the participants failed on points alone in the study sample. The above values are comparable with those shown in Masten (1998).

Table 13

Number of SDPE Fails and Percent Who
Failed by Committing One or More SDPE Structured-CDEs

Age group	Participant	*N*	1 or more CDEs
19-39	Renewals	18	94.4%
	Road Test Referrals	17	100.0%
	Visual Acuity Referrals	0	N/A
40-69	Renewals	9	88.9%
	Road Test Referrals	30	93.3%
	Visual Acuity Referrals	1	N/A
70-96	Renewals	68	97.1%
	Road Test Referrals	94	95.7%
	Visual Acuity Referrals	22	95.5%

Pass/Fail Screening Characteristic Of Novel ATs Vis-à-Vis Performance on SDPE

Tables 14-17 summarize novel AT pass/fail screening characteristics (described in the Methods in relation to Table 5, p. 88) for elderly Renewals[28]. Table 14 compares the screening characteristics of seven possible Tier 1 ATs. Because the screening characteristics of FACT Row 2 were found to be substantially better than those of FACT Row 1, we only report the results for FACT Row 2. See Appendix I for further information than that summarized in Tables 14-17, including, for all three age categories and participant status groups, the *p*-values for the 2x2 Chi Square: AT (pass/fail) x SDPE (pass/fail). Odds ratios are also reported for the elderly Renewals in Appendix I. For comparison purposes, Appendix I also reports the values of the above measures for the DMV written knowledge test.

[28] As was noted with respect to the previously reported AT intercorrelations, only the oldest age group was used because AT performance of older drivers ranged from very poor to very good—unlike the generally good and much less variable AT performance of the younger participants. Only Renewals were used because unlike Road Test Referrals and Visual Acuity Referrals they must be screened on Tiers 1 and 2 for possible Tier 3 road testing.

Table 14

Pass/Fail Screening Characteristics of Possible Tier 1 ATs vis-à-vis SDPE Performance for **Renewals Aged 70- to 96-years-old**

Possible Tier 1 assessment tool (AT)	AT fail rate (95% CI)	Relative risk of failing SDPE (95% CI)	AT specificity proportion of SDPE passes who passed AT (95% CI)	AT sensitivity proportion of SDPE fails who failed AT (95% CI)
Physical limitation (physical)	.168 (.117 -.234)	**.708/.411 = 1.72 (1.24 - 2.40)**	.913 (.830 - .957)	.250 (.162 - .364)
Did not recall SSN	.174 (.123 - .242)	.615/.426 = 1.44 (1.00 - 2.08)	.875 (.785 - .931)	.235 (.150 - .349)
Intersection problem	.232 (.173 - .305)	.588/.421 = 1.40 (0.98 - 1.99)	.825 (.727 - .893)	.294 (.199 - .411)
Pelli-Robson letters correct	.542 (.463 - .618)	.500/.412 = 1.21 (0.85-1.74)	.500 (.393 - .607)	.588 (.467 - .697)
SKILL dark letters correct	.520 (.440 - .499)	.532/.381 = 1.40 (.974-2.01)	.550 (.441 - .654)	.603 (.484 -.711)
SKILL light - dark	Numbers are virtually identical to those for dark letters correct – see Appendix I-8			
FACT row 2	.626 (.547 - .698)	**.554/.303 = 1.83 (1.18-2.83)**	.488 (.381 - .595)	.750 (.636 - .838)

Note. See Table 5 (p. 88) for detailed definitions of screening characteristics. Relative risk values with a *P*-value less than .05 are bolded. A 95% CI for relative risk that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Table 15 compares selected possible combinations of the Tier 1 ATs. How the results of the different possible Tier 1 ATs were combined is described in the Methods (p. 86).

Table 15

Pass/Fail Screening Characteristics of Possible Tier 1 AT-Combinations vis-à-vis SDPE Performance for **Renewals Aged 70- to 96-years-old**

Possible Tier 1 AT combinations	AT fail rate (95% CI)	Relative risk of failing SDPE (95% CI)	AT specificity proportion of SDPE passes who passed AT (95% CI)	AT sensitivity proportion of SDPE fails who failed AT (95% CI)
Tier 1 (physical, SSN, P-R)	.639 (.561 - .710)	**.537/.321 = 1.67 (1.08 - 2.58)**	.450 (.346 - .559)	.750 (.636 - .838)
Tier 1 (physical, intersection, P-R)	.658 (.580 - .728)	**.541/.300 = 1.80 (1.14 - 2.86)**	.438 (.334 - .547)	.779 (.667 - .862)
Tier 1 (physical, SSN, intersect., P-R)	.690 (.614 - .758)	**.339/.183 = 1.85 (1.13 - 3.03)**	.400 (.300 - .510)	.809 (.700 - .885)
Tier 1 (physical, SSN, FACT row 2)	.703 (.625 - .771)	**.548/.250 = 2.19 (1.28 - 3.77)**	.413 (.311 - .522)	.838 (.733 - .907)
Tier 1 (physical, SSN, SKILL dark letters)	.626 (.545 - .700)	**.554/.309 = 1.79 (1.16 – 2.77)**	.481 (.374 - .590)	.750 (.636 - .838)

Note. See Table 5 (p. 88) for detailed definitions of screening characteristics. Relative risk values with a *P*-value less than .05 are bolded. A 95% CI for relative risk that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

In contrast to the ATs examined individually in Table 14, it is more likely that drivers will fail the SDPE if any one of the Tier 1 AT-combinations is failed than if a particular Tier 1 AT-combination is passed.[29] All of the Tier 1 AT-combinations have high sensitivities of almost 80% (proportion of SDPE fails who failed AT). This means that with any one of the possible Tier 1 AT-combinations, almost 80% of the elderly Renewals who would fail the SDPE road test would have failed Tier 1 and be required to go onto Tier 2. However, this is at the cost of low specificity (proportion of SDPE passes who passed AT), found to be about 44%, which is probably unacceptably low. What is needed, then, in Tier 2 assessment is to improve specificity by reducing the rate of false positives, while maintaining high sensitivity (see p. 88).

[29] All of the relative risk *p*-values are less than .05 for the corresponding 2x2 Chi Squares: AT (pass/fail) x SDPE (pass/fail), see Appendix I.

Table 16 explores PRT as the only novel AT for Tier 2.

Table 16

Pass/Fail Screening Characteristics of Possible Tier 2 AT vis-à-vis SDPE Performance for **Renewals Aged 70- to 96-years-old**

Possible Tier 2 AT	AT fail rate (95% CI)	Relative risk of failing SDPE (95% CI)	AT specificity proportion of SDPE passes who passed AT (95% CI)	AT sensitivity proportion of SDPE fails who failed AT (95% CI)
PRT	.342 (.271 - .421)	**.600/.392 = 1.53 (1.08 - 2.08)**	.747 (.676 - .813)	.441 (.359- .518)

Note. See Table 5 (p. 88) for detailed definitions of screening characteristics. Relative risk values with a *P*-value less than .05 are bolded. A 95% CI for relative risk that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Table 17 explores selected combinations of Tier 1 ATs and PRT**,** for their suitability in making up the Tier 1 and 2 ATs. Table 6 (p. 90) defines Screening Pass and Screening Fail.

Table 17

Pass/Fail Screening Characteristics of Possible Tier 1 AT-Combinations Combined with Tier 2 PRT vis-à-vis SDPE Performance for **Renewals Aged 70- to 96-years-old**

Selected combinations of Tier 1 ATs combined with Tier 2 PRT	AT fail rate (95% CI)	Relative risk of failing SDPE (95% CI)	AT specificity proportion of SDPE passes who passed AT (95% CI)	AT sensitivity proportion of SDPE fails who failed AT (95% CI)
Tier 1 (physical, SSN, P-R) & Tier 2 (PRT)	.379 (.306 - .458)	**.643/.352 = 1.83 (1.30- 2.49)**	.747 (.641 - .830)	.529 (.445 - .605)
Tier 1 (physical, SSN, FACT row 2) & Tier 2 (PRT)	.416 (.341 - .495)	**.705/.291 = 2.42 (1.68 - 3.50)**	.772 (.668 - .851)	.632 (.514 - .737)
Tier 1 (physical, SSN, SKILL dark letters) & Tier 2 (PRT)	.395 (.319 - .475)	**.621/.360 = 1.73 (1.23 – 2.43)**	.722 (.614 - .808)	.529 (.412 - .643)

Note. See Table 5 (p. 88) for detailed definitions of screening characteristics. Relative risk values with a *P*-value less than .05 are bolded. A 95% CI for relative risk that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Considering the estimated 95% confidence intervals for the various statistics shown in Table 17, the screening characteristics of the different possible Tier 1-Tier 2 combinations are very similar to one another. Regardless of which combination is selected:

- One can expect to identify, with any one of the Tier 1-Tier 2 combinations, at least half of the elderly Renewals who would fail the SDPE (by almost always making an SDPE structured-CDE [Table 13]) if they were road-tested with the SDPE. Once again, only the 70- to 96-year-old age group was examined, because most of the younger drivers pass the novel ATs. In fact, none of the Renewals aged 19- to 39-years-old and only 3.5% of those aged 40- to 69-years-old failed the selected Tier 1-Tier 2 combinations (see Appendix I).

- One can expect that about 75% of the elderly Renewals who could pass the SDPE will pass the Tier 1-Tier 2 combinations. This is consistent with the department's emphasis on minimizing "false positives," that is, minimizing the number of applicants who are misidentified as needing to be road tested, in this case 25% of the elderly Renewals (see Table 5, p. 88).

- One can expect that about 40% of the elderly Renewals would fail Tier1 and Tier 2 combined and be required to take a road test. This could be the SDPE or**,** for those who are identified as extremely functionally limited, it might be, as discussed in the Recommendations section, the department's ADPE. This is designed to evaluate drivers who can probably drive safely only in limited, familiar, and well practiced areas around their homes.

About 86% of elderly Renewal Screening Fails are expected to be XFails (Table 18). If all of the elderly Renewal Screening Fails were required to take the SDPE, rather than testing most of them on a content-valid ADPE, then about 64% (36/56)[30] of the above 40%, or about 26% of the elderly Renewals would fail the SDPE if, as in this study, they were *not* accorded relevant interventions.

[30] Estimate based on applying D/C+D in Table 5 (p. 88) to counts reported in Appendices I-15.

Proposed Tiers 1 and 2 ATs for Making a Driving-Centered Assessment of Driving Wellness

Criteria for deciding whether or not a particular AT should be considered for inclusion in Tiers 1 and 2 included the following:

- Time and cost to both DMV staff and customers**.** It was necessary to limit the number of ATs and the AT administration times to the minimum possible for valid and reliable assessment of driving wellness.

- Field-Office operational feasibility**.** A number of factors were considered in determining the operational feasibility of the non-driving ATs, including the time and effort involved in training DMV technicians to administer them, whether the AT had too high a likelihood of being damaged when used in a field office environment (the AT had to work reliably in the field office environment), and whether or not the AT required little technician effort to administer. On these grounds, a decision was made not to use the PC-based version of Doron Precision Systems' Critical Cue Recognition test (Cue III), because it did not work reliably. We also recommended that the Pelli-Robson chart rather than the FACT be chosen as the 3-Tier contrast sensitivity instrument because the FACT required considerable effort for technicians to learn and administer, making it less reliable in this setting than the Pelli-Robson chart. Also, FACT would require instructing each customer on unfamiliar testing procedures, while little if any such instruction was needed with the Pelli-Robson test. The Pelli-Robson chart was also chosen over the SKILL card, the low-luminance, low-contrast acuity test. Having to seat a customer 16 inches away from the SKILL card or having the customer hold the SKILL card in an operational field office environment makes damage likely. Finally, the intersection test was not operationally feasible because in administering this test, study MVFRs frequently mislaid the stopwatch required to time the customers' response to the intersection question.

- Resistance to learning effects**.** Schieber's Auto-Trails was not used because there was evidence that nonspecific learning, perhaps learning to search and scan the field more efficiently, occurred between the ascending (administered first) and descending (administered second) portions of the test. (The locations of specific stimuli could not be learned because the configurations of numbers to be sequenced in the two tasks were never the same.) Despite the expectation that the descending version, following an

ascending version, would be more difficult because of the need to switch response set, nonspecific positive-learning effects could be inferred from the fact that nearly 50% of renewal applicants did better on the descending than on the presumably less-challenging ascending task. Resistance of a licensing test to learning effects that may operate in retesting situations is important in the DMV field office, since repetition of such tests is almost unavoidable—for example, when an applicant challenges a test result. Nonspecific learning effects are less likely with PRT, which only demands recognition of a stimulus; therefore, retesting is not so problematical. PRT is not as complicated a task as Auto-Trails, and there is less scope for nonspecific learning. Nonetheless, it is true that during the PRT practice trials, examinees may identify and perhaps verbalize a critical defining feature of the car or truck stimulus, making their performance faster.

- Face validity**.** The desirability of a licensing test's *looking like* it is relevant to driving safely to both customers and staff is discussed in the Introduction and Rationale section.

Based on these considerations and the pass/fail screening characteristics summarized in Tables 14-17, Pelli-Robson Contrast Sensitivity along with the current Snellen tests of visual acuity as discussed in the Introduction and Rationale, Recall SSN, and Physical Limitation are the proposed ATs for Tier 1. PRT is proposed as one of the computer-based Tier 2 ATs, along with the current knowledge test as discussed in the Introduction and Rationale.

Table 18 presents, for elderly Renewals, correlations of the scores for each of the proposed Tier 1 and Tier 2 ATs with the score on Tiers 1 and 2 combined: PP was scored as 0, SFail was scored as 1, and XFail was scored as 2. Variation in the score for Tiers 1 and 2 combined was accounted for most strongly by variation in Pelli-Robson contrast sensitivity and Physical Limitation. These results show the level of association between individual ATs and the Tier 1 and 2 ATs combined.

Table 18

Pearson Correlation Coefficients and Corresponding *P*-Values for Individual ATs and Tiers 1 and 2 ATs Combined for **Renewals Aged 70- to 96-years-old** (*N*=137[a])

AT (AT range)	Correlation of AT with Tiers 1 and 2 combined (0,1,2)	Percent of variation in Tiers 1 and 2 combined accounted for by variation in AT[b]
Physical limitation (0, 1, 2)	**.523 p=.000**	27.3%
Recall SSN (0, 1)	**.410 p=.000**	16.8%
Pelli-Robson Contrast Sensitivity # incorrect[c] (0-16)	**.614 p=.000**	37.7%
PRT (16-500)	**.377 p=.000**	14.2%

Note. *P*-values less than .05 and the associated correlation coefficients are bolded.

[a] The 15 elderly renewals who passed Tier 1 and failed Tier 2 were excluded from this analysis.

[b] The Pearson correlation coefficient squared.

[c] Number of letters not correctly identified or not attempted.

Performance on Tiers 1 and 2 combined. The combined results of the proposed Tier 1 and Tier 2 novel ATs for each of the three age groups and participant statuses are summarized in Table 19. As indicated by Table 6 (p. 90), the projected proportion of Screening Fails can be obtained by adding the values for Tier 1 SFail, Tier 2 SFail's with those for Tier 1 &/or Tier 2 XFail's. For example, as shown in Table 19, 38.2 % (5.3%+32.9%) of the elderly Renewals are projected to be Screening Fails.

About 10 % of the elderly Renewals passed Tier 1 and then (in the study) SFailed or XFailed the Tier 2 PRT test (see Table 19). In practice, based on Tier 1 performance, such drivers in an operational system would *generally* not be required to complete the PRT part of Tier 2, and therefore, they would remain unidentified as possible candidates for an education intervention or possibly a content-valid road test. However, based on performance on the Tier 2 knowledge test, some yet-to-be determined percentage of these Tier 1 Pass, Tier 2 Fail Renewals *would be required* to take the PRT. As was indicated in the Introduction and Rationale (pp. 54-55), Renewals who pass Tier 1, but fail the knowledge test two or more times before passing it, would be required to take the PRT.

Table 19

Performance on Proposed Tiers 1 and 2 Combined[a] by Age and Participant Status

Age group	Study participant	*N*	Screening pass				Screening fail
			PP		SFail		XFail
			Tier 1 Pass, Tier 2 Pass	Tier 1 Pass, Tier 2 Fail[b]	Tier 1 SFail, Tier 2 Pass	Tier 1 SFail, Tier 2 SFail	Tier 1 &/or Tier 2 XFail[c]
19-39	Renewals	134	92.5%	1.5%	6.0%	0.0%	0.0%
	Road Test Referrals	62	77.4%	1.6%	17.7%	0.0%	3.2%
	Visual Acuity Referrals	0	N/A	N/A	N/A	N/A	N/A
40-69	Renewals	57	82.5%	3.5%	10.5%	0.0%	3.5%
	Road Test Referrals	114	52.6%	6.1%	16.7%	2.6%	21.9%
	Visual Acuity Referrals	3	N/A	N/A	N/A		N/A
70-96	Renewals	152	26.3%	9.9%	25.7%	5.3%	32.9%
	Road Test Referrals	148	10.1%	4.7%	22.3%	11.5%	51.3%
	Visual Acuity Referrals	55	0.0%	0.0%	20.5%	5.5%	72.7%

Note. Shown are % of *N*.

[a] Novel ATs.

[b] Failed Tier 2 PRT (either SFail or XFail).

[c] XFail on Tier 1 or Tier 2 or both.

In the 19- to 39-years-old age group, 8 Renewals, or 6%, SFailed Tier 1 and then passed Tier 2. None of the Tier 1 SFails went on to fail the PRT. In the smaller group of Road Test Referrals aged 19- to 39-years-old, 11 or 17.7%, a larger proportion, SFailed Tier 1 and then passed Tier 2. None of these Tier 1 SFails went on to fail the PRT either. (As discussed later in relation to Table 20, consistent with a Tier 1 SFail, Tier 2 Pass being defined as a Screening Pass, these and the other Tier 1 SFail, Tier 2 Pass's were found to be more likely than not to pass the SDPE.) All of these *young drivers* had one marginally-limited driving-relevant ability as assessed with the 3-Tier ATs. Therefore, as discussed in the Introduction and Rationale, they would be primary candidates for an educational intervention designed to teach them about (1) their specific limitation, (2) the types of driving conditions that are made more challenging for them by their limitation, and (3) ways of compensating for their respective limitations that cannot be corrected or remediated. The Tier 1 SFail, Tier 2 Pass's in the two older age groups as well as the Tier 1 SFail, Tier 2 SFail's[31] would also be primary candidates for an educational intervention. The *potentially* great value of an educational intervention for SFails (Tiers 1 and 2 combined) is suggested later in Table 21 (p. 121) by the substantially elevated crash involvement of elderly Renewal SFails.

Figure 8 shows the age distributions of Renewal PPs versus SFails. Figure 9 shows the age distributions of Renewal PPs versus XFails. XFails occurred only at the upper age ranges. In contrast, the distribution of SFails, shown in Figure 8, spans essentially the entire range of ages, but most of them also occurred in the upper age ranges. PPs also span almost the entire range of ages. These participants, who were free of the sorts of driving-relevant functional limitations assessed in Tiers 1 and 2, were found at ages ranging up to 87. In fact 26.3% (Table 19) of the elderly Renewals were found to be 3-Tier limitation-free.

[31] Recall that the Tier 1 SFail, Tier 2 SFail's were combined with Tier 1 SFail, Tier 2 Pass's to yield SFails (Tiers 1 and 2 combined) because compared to drivers who XFail on either Tier 1 or 2 or both, drivers who SFail on both Tiers 1 and 2 were deemed to be more like Tier 1 SFail, Tier 2 Pass's due to their likelihood of having little awareness of their functional limitations.

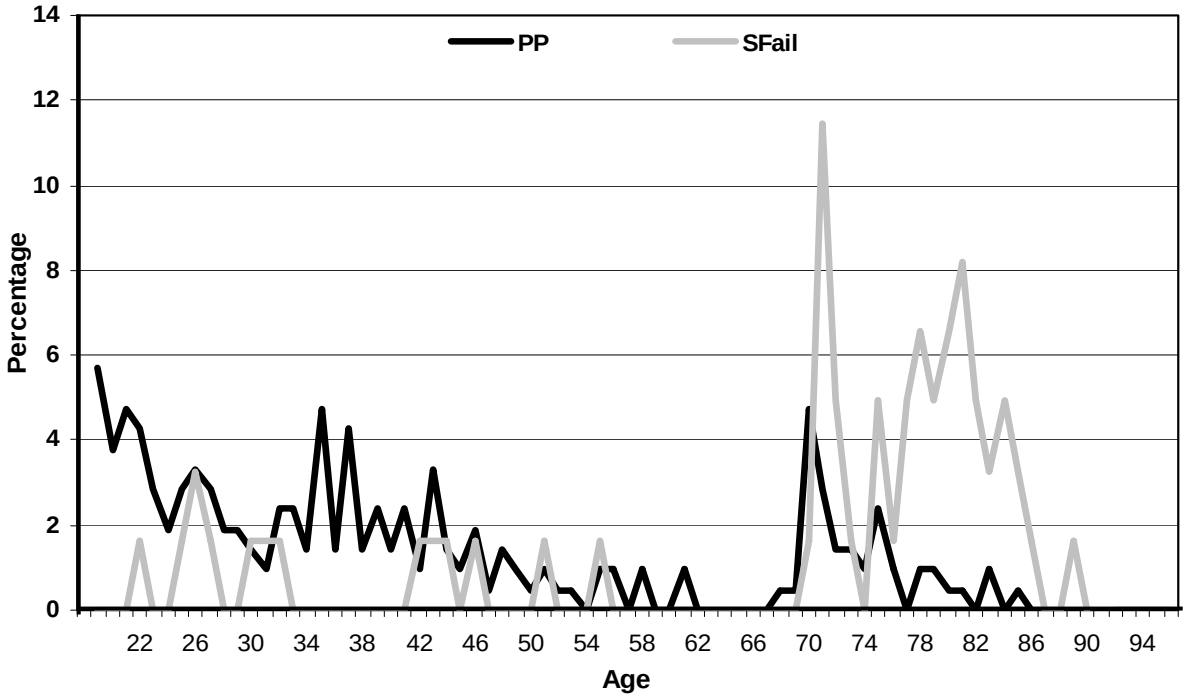

Figure 8. Age distributions of Renewal PPs vs. SFails.

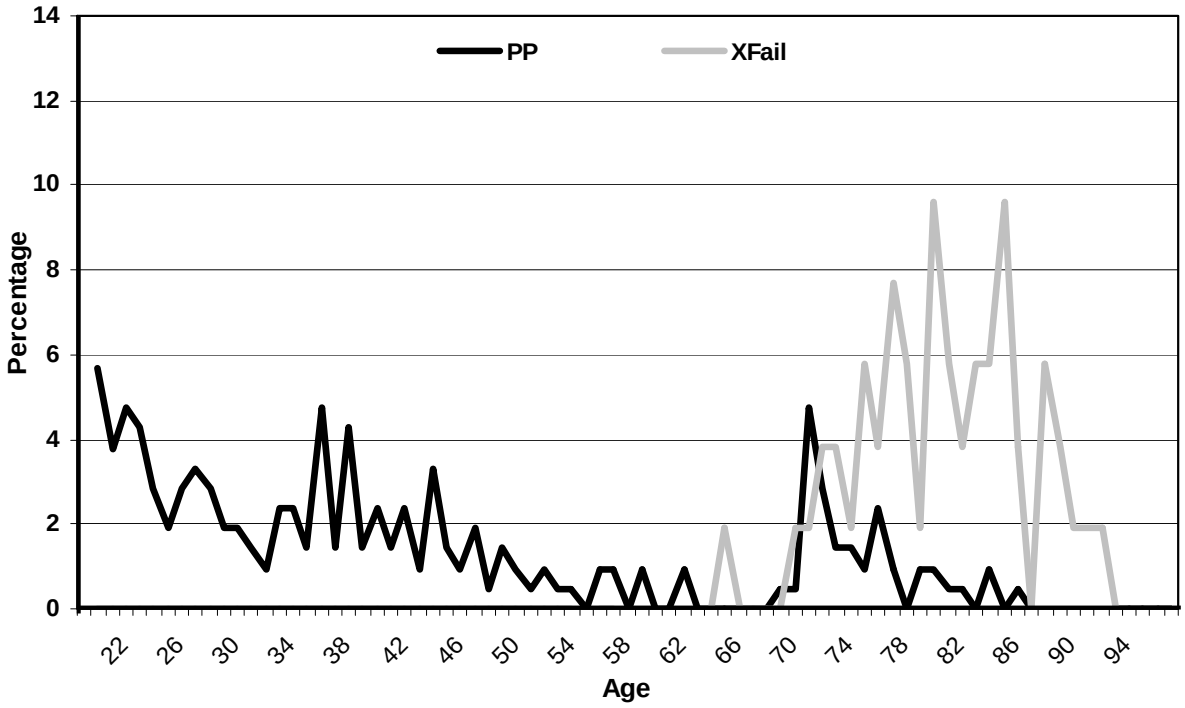

Figure 9. Age distributions of Renewal PPs vs. XFails.

Figures 10 and 11 give information similar to that in Figures 8 and 9, but for Road Test Referrals rather than Renewals. It is interesting to note a striking age mode of 45 among the Road Test Referral PPs, but hard to explain it without knowledge of who referred these drivers, and for what reason. Generally, Road Test Referrals come from physicians or other health care professionals because of a medical condition, or from law enforcement because of an egregious traffic error that might be due to chronic physical or mental limitations. Road Test Referrals are a less healthy group, overall, than Renewals, and it is not surprising to find that XFails younger than 50 can be found among them. In fact, both SFails and XFails were found at relatively young ages among Road Test Referrals, who differ from Renewals not only in their health-related manner of selection, but also because the under-representation of middle-aged drivers in the renewal sample, caused by renewal-by-mail, does not apply to Road Test Referrals. As with the Renewals, Road Test Referral PPs also span almost the entire range of ages, with 10.1% of the elderly Road Test Referrals (Table 19) found to be 3-Tier limitation-free (less than half this rate for elderly Renewals).

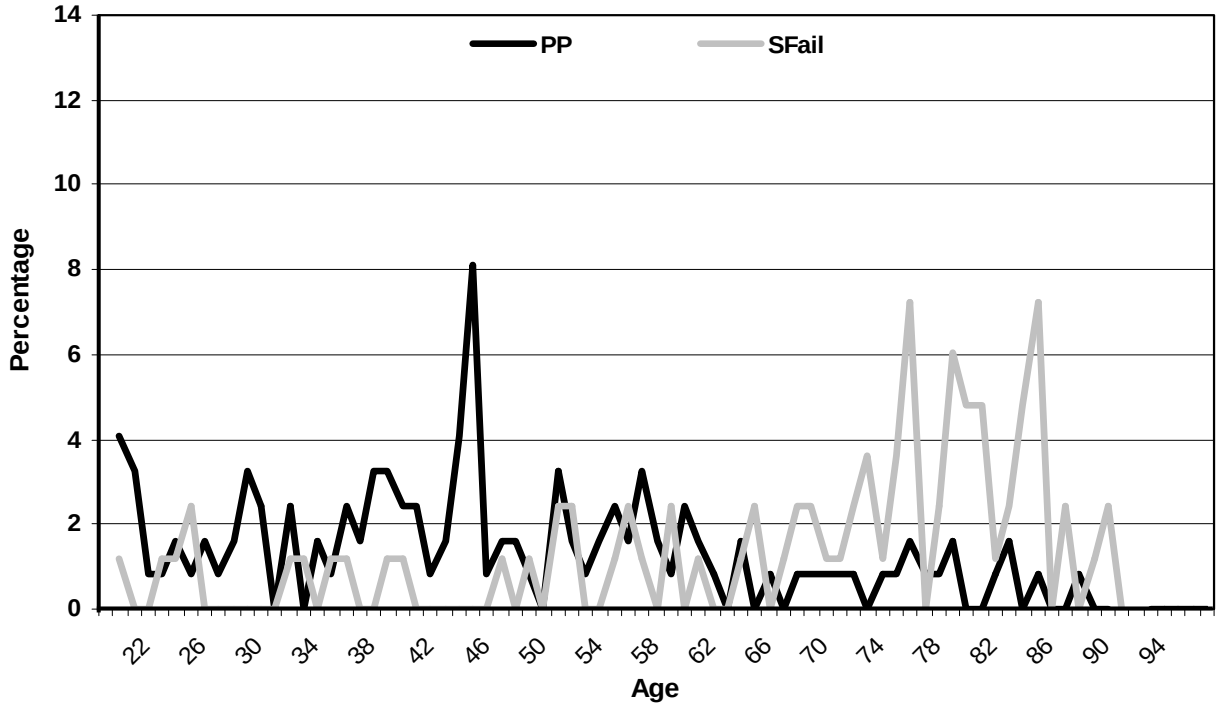

Figure 10. Age distributions of Road Test Referral PPs vs. SFails

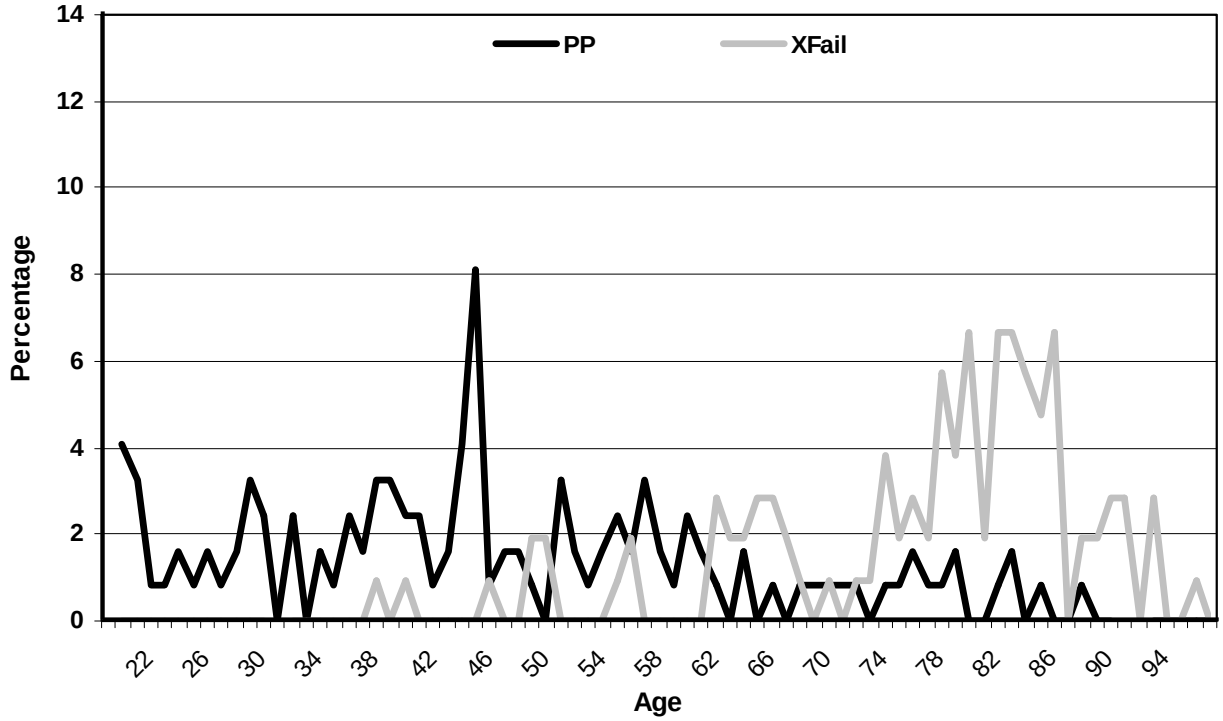

Figure 11. Age distributions of Road Test Referral PPs vs. XFails

Part II: Outcome Pattern Matching

Part II is divided into three major sections:

- Validating the Three Operationalizations for Making a Driving-Centered Assessment of Driving Wellness.
- Elderly Renewal PP, SFail and XFail Performance on Selected SDPE Elements.
- Evidence of Elderly Renewal XFails Differentially Compensating for Their Functional Limitations.

Validating the Three Operationalizations for Making a Driving-Centered Assessment of Driving Wellness

Outcome pattern matching

Outcome pattern matching was described in the Introduction and Rationale as a method for validating the operationalizations of the three functional categories: driving well (as PP), somewhat functionally limited (as SFail), and extremely functionally limited (as XFail). With regard to performance on a structured road test, it was hypothesized that:

1. Compared to driver-license-renewal candidates assessed as extremely functionally limited, renewal candidates assessed as driving well are substantially *less likely* to make a structured- CDE on an office-based structured road test (for examples of structured-CDEs, see Appendix G).

2. Compared to driver-license-renewal candidates assessed as extremely functionally limited, renewal candidates assessed as somewhat functionally limited are substantially *less likely* to make a structured-CDE on an office-based structured road test.

Table 20 gives the percentage of Renewals, Road Test Referrals, and Visual Acuity Referrals in the three study age groups who failed the SDPE (by almost always making an SDPE structured-CDE [Table 13]). The percentage failing the SDPE is reported separately for PPs, SFails and XFails (Table 6). Table 20 also shows (1) the differences between fail rates for XFails and PPs,

together with the *p*-value for the corresponding Pearson's 2x2 Chi-square: [SDPE Pass/ Fail] x [PP/XFail] and (2) the differences between fail rates for XFails and SFails, together with the *p*-value for the corresponding Pearson's 2x2 Chi-square: [SDPE Pass/ Fail] x [SFail/XFail]. SDPE fail rates increase by age group, and are consistently greater for Road Test Referrals than for Renewals (though "Visual Acuity Referrals," who tended to be found only among the oldest participants, are more similar to Renewals than to Road Test Referrals).

Table 20

Percentage Failing **SDPE** by Age Group, Participant Status, and Performance on Tiers 1 and 2 Combined[a]

Age group	Study participant	*N*	Total	PP	SFail	XFail	XFail – PP[b] *p*-value	XFail – SFail[b] *p*-value
19-39	Renewals	131	13.7%	13.3%	N/A	N/A	N/A	N/A
	Road Test Referrals	59	28.3%	29.8%	18.2%	N/A	N/A	N/A
	Visual Acuity Referrals	0	N/A	N/A	N/A	N/A	N/A	N/A
40-69	Renewals	52	17.3%	13.6%	N/A	N/A	N/A	N/A
	Road Test Referrals	114	25.9%	20.0%	36.4%	36.0%	+16.0 .119	-0.4 .979
	Visual Acuity Referrals	3	N/A	N/A	N/A	N/A	N/A	N/A
70-96	Renewals	148	45.9%	31.6%	41.3%	66.0%	**Hypothesis 1** **+34.4** **.002**	**Hypothesis 2** **+24.7** **.017**
	Road Test Referrals	144	63.1%	53.3%	46.0%	72.4%	+19.1 N/A	**+26.4** **.003**
	Visual Acuity Referrals	52	40.0%	N/A	35.7%	42.5%	N/A	+7.8 .657

Note. *P*-values less than .05 and the associated difference values are bolded. "N/A" in this table indicates that either a percentage is not available because the *N* for that cell was less than 8 or a *p*-value is not available because one or more of the 2x2 Chi Square cells have an expected count less than 5.

[a] See Table 6, p. 90.

[b] Absolute percentage difference.

The differences in SDPE fail rates in the elderly Renewals between XFails and PPs and between XFails and SFails are consistent with hypothesized outcomes 1 and 2 above. That is, the SDPE fail rate for elderly Renewals who were assessed as extremely functionally limited is significantly higher than the fail rates for elderly Renewals who were assessed as driving well or somewhat functionally limited.

Not shown in Table 20 is that, consistent with a Tier 1 SFail, Tier 2 Pass being defined as a Screening Pass (Table 6, p. 90), the SDPE fail rates for Tier 1 SFails who passed Tier 2 are all *under* 50% (18.2%-39.5%). Furthermore, consistent with a Tier 1 SFail, Tier 2 SFail being defined as a Screening Fail (Table 6, p. 90), the SDPE fail rates for the elderly Renewals and Road Test Referrals who SFailed both Tiers 1 and 2 (see Table 19) are 50% and 64.7% respectively.

With regard to crash involvement, it was hypothesized that:

3. Compared to driver-license-renewal candidates assessed as driving well, renewal candidates assessed as extremely functionally limited are *no more likely* to have been crash-involved in the prior 3 years.

4. Compared to driver-license-renewal candidates assessed as extremely functionally limited, renewal candidates assessed as somewhat functionally limited are substantially *more likely* to have been crash-involved in the prior 3 years.

Table 21 gives the percentage of Renewals, Road Test Referrals, and Visual Acuity Referrals in the three study age groups who crashed at least once in the 3 years prior to study participation. The percentage who crashed is reported separately for PPs, SFails and XFails. Table 21 also shows (1) the differences between crash rates for XFails and PPs, together with the *p*-value for the corresponding Pearson's 2x2 Chi-square: [Crash Involved Yes/ No] x [PP/XFail] and (2) the differences between crash rates for XFails and SFails, together with the *p*-value for the corresponding Pearson's 2x2 Chi-square: [Crash Involved Yes/ No] x [SFail/XFail].

As previously noted, when looking at Renewals it is not surprising to find that the youngest group had the worst crash record, followed by the oldest, and then the middle-aged groups. Road Test Referrals in each age group had worse crash records than Renewals, again not surprising due to the fact that one of the reasons for becoming a Road Test Referral is involvement in a crash which has questionable features that motivates the investigating officer to

make the referral. The 1 percentage point difference between elderly Renewal XFails and PPs (see also Figure 12), which is not statistically significant at the .05 level, and the difference in crash rates in the elderly Renewals between XFails and SFails, which closely approaches but does not reach statistical significance at the .05 level, are consistent with hypothesized outcomes 3 and 4, respectively.

Table 21

Percentage **Crashing** At Least Once in the 3 Years Prior to Study Participation by Age Group, Participant Status, and Performance on Tiers 1 and 2 Combined[a]

Age group	Study participant	*N*	Total	PP	SFail	XFail	XFail – PP[b] *p*-value	XFail – SFail[b] *p*-value
19-39	Renewals	134	28.8%	30.6%	0.0%	N/A	N/A	N/A
	Road Test Referrals	62	36.1%	33.3%	45.5%	N/A	N/A	N/A
	Visual Acuity Referrals	0	N/A	N/A	N/A	N/A	N/A	N/A
40-69	Renewals	57	10.9%	8.5%	N/A	N/A	N/A	N/A
	Road Test Referrals	114	38.7%	35.0%	50.0%	37.5%	2.5 .930	-12.5 .393
	Visual Acuity Referrals	3	N/A	N/A	N/A	N/A	N/A	N/A
70-96	Renewals	152	19.7%	15.0%	29.8%	14.0%	**Hypothesis 3** -1.0 .893	**Hypothesis 4** -15.8 .059
	Road Test Referrals	148	48.3%	53.3%	52.0%	44.9%	-8.4 .542	-7.1 .431
	Visual Acuity Referrals	55	14.5%	N/A	21.4%	12.2%	N/A	-9.2 N/A

Note. "N/A" in this table indicates that either a percentage is not available because the *N* for that cell was less than 8 or a *p*-value is not available because one or more of the 2x2 Chi Square cells have an expected count less than 5.

[a] See Table 6, p. 90.

[b] Absolute percentage difference.

Finding, as hypothesized, an elevated crash rate in elderly Renewal SFails over both PPs and XFails is consistent with the three education objectives of identifying somewhat functionally-limited drivers: educating them about (1) their specific limitation(s)[32], (2) the types of driving conditions that are made more challenging for them by their limitation(s), and (3) ways of compensating for their limitation(s). Please note that even if a driving-relevant functional ability becomes extremely limited, this type of educational intervention might still generally improve driving fitness over what it would otherwise be. Relative to SFails, even though the crash involvement percentage for elderly Renewal XFails is relatively low at 14.0%, there still may be a role for further training in compensating or more stringent license restriction.

Figure 12 summarizes for elderly Renewals assessed as "driving well", "somewhat functionally limited" and "extremely functionally limited" the percentage failing the SDPE and the percentage who crashed at least once in the 3 years prior to study participation. It illustrates the hypothesized opposite-outcome patterns for performance on a structured road test and real-world crashes (p. 57). More specifically, Figure 12 illustrates the hypothesized *similar*-crash rates for the driving well and the extremely functionally-limited elderly Renewals (Hypothesis 3), as well as the substantially elevated crash rate for the somewhat functionally-limited elderly Renewals (Hypothesis 4). And finally, it illustrates XFails having higher SDPE fail rates than both PPs (Hypothesis 1) and SFails (Hypothesis 2).

The chances are small (see difference values and *p*-values in Tables 20 and 21) that the data summarized in Figure 12 are consistent with the two study null hypotheses. In particular, it is not likely that a chance or sampling-error explanation could account for the finding that elderly Renewal SFails have, as hypothesized, a substantially greater (not smaller, as is generally assumed) crash rate than XFails. *These results confirm this study's operationalizations of "driving well," "somewhat functionally limited," and "extremely functionally limited" (this includes the selection of specific ATs, the scoring procedures, the cut scores, and the way of combining the results of the ATs).*

Excluding Xfails from calculating Pearson correlation coefficients

Related to the above-described opposite-outcome validation strategy is the general *driving-centered* prediction made in the Introduction and Rationale that there should be a more positive correlation between AT performance (scored in terms of errors) and crash involvement when

[32] Some of the SFails have two marginally-limited abilities—Tier 1 SFail, Tier 2 SFail's.

XFails are *excluded* from calculating Pearson correlation coefficients—even though this means a smaller sample and, by definition, a more restricted range of functional limitation. Conversely, the opposite should be the case for correlations of AT performance with SDPE performance.

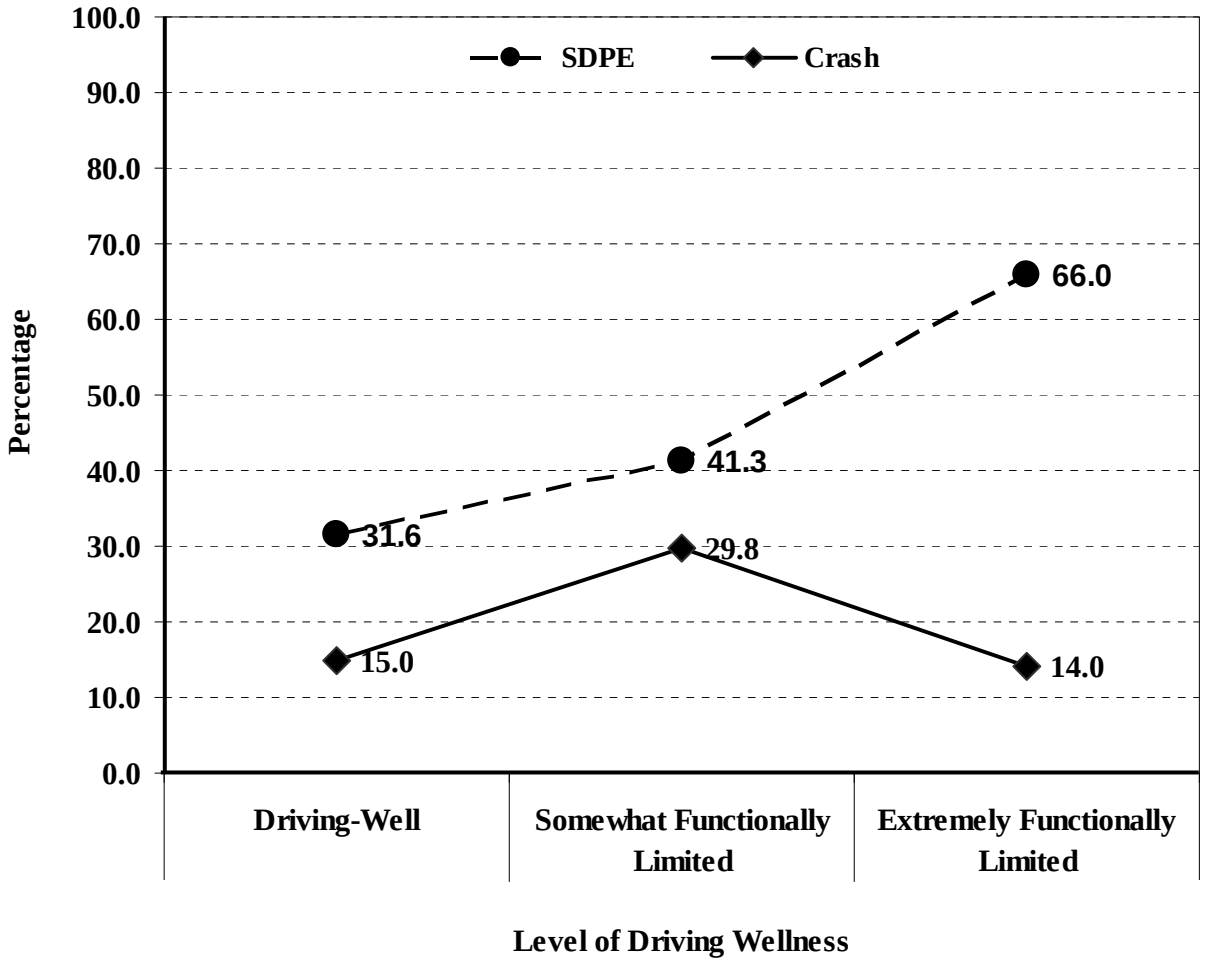

Figure 12. Percentage of Renewals Aged 70- to 96-years-old failing the SDPE and the percentage who crashed at least once in the 3 years prior to study participation.

Table 22 explores these predictions for elderly Renewals. As was done in calculating the correlation coefficients in Table 18, the 15 elderly Renewals who passed Tier 1 and failed Tier 2 (see Table 6, p. 90) were excluded from the calculations summarized in Table 22.

Table 22

Pearson Correlation Coefficients and Corresponding *P*-Values for ATs With SDPE Failure and Having Crashed—Including and Excluding XFails—for **Renewals Aged 70- to 96-years-old** (*N*=137[a])

AT **(AT range with/without XFails)**	SDPE failed (0, 1)		Crashed (0,1)	
	N = 137 includes XFails	*N* = 87 excludes XFails	*N* = 137 includes XFails	*N* = 87 excludes XFails
Physical limitation (0, 1, 2)/(0, 1)	**.229** **.009**	.144 .193	.030 .728	-.059 .588
Recall SSN (0, 1)/(0, 1)	.142 .107	.037 .737	**-.199** **.020**	-.162 .135
Pelli-Robson Contrast Sensitivity **# incorrect** (0-16)/(0-12)	.064 .469	.031 .780	.114 .185	**.217** **.044**
PRT (16-500)/(16-40)	**.308** **.000**	.063 .571	-.075 .385	.080 .462
PP vs. SFail (vs. XFail) (0, 1, 2) /(0, 1)	**.281** **.001**	.100 .364	-.022 .798	.175 .105

Note. *P*-values less than .05 and the associated correlation coefficients are bolded.

[a] The 15 elderly renewals who passed Tier 1 and failed Tier 2 were excluded from this analysis.

Consistent with Table 10 (p. 101), Table 22 shows a substantial *negative* correlation between SSN recall and crash involvement when XFails are *included*, but *much less so when they are excluded*.[33] This result is consistent with Hypothesis 4 which states that compared to driver-license-renewal candidates assessed as extremely functionally limited, renewal candidates assessed as somewhat functionally limited are substantially *more likely* to have been crash-

[33] This is not to imply that the two Pearson correlation coefficients are necessarily significantly different from each other.

involved in the prior 3 years. Also consistent with Hypothesis 4 is finding that the *positive* correlation between crash involvement and Pelli-Robson contrast sensitivity is substantially more positive when XFails are excluded than when they are included. Table 22 also shows that, consistent with Hypotheses 1 and 2, the three positive correlations between SDPE failure and (1) Physical Limitation, (2) PRT, and (3) performance on Tiers 1 and 2 combined are substantially more positive when XFails are *included* in the analysis than when they are excluded. The positive correlations between SDPE failure and Recall SSN and Pelli-Robson Contrast Sensitivity are also more positive, but to a lesser degree. *Altogether, the results summarized in Table 22 further confirm the three operationalizations for assessing driving wellness.*

Elderly Renewal PP, SFail, and XFail Performance on Selected SDPE Elements

Table 23 shows the percentage of elderly Renewal PPs, SFails, and XFails (Tiers 1 and 2 combined), who scored one or more errors on the Multiple Directions or Way Finding SDPE elements, or made one or more hazardous structured-CDEs on the SDPE. As described in the Methods section, Multiple Directions, Concentration, and Way Finding were designed to test cognitive functioning, though the Concentration element was not included in Table 23 because the error rates were generally very low. Hazardous structured-CDEs are a subset of the possible kinds of structured-CDEs that can be made on an SDPE. The subset consists of those errors that the examiner records as a "dangerous maneuver," plus those requiring examiner intervention (Appendix G). The first three columns in the second row of Table 23 should be interpreted as indicating, for example, that 13.2% of the 40 PPs in the elderly-Renewal group made an error on the Way Finding task, as did 17.4% of SFails and 29.8% of XFails.

Table 23

Percent Who Performed as Indicated on Selected SDPE Elements by Performance on Tiers 1 and 2 Combined (PP, SFail, and XFail) for **Renewals Aged 70- to 96-years-old** (*N*=137[a])

	PP *N* = 40	SFail *N* = 47	XFail *N* = 50	SFail – PP[b] *p*-value	XFail – SFail[b] *p*-value
Multiple directions: 1 or more errors	21.1%	26.1%	48.9%	5.0 .590	**22.8** **.023**
Way finding: 1 or more errors	13.2%	17.4%	29.8%	4.2 .593	12.4 .160
Hazardous structured-CDE: 1 or more	10.5%	21.7%	48.9%	11.2 .170	**27.2** **.006**

Note. *P*-values less than .05 and the associated difference values are bolded.

[a] The 15 elderly renewals who passed Tier 1 and failed Tier 2 were excluded from this analysis.

[b] Absolute percentage difference.

The last two columns of the table show the differences in error rates between SFails and PPs and between XFails and SFails, together with the *p*-values for the two corresponding Pearson's 2x2 Chi Squares: [SDPE Element: No Errors/ Error(s)] X [PP/SFail] and [SDPE Element: No Errors/ Error(s)] X [SFail/XFail].

In agreement with the reasoning in the Introduction and Rationale, Table 23 indicates that a functional limitation(s) is chiefly a problem on the SDPE when it is extreme—that is, at the XFail level. The differences between XFail and SFail, and the corresponding *p*-values for Multiple Directions and Hazardous CDEs, are evidence for that. The results for Way Finding are consistent directionally with the other two SDPE elements; however they are not nearly as great.

From Tables 20 and 21, it has already been seen that, even though they crashed at a similar low rate as PPs, elderly Renewal XFails were more likely than PPs to fail the SDPE and, moreover, to fail by committing a structured-CDE, hazardous or not, as shown in Table 13 (p. 105). Relative to the other two groups, Table 23 shows that XFail structured-CDEs were substantially more likely to be hazardous ones. XFails were also found to be substantially more likely to have problems with short-term memory as indicated by findings on the Multiple Directions element.

Evidence of Elderly Renewal XFails Differentially Compensating for Their Functional Limitations

As discussed in the Introduction and Rationale (pp. 46-47), the proportion of extremely functionally-limited drivers who crashed was hypothesized to be relatively low because they would be *knowledgeably* compensating for their functional limitations. According to this supposition, restricting themselves to familiar and well-practiced routes near home and/or avoiding a wide variety of specific driving tasks and driving environments/conditions would also have the non-specific effect of reducing the quantity of their driving and thus reduce their level of exposure to crash risk. There is some evidence bearing on these two expectations (XFails knowledgeably compensating and XFails reducing the quantity of their driving) acquired from the Driving Information Survey (Appendix A) and from drivers declining the freeway portion of the SDPE. While survey responses should never be taken as wholly reliable, since people can err or be untruthful, this sort of evidence can at least be regarded as an indicator with an unknown, though not necessarily low, reliability.

Figure 13 gives the frequency distributions of reported days driving per week (a measure of driving quantity) for elderly renewal PPs, SFails, and XFails. The reported number of days driving for XFails is certainly less than that reported for PPs, who have a very prominent mode of 7 and a small representation on the other days. But it is not clear that XFails report driving fewer days in a week than SFails, who have a much less prominent mode of 7 compared to PPs, but also frequently report 5 and 6. The XFail distribution of days driving is more bimodal than the other two, with its most prominent mode at 7 and a less prominent mode at 3. The median drops from 7 days for PPs to 6 days for SFails and to 5 days for XFails but, looking at the distribution of their survey responses, it cannot be simply concluded that XFails drive fewer days than SFails, who have a much higher crash rate. Nonetheless, the XFail mode of 3 days is consistent with a subgroup of XFails having greatly reduced the quantity of their driving, and therefore, their level of exposure to crash risk. The paucity of crashes among XFails overall may be due in part to the low level of exposure of these drivers. It should be emphasized that the number of days per week on which driving occurs may not be the best measure to use as a gauge of how much one drives, even though it is relatively easy to estimate compared to miles driven per week. For example, a report of "5 days" might indicate single short trips in light traffic on those 5 days or multiple, more extensive trips on each of the days.

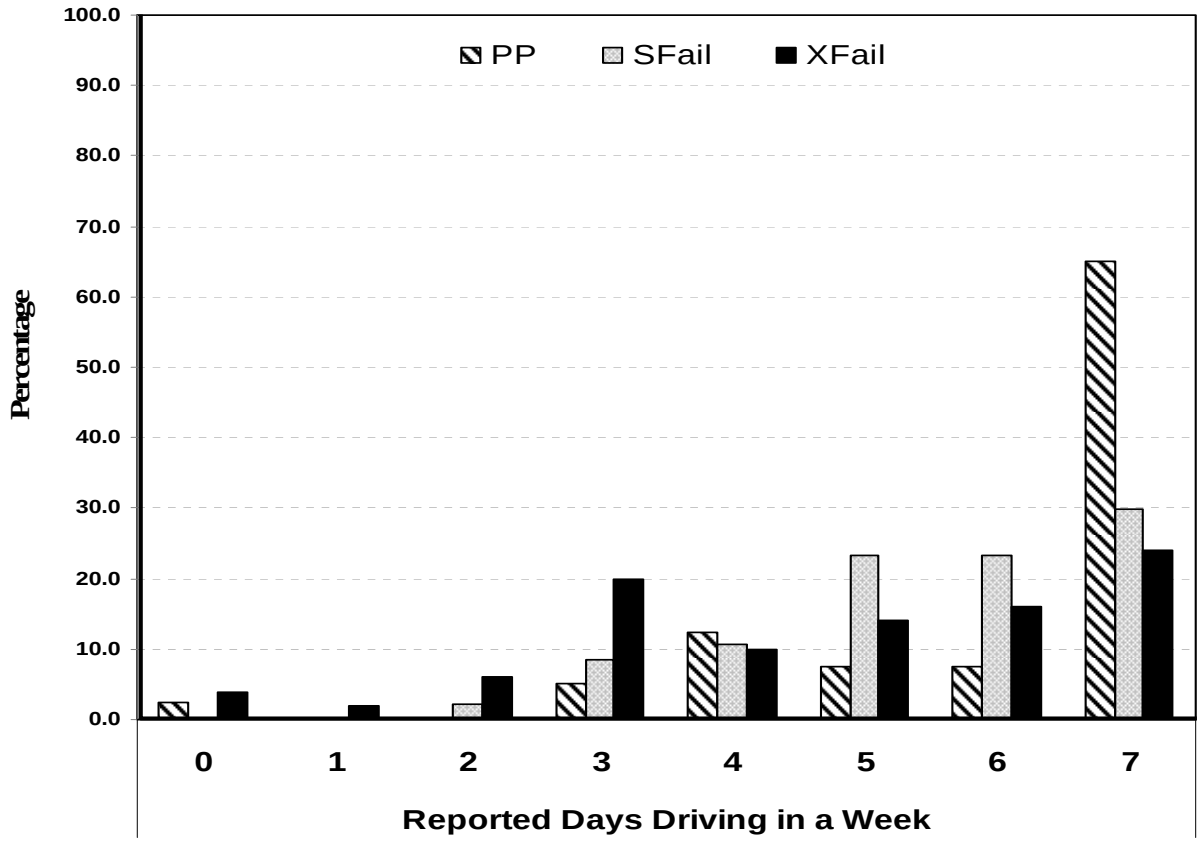

Figure 13. Percentage of reported days driving in a week for 70- to 96-year-old Renewal PPs, SFails and XFails. Total percentage equals 100% for each Renewal subgroup.

Table 24 addresses the question: What tactics do XFails use, substantially more than SFails, which could explain their substantially lower crash rate? It is these tactics that could be prescribed in conditional licensure and in educating SFails. Table 24 shows the percentage of elderly Renewal PPs, SFails, and XFails (Tiers 1 and 2 combined) who declined real-world freeway driving on the SDPE, or reported often/always avoiding various maneuvers, conditions, and situations. Table 24 can be interpreted similarly to Table 23. For example, 7.5% of PPs reported avoiding freeways often or always, and 10.5% actually declined to be assessed on the freeway during the SDPE. For some drivers, this may suggest either greater avoidance than reported, for whatever reason, or reluctance to be tested in a freeway situation, where traffic may be fast and merging-on may be difficult. The last two columns of the table show the differences in avoidance rates between SFails and PPs and between XFails and SFails, together with the *p*-values for the two corresponding Pearson's 2x2 Chi Squares: [Avoidance High/Low] X [PP/SFail] and [Avoidance High/Low] X [SFail/XFail]. As discussed in the Methods, even though freeway driving is a standard part of the SDPE, drivers can refuse to go on the freeway,

Table 24

Percent of **70- to 96-years-old** (*N*=137[a]) Renewal PPs, SFails, and XFails Who Declined Freeway Portion of SDPE (first row) or Reported Often/Always Avoiding Various Maneuvers, Conditions and Situations

	PP *N* = 40	SFail *N* = 47	XFail *N* = 50	SFail – PP[b] *p*-value	XFail – SFail[b] *p*-value
SDPE:					
Declined freeway portion of SDPE	10.5%	8.7%	27.7%	-1.8 .776	**19.0** **.018**
Reported often/always avoiding:					
Freeway	7.5%	19.1%	34.7%	11.6 .116	15.6 .087
Sunrise/sunset glare	2.5%	10.6%	20.8%	8.1 .135	10.2 .173
Left-hand turns	7.5%	14.9%	22.9%	7.4 .281	8.0 .318
Rain or fog	12.5%	29.8%	22.4%	17.3 .052	-7.4 .413
Heavy traffic	12.5%	29.8%	20.4%	17.3 .052	-9.4 .289
Night driving	15.0%	27.7%	30.6%	12.7 .154	2.5 .750
Driving alone	5.0%	6.4%	10.4%	1.4 .782	4.0 .620
Unfamiliar routes	17.5%	21.3%	26.5%	3.8 .658	5.2 .547

Note. The one *p*-value less than .05 and the associated difference value are bolded.

[a] The 15 elderly renewals who passed Tier 1 and failed Tier 2 were excluded from this analysis.

[b] Absolute percentage difference.

and in that case they cannot be licensed without a license restriction prohibiting freeway driving. It is important to note that elderly Renewals who refused to go on the freeway, despite the fact that they thereby performed fewer maneuvers on the SDPE that could be scored and thus had fewer opportunities to make errors, were more likely to fail the SDPE than similar elderly Renewals who agreed to be assessed on the freeway (73.9% for refusers vs. 40.8% for consenters, $p = .003$). Since almost all of those who failed did so by making a structured-CDE, this means that elderly Renewals who refused to go on the freeway were more likely to make a structured-CDE on the SDPE. A similar difference in structured-CDE rates was found for elderly Renewals reporting "often or always" avoiding freeway driving on the survey (65.5%) versus the others reportedly more comfortable with the freeway (40.7%: $p = .016$). Because speed-related challenges are only partially avoidable on the SDPE by declining to go on the freeway,[34] and because most Freeway Refusers ended up making a structured-CDE, these results suggest that freeway avoidance may be indicative of avoiding speed-related challenges in general, for example, as in accommodating one's speed to others' in a merging situation.

With respect to the self-reports of often/always avoiding the freeway, the XFail increase of 15.6 percentage points over the SFail value shown in the last column of Table 24 is consistent with the XFail increase of 19.0 percentage points over the SFail value for actually declining the freeway portion of the SDPE. This XFail elevation in avoidance of freeways, and possibly other speed-related challenges, may partially account for the XFail decrease of 15.8 percentage points in having crashed relative to SFails (Table 21, p. 121). Fuller et al. (2006) make the following relevant observations:

> A collision or road run-off occurs where the demands of the driving task exceed the driver's capability and the driver loses control of the task. There are many determinants of the level of task demand on the driver, some very remote (such as choice of vehicle) and some less remote (such as choice of route). In contrast, others are very immediate, such as the actions of other road users. However, the key determinant of task difficulty, which is under the direct control of the driver, is speed. Speed is important because it determines the 'time window' of opportunity for the driver to detect and recognise what is going on, decide what to do about it and to execute any action decisions…. (p. 70)

On the whole, Table 24 strongly supports the continued inclusion of a freeway task on the SDPE in an operational 3-Tier system. In the event that a driver passes an SDPE after declining <u>or</u>

[34] Changing lanes, for instance, is tested throughout, but usually at lower speed than on the freeway.

failing the freeway portion, the SDPE serves to identify a relevant safe-mobility intervention, namely, formally restricting such drivers from freeway driving. Table 24 also strongly suggests that Tier1 SFails who pass Tier 2 (not required to take a road test) should be *cautioned/educated* about speed-related challenges, such as merging onto a freeway.

Except for the freeway results, which include actual freeway avoidance, Table 24 is equivocal in regard to discovering avoidance tactics that XFails use substantially more than SFails. Avoiding sunrise/sunset glare and left-hand turns might be good candidates. Avoiding rain or fog, heavy traffic, or night driving do not appear to be good candidates.

The finding that, compared with 3-Tier limitation-free drivers, somewhat-limited elderly Renewals are substantially more likely to report "often/always" avoiding rain or fog, heavy traffic, and night driving indicates that some of the elderly SFails may be *sensitive* to their marginal limitation, more so than might be expected.

While some of the survey results and the results for drivers declining the freeway portion of the SDPE suggest that XFails avoid certain driving conditions/environments more than SFails as hypothesized in the Introduction and Rationale (pp. 46-49), the lack of statistically-significant survey results coupled with the finding that SFails report greater avoidance of certain driving conditions than XFails indicates that the survey responses should be viewed as suggestive at best, and shows the need for further investigation.

Part III: Exploring the Positive Correlation Between Knowledge-Test Errors and Failing the SDPE

Table 25 shows the numbers of study participants in categories formed by their age and participant status (Renewal, Road Test Referral, Visual Acuity Referral), and the percentage of them who failed the written renewal knowledge test, which was taken by every study participant.

Table 25

Percentage Failing Written Knowledge Test
by Age Group and Participant Status

Age group	Status	*N*	% who failed written knowledge test
19-39	Renewals	134	27.8%
	Road Test Referrals	62	39.0%
	Visual Acuity Referrals	0	N/A
40-69	Renewals	57	25.0%
	Road Test Referrals	114	37.4%
	Visual Acuity Referrals	3	N/A
70-96	Renewals	152	25.5%
	Road Test Referrals	148	36.1%
	Visual Acuity Referrals	55	40.4%

Although we do not know how many of the study-Renewal participants were making a first attempt at this knowledge test on their then-current license application, the failure percentages given for Renewals in all age groups of the present sample are comparable to the 31.1% failure rate, reported by Chapman & Masten (2002), for all first-attempt Renewals on the English version of the written knowledge test. This comparability lends support to the generalizability of the present study's findings in regards to the knowledge test.

Table 26 shows percentages of participants who failed the SDPE by age, status, and having passed or failed the written knowledge test. Thus, for example, only 16.7% of the Road Test Referrals aged 19-39 who *passed* the knowledge test went on to fail the SDPE, whereas 47.8% of the 19-39-year-old Road Test Referrals who *failed* the knowledge test also went on to fail the SDPE. The last column of the table shows the difference in SDPE fail rates between Knowledge-Test Failures and Knowledge-Test Passes, together with the *p*-values for the corresponding Pearson's 2x2 Chi Square: [SDPE Pass/Fail] x [Knowledge Test Pass/Fail]. Thus, for the age group 19-39, the percentages of Renewals failing the SDPE for both the Knowledge-Test Passes (14.9%) and the Knowledge-Test Failures (10.8%) are very similar, ($p = .541$), indicating that, within that age/status group, performance on the knowledge test gave no basis for predicting failure of the SDPE. However, the difference in the SDPE fail rates for the oldest group of Renewals was much greater (71.8% vs. 36.7%, $p < .001$). *Among elderly Renewals, it appears that poor performance on the knowledge test predicts failing the SDPE possibly due to driving–relevant functional limitations in the cognitive abilities necessary for both tasks.*

The results for Road Test Referrals under the age of 70 shown in Table 26 are consistent with a hypothesis that not knowing the rules of the road and safe driving practices can result in failing the SDPE due to making a structured-CDE. For members of the oldest age group, a hypothesis of cognitive disability might also be tenable in some cases, as suggested above. Members of this group are old enough to have taken and passed a written traffic-knowledge test many times before if licensed in California, so a decline from a former level becomes a more tenable hypothesis than for younger people. *The evidence shown in Table 26 of a link between knowledge-test performance and performance on the SDPE, in the case of the oldest Renewals, supports DMV's policy of discontinuing RBM at age 70 and supports requiring Renewals 70 and older to pass the written knowledge test.*

An analysis, similar to that which yielded the results shown in Table 26 for SDPE failure, was done for prior crash involvement. It was found that failing the written test was not associated, for any age or status group, with having crashed. The probability of finding a *positive* association between knowledge-test errors and crashes in elderly Renewals is diminished to the extent that elderly Renewals failing the knowledge test are doing so due to a rote-memory failure rather than failure to study the *Driver Handbook* and, therefore, are limiting their driving, perhaps knowledgably as discussed above. Evidence that elderly Renewals with rote-memory problems (as indicated by failing to recall their SSN) are more likely to fail the knowledge test and, by inference, may substantially limit their driving (they crash less) is given in Table 28.

Table 26
Percentage Failing SDPE by Age Group, Participant Status, and Having Passed or Failed the Written Knowledge Test[a]

Age group	Status	Written knowledge test		Fail − pass[b] *p*-value
		Passed	Failed	
19-39	Renewals	14.9% (*N* = 94)	10.8% (*N* = 37)	-4.1 .541
	Road Test Referrals	16.7% (*N* = 36)	47.8% (*N* = 23)	**+31.1 .010**
	Visual Acuity Referrals	N/A	N/A	N/A
40-69	Renewals	15.4% (*N* = 39)	23.1% (*N* = 13)	+7.7a
	Road Test Referrals	18.1% (*N* = 71)	39.5% (*N* = 43)	**+21.4 .011**
	Visual Acuity Referrals	N/A	N/A	N/A
70-96	Renewals	36.7% (*N* = 109)	71.8% (*N* = 39)	**+35.1 .000**
	Road Test Referrals	57.6% (*N* = 92)	73.1% (*N* = 52)	+15.5 .065
	Visual Acuity Referrals	25.8% (*N* = 31)	61.9% (*N* = 21)	**+36.1 .009**

Note. *P*-values Less Than .05 and the Associated Difference Values Are Bolded.

[a] "N/A" indicates either that a percentage is not available because the *N* for that cell was less than 8 or that a *p*-value is not available because one or more of the 2X2 Chi Square cells have an expected count less than 5. The sums of the frequencies given in the table as passing/failing the knowledge test are somewhat smaller than the corresponding total *N*s from Table 25. As indicated earlier, this is because an SDPE could not be administered to every participant (for lack of insurance, because brake lights did not work, etc.) who completed the knowledge test.

[b] Absolute percentage difference.

Part IV: Exploring the Negative Correlation Between SSN Recollection and Having Crashed

Of all the ATs administered in the 3-Tier study, the one associated most strongly with prior crashes, as shown by a simple correlation, was recall of the social security number (Tables 10 and 11, pp. 101-102). Not being able to recall one's SSN was associated, for Renewals and Road Test Referrals, with *not* having crashed one or more times in the 3 years prior to study participation. Recall that Table 22 (p. 124) shows, consistent with Hypothesis 4, a substantial *negative* correlation between SSN recall and crash involvement when XFails are *included*, but *much less so when they are excluded*.

Table 27 shows the percentage of participants failing to recall their SSN in the various participant categories formed by their age and status. It is apparent that only in the oldest group was failure to recall one's SSN a relatively common problem, though it was by no means unheard of among younger people.

Table 27

Percentage Failing to Recall SSN by Age Group and Participant Status

Age group	Status	*N*	% who did not recall SSN
19-39	Renewals	134	2.9%
	Road Test Referrals	62	4.8%
	Visual Acuity Referrals	0	N/A
40-69	Renewals	57	1.8%
	Road Test Referrals	114	9.4%
	Visual Acuity Referrals	3	N/A
70-96	Renewals	152	17.4%
	Road Test Referrals	148	14.6%
	Visual Acuity Referrals	55	12.5%

Tables 28 and 29 show the percent of elderly Renewals and Road Test Referrals who performed poorly on a variety of study variables by whether the driver recalled his or her SSN. For

example, only 3.7% of the elderly Renewals who did not recall their SSN had been crash-involved, whereas 21.9% of the elderly Renewals who did recall their SSN had been crash-involved. As with the previous tables, the last column shows the difference in the percentages for the first two columns together with the *p*-values for the corresponding Pearson's 2x2 Chi Squares, for example, [Crash Involved Yes/No] x [Recalled SSN Yes/No].

Table 28 indicates that elderly Renewals who failed to recall their SSN were much less likely to have had a prior crash than were the elderly Renewals who successfully recalled it. In fact, the percentage of elderly Renewals having crashed at least once within the prior 3 years was 83% less ([21.9%-3.7%]/21.9%) for those who could not recall their SSN compared to elderly Renewals who could recall their SSN. A similar result was found for elderly Road Test Referrals; the percentage of elderly Road Test Referrals having crashed at least once within the prior 3 years was 57% less ([52.7%-22.7%]/52.7%; Table 29) for those who could not recall their SSN compared to elderly Road Test Referrals who could recall their SSN. Unlike elderly Road Test Referrals, elderly Renewals who failed to recall their SSN were also much more likely to have committed one or more hazardous CDEs on the SDPE—making a hazardous CDE on the SDPE was 126% higher ([50.0%-22.1%)/22.1%) for those who could not recall their SSN. And finally, elderly Renewals who failed to recall their SSN were substantially more likely to have failed the knowledge test—failing that test was 92.3% higher ([42.3-22.0]/22.0%) for those who could not recall their SSN. This is consistent with the hypothesis that, among elderly Renewals, failing to recall SSN and failing the knowledge test may be indicators of rote memory decline. Performance on the PRT was included in Tables 28 and 29 as a kind of control. If failing to recall SSN is indeed an indicator of rote memory decline then it should not be positively associated with PRT—it is not. Whatever the full nature is of the underlying limitation in cognitive ability(s), ***inability to recall SSN is driving relevant*** as indicated by the elevation in hazardous CDEs on the SDPE and the crash potentiating effects of the underlying cognitive limitation(s) being consistently and adequately compensated for as indicated by the results for prior crashes. When analyses were run on the other self-reports of avoidance, as with freeway avoidance (Table 28), no notable differences were found between participants who recalled their SSN and participants who did not. There were too few cases of participants' not recalling their SSN to draw any conclusions from the distribution of days driving.

Table 28

Percent of **Renewals Aged 70- to 96-years-old** Who Performed Poorly on indicated Variables by Whether They Recalled SSN[a]

Status	Recalled SSN *N* = 126	Did not recall SSN *N* = 26	Did not recall − recalled[b] *p*-value
Crashed	21.9%	3.7%	**-18.2** **.028**
Failed SDPE	42.6%	61.5%	+18.9 .079
Multiple directions: 1 or more errors	28.7%	42.3%	+13.6 .173
Way-finding error	20.5%	19.2%	-1.3 .885
Hazardous CDEs: 1 or more	22.1%	50.0%	**+27.9** **.004**
Declined freeway portion of SDPE	16.4%	11.5%	-4.90 N/A
Reported often/always avoid freeway	21.3%	18.5%	-2.80 .750
Failed written knowledge test	22.0%	42.3%	**+20.3** **.031**
PRT	33.6%	37.0%	+3.4 .733

Note. *P*-values less than .05 and the associated difference values are bolded.

[a] "N/A" indicates that one or more of the 2x2 Chi Square cells have an expected count less than 5.

[b] Absolute percentage difference.

Table 29

Percent of **Road Test Referrals Aged 70- to 96-years-old** Who Performed Poorly on Indicated Variables by Whether They Recalled SSN[a]

Status	Recalled SSN *N* = 127	Did not recall SSN *N* = 21	Did not recall − recalled[b] *p*-value
Crashed	52.7%	22.7%	**-30.0** **.009**
Failed SDPE	62.5%	66.7%	+4.2 .714
Multiple directions: 1 or more errors	38.6%	38.1%	-0.50 .966
Way-finding error	23.8%	40.0%	+16.2 .125
Hazardous CDEs: 1 or more	39.1%	42.9%	+3.80 .742
Declined freeway portion of SDPE	16.7%	30.0%	+13.3 N/A
Reported often/always avoid freeway	14.4%	31.8%	+17.4 N/A
Failed written knowledge test	33.9%	50.0%	+16.1 .163
PRT	54.0%	40.9%	-13.1 .258

Note. *P*-values less than .05 and the associated difference values are bolded.

[a] "N/A" indicates that one or more of the 2x2 Chi Square cells have an expected count less than 5.

[b] Absolute percentage difference.

RECOMMENDATIONS

This study yielded 22 recommendations for statewide implementation of a 3-Tier driving-centered assessment system. As noted in Part IV, a future pilot study is recommended to evaluate the operational feasibility, costs, and customer and staff acceptance of the 3-Tier system described in the 22 recommendations. A rigorous evaluation of this 3-Tier pilot will yield specific recommendations of whether and how the California DMV would implement a 3-Tier driving-centered assessment system.

The Recommendations are divided into four main parts:

I. Recommendations directly supported by this 3-Tier study

II. Procedural and policy changes recommended for a 3-Tier system to be effective

III. Complementary recommendations that make general good sense

IV. Future multi-phase pilot study

Part I: Recommendations Directly Supported by the 3-Tier Study

Part I is comprised of Recommendations 1- 10.

Recommendation #1

Implement the following "Unobtrusive Structured Observations for Physical Limitations & Cognitive Screen" and use the "Observations Checklist and Worksheet" given below to indicate what is observed.

Unobtrusive Structured Observations for Physical Limitations & Cognitive Screen

Instructions to field office technician: Discreetly observe the behavior of customers whom you serve in order to identify any of the failure criteria listed in the following table, and indicate your observations on the Observations Checklist, shown below. You have authority, given in CVC §12814, to make and act on structured observations.

Ability	Observe Customer	Failure Criteria
1. Adequate lower body (below waist) strength, range of motion, mobility and coordination to use foot-operated vehicle controls	Walking to DMV service counter. You will need to be standing to make this observation.	1.1 Customer is unable to walk to DMV service counter if not aided physically by another person or significant support device (i.e., walker, cane, wheel chair, breathing apparatus, or artificial limb), and license is not appropriately restricted or condition not noted on driver record, e.g., by using a DMV Transmittal Form (DL11). 1.2 Full or partial loss of use of a leg or foot and license is not appropriately restricted, or condition not noted on driver record. 1.3 Obvious/Excessive shaking[a] and license is not appropriately restricted, or condition not noted on driver record. 1.4 Obvious/Excessive stiffness or rigidity, and license is not appropriately restricted, or condition not noted on driver record.
2. Adequate memory	Recalling social security number.[b] (While you are still holding the customer's paper work).	2.1 Customer failed to correctly recall complete Social Security Number from memory.
3. Adequate upper body (above waist) strength, range of motion, mobility, and coordination to use hand-operated vehicle controls	Turning head and using arms and hands, especially while signing name to Form DL44[c] or DL 1RN[d].	3.1 Full or partial loss of use of an arm or hand, and license not appropriately restricted or condition not noted on driver record. 3.2 Obvious/Excessive shaking[a] and license not appropriately restricted, or condition not noted on driver record. 3.3 Obvious/Excessive stiffness or rigidity, and license not appropriately restricted, or condition not noted on driver record.
4. Other possibly driving-relevant functional limitations	Showing, or reporting, other driving-relevant functional limitations.	4.1 For example, speech that is markedly slow or slurred (a possible sign of mental limitation) or customer reports a back problem/injury that may hinder movement.

[a]Severe and apparently uncontrollable**.**

[b]While you are still holding the customer's paper work, say: "I need to verify some of your driver record information. What is your social security number?" Alternatively, while you are still holding the customer's paper work, instruct the customer to write their SSN below their signature on their Renewal Notice or their Driver License Application.

[c]Driver License or Identification Card Application**.**

[d]Renewal Notice**.**

Observations Checklist and Worksheet

Instructions to field office technician: Start a new column for each customer you observe. Draw a line through its corresponding number for each passed item. Draw a circle around its corresponding number for each failed item.

Unable to walk if not aided	1	1	1	1	1	1	1	1
Loss of use of leg or foot	2	2	2	2	2	2	2	2
Lower body - Obvious/Excessive shaking	3	3	3	3	3	3	3	3
Lower body - Obvious/Excessive stiffness	4	4	4	4	4	4	4	4
Did not recall social security number	5	5	5	5	5	5	5	5
Loss of use of arm or hand	6	6	6	6	6	6	6	6
Upper body - Obvious/Excessive shaking	7	7	7	7	7	7	7	7
Upper body - Obvious/Excessive stiffness	8	8	8	8	8	8	8	8
Other functional limitations	9	9	9	9	9	9	9	9

Recommendation #2

The Pelli-Robson test, rather than the FACT (or the SKILL) tests, should be the 3-Tier system's measure of contrast sensitivity.

Rationale. FACT, which was the closest competitor to the Pelli-Robson, has several disadvantages as a screening AT. Most of these are explained in the Results and Discussion section. Other considerations include the FACT chart's costing twice as much as the Pelli-Robson chart and taking twice as much space to hang. And finally, the Pelli-Robson chart has been demonstrated to be reliable under large variations in chart distances, lighting, and blur (Zhang, Pelli, and Robson, 1989).

Recommendation #3

Implement the 2001 DMV Medical Advisory Board Vision Panel recommendation to eliminate screening acuity in both eyes together and screen only each eye separately.[35]

Rationale. Eliminating screening acuity in both eyes together will help offset the additional time required to administer the Pelli-Robson contrast sensitivity test (the Fog Chart).

Recommendation #4

Tier 2 should have two parts. These parts would be Tier 2 Part A (the PRT), and Tier 2 Part B (the current written knowledge test).

Rationale. Apart from this study's demonstrating the usefulness of knowledge-test failure as an indicator of a driving-relevant cognitive limitation in drivers who have taken and passed the test before, the knowledge test was placed in Tier 2 rather than Tier 1, in large part because a decision was made to automate the knowledge test. With its automation, it more naturally fits with the computer-based test of PRT on Tier 2.

Recommendation #5

Based on the ATs selected and confirmed for making a driving-centered assessment of driving wellness, Figure 14 gives an overview of a recommended 3-Tier driving-centered assessment system for Renewal applicants who Pass or SFail Tier 1 as defined in the Methods and for Snellen Test Fails whose visual acuity is corrected to 20/40 or better after referral to a vision specialist. A description of the processing steps follows Figure 14. Figure 15 gives an overview of the recommended 3-Tier driving-centered assessment system for Renewal applicants who XFail Tier 1 as defined in the Methods, and for Snellen Fails whose visual acuity, after referral, is not correctable to 20/40 or better. A description of the processing steps follows Figure 15.

[35] Recall that the department screens for best-corrected high-contrast 20/40 visual acuity in both eyes together and in each eye separately.

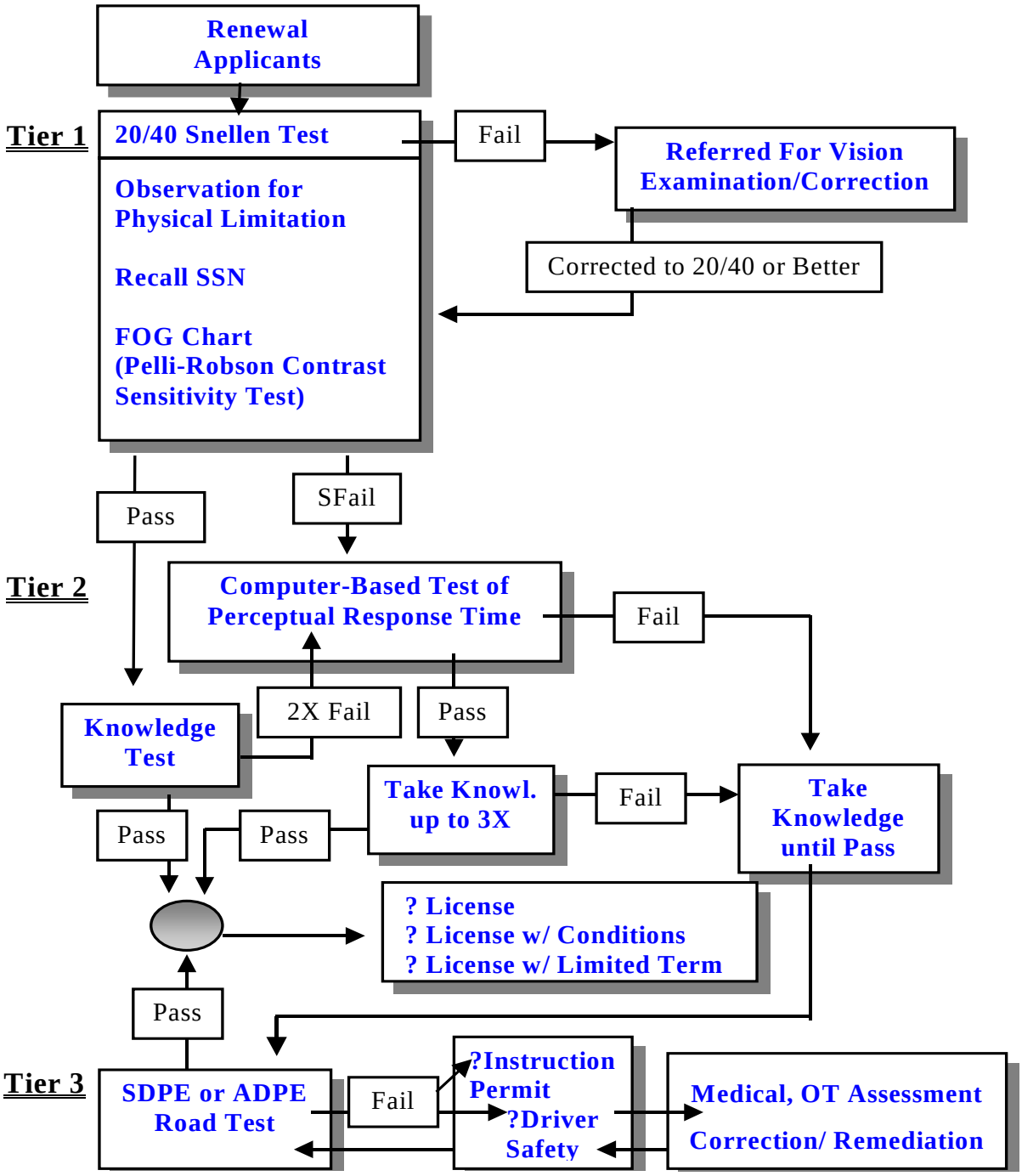

Figure 14. Overview of recommended 3-Tier driving-centered assessment system for Renewals who Pass or SFail Tier 1 and Snellen fails whose visual acuity, after referral to a vision specialist, is corrected to 20/40 or better.

Brief description of the processing steps summarized in Figure 14.

1. Pass Tier 1: Renewal applicants who pass all four Tier 1 ATs go directly to take the knowledge test in Tier 2.

a. If the knowledge test is passed on the first attempt, licensure can occur. (Go to item 6 below.)

b. If the knowledge test (Tier 2) is failed twice, the PRT must be taken.

i. If the PRT is passed, the knowledge test must be taken again, with applicants given up to *three chances to pass on one application*.

1. If the knowledge test is passed after three or fewer attempts, licensure can occur. (Go to item 6 below.)

2. If the knowledge test is failed after three attempts go to item 3b.

ii. If the PRT is failed, go to item 3b.

2. Fail Snellen Test on Tier 1: Renewal applicants who fail the Snellen test on Tier 1 are instructed to go to a vision specialist of their choice for an examination, possible correction, and completion of the Report of Vision Examination, DMV's form DL62. Upon return to the field office they must take the Snellen test again before being administered the other Tier 1 ATs. (This chart assumes that the applicant now ***passes*** the Snellen test. See Figure 15 for the procedure when the applicant fails the Snellen test on return to the field office.)

a. If all the other Tier 1 ATs are then passed, the knowledge test is taken. (Go to step 1a above.)

3. Somewhat-Fail Tier 1[36]: Renewal applicants who somewhat-fail (SFail) Tier 1 must take the PRT on Tier 2.

[36] Recall that a Tier 1 SFail has only one marginally-limited driving-relevant functional ability.

a. If the PRT is passed, applicants take the knowledge test. (Go to step 1bi above.) *It is also recommended that these Tier 1 SFail's be educated about (1) their Tier 1 driving-relevant functional limitation, (2) the types of driving conditions that are made more challenging for them by their limitation, and (3) ways of compensating for their limitations that cannot be corrected or remediated.* See Recommendations below for details.

b. If the PRT is failed, or if the PRT is passed but applicants cannot pass the knowledge test on their first 3 attempts, they must retake the knowledge test until it is passed before taking either an SDPE or an ADPE road test.

   i. If the knowledge test is finally passed, the applicant must take either the SDPE or, for those who initially request it or who fail the SDPE, a content-valid ADPE. As discussed in the Introduction and Rationale, the ADPE is for drivers who, if they are able to drive safely, can probably do so only in a limited, familiar area around their home on well practiced routes (see Recommendation 13).

   ii. If the knowledge test is not passed, no road test will be given and no license will be issued.

4. Pass Supplemental Driving Performance Evaluation or Area Driving Performance Evaluation road test:

a. Licensure can occur. (Go to item 6 below.)

5. Fail Supplemental Driving Performance Evaluation or Area Driving Performance Evaluation road test:

a. A decision must be made whether to refer the applicant to Driver Safety (done when there is a likely physical or mental medical reason for failure) or to issue a restricted limited-term license or an instruction permit for the applicant to obtain driving instruction, done when failure appears more likely due to bad or inadequate driving habits. Whatever the reason for road-test failure, an SDPE or an ADPE must eventually be passed in order for licensure to follow.

i. Possible Driver Safety referral for medical and/or occupational therapy (OT) assessment and possible correction of driving-relevant limitation and/or driving rehabilitation.

6. Licensure decision:

a. When renewal applicants qualify for licensure, a decision must be made on the license type: (1) full licensure, (2) licensure with conditions (e.g., must use corrective lenses while driving), or (3) continuance of a previous limited-term licensure (typically limited to one or two years).

i. Limited-term licensure is typically used if the department is aware that the applicant has a medical condition that is likely to be progressive.

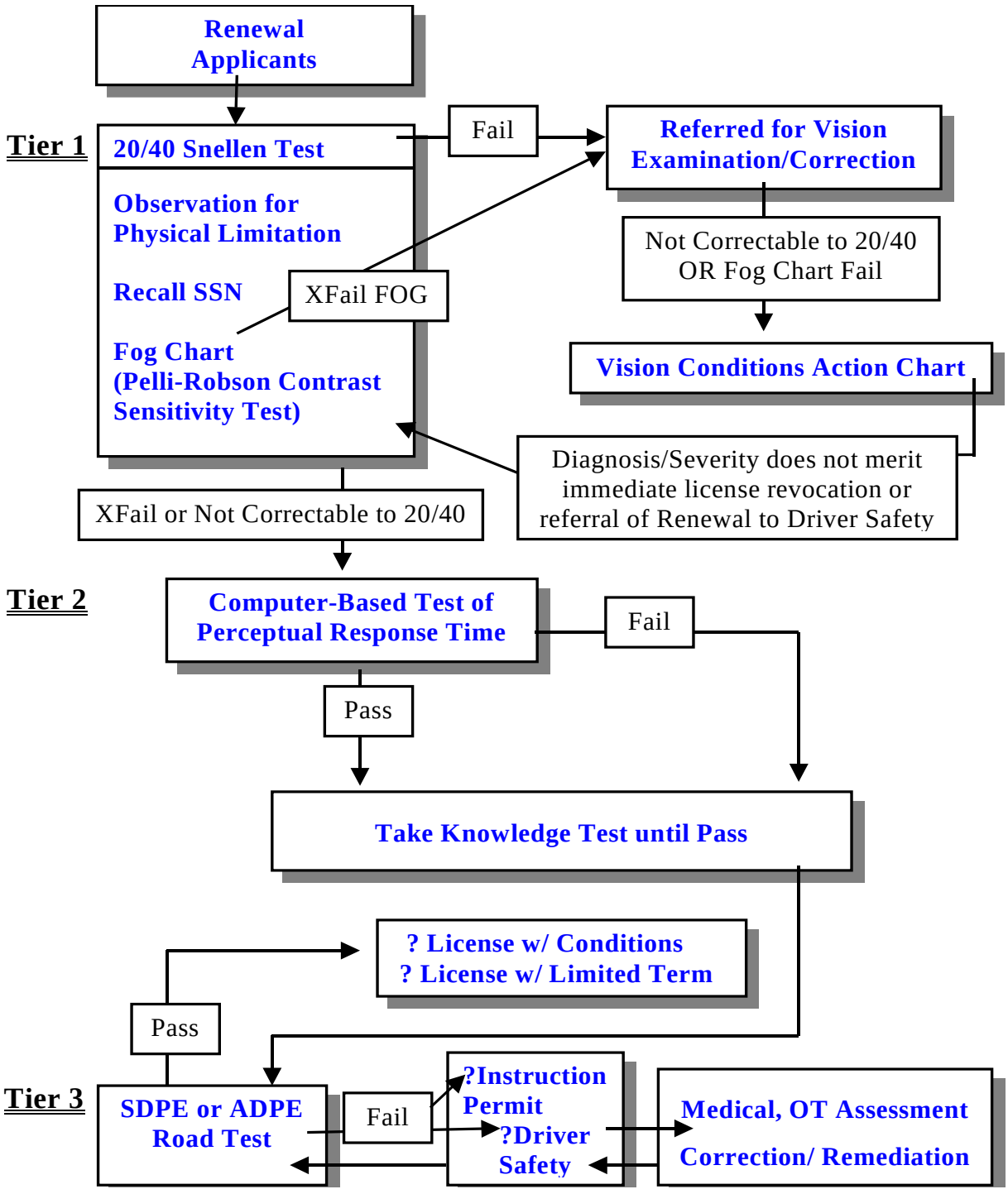

Figure 15. Overview of recommended 3-Tier driving-centered assessment system for Renewals who XFail Tier 1 and Snellen Fails whose visual acuity, after referral, is not correctable to 20/40 or better.

Brief description of the processing steps summarized in Figure 15.

1. **Fail Snellen Test on Tier 1:** Renewal applicants who fail the Snellen test on Tier 1 are instructed to go to a vision specialist of their choice for an examination, possible correction, and completion of the Report of Vision Examination, DMV's form DL62. Upon return to the field office they must take the Snellen test again before being administered the other Tier 1 ATs. (This chart assumes that the applicant now ***fails*** the Snellen test **[Not correctable to 20/40]**. See Figure 14 for the procedure when the applicant passes the Snellen test on return to the field office.) The Vision Conditions and Actions Chart (VCAC) in the Driver License Manual is checked and:

    a. If the diagnosis or severity of the applicant's condition does not merit immediate license revocation or referral to Driver Safety, then the applicant returns to Tier 1 assessment, unless the applicant has already completed all the Tier 1 ATs. (Go to item 2 below.)

    b. If the diagnosis or severity of the applicant's condition does merit it, license revocation or a Driver Safety referral is made.

2. **Not correctable to 20/40 and/or XFail Tier 1.** Must take the PRT. Whether applicants pass or fail the PRT, they take the knowledge test until it is passed and then must take either an SDPE or, for those who initially request it or who fail the SDPE, a content-valid ADPE (see Recommendation 13).

    a. If the road test is passed, a licensing decision is made. Licensure with conditions is recommended whether the perceptual response time was passed or failed. In either case, limited term licensure should be seriously considered, especially for those who failed the PRT and may therefore have cognitive/perceptual limitations. In particular, if the driver has only been able to pass the ADPE, that driver's license and future driving will be restricted to the area tested.

    b. If a road test is failed, a decision must be made whether to refer the applicant to Driver Safety (done when there is a likely physical or mental medical reason for failure) or to issue an instruction permit for the applicant to obtain driving instruction,

done when failure appears more likely due to bad or inadequate driving habits. Whatever the reason for road-test failure, an SDPE or an ADPE must eventually be passed in order for licensure to follow.

i. Possible Driver Safety referral for medical and/or occupational-therapy (OT) assessment and possible correction of driving-relevant limitation and/or driving rehabilitation.

Recommendation #6

Require a driver who XFails the Pelli-Robson contrast sensitivity test to have a Report of Vision Examination (DL62) completed by a vision specialist on which should be noted that the applicant's log contrast sensitivity is worse than 1.35 as measured by the Pelli-Robson chart. If the Vision Conditions and Actions Chart indicates that the diagnosis and/or severity of the applicant's condition indicated on the DL62 merits neither immediate license revocation nor referral of that applicant to Driver Safety, then the applicant should be tested on the PRT in Tier 2 (See flow chart in Figure 15).

Recommendation #7

Require all renewal applicants who are required to pass the knowledge test (Tier 2 Part B) to complete Tier 1 and, if Tier 1 is failed, the PRT on Tier 2.

Rationale. Renewal applicants who are required to pass the knowledge test were the primary focus of this 3-Tier study. As indicated in the Methods (p. 71), these are renewal applicants younger than 70 whose flawed records made them ineligible for RBM, and renewal applicants aged 70 or more at the expiration of their current licenses.

Recommendation #8

Require Road Test Referrals to pass the knowledge test before being allowed to take an SDPE.

Rationale. The data summarized in Table 26 (p. 134) shows that Road Test Referrals who failed the knowledge test are substantially more likely to fail the SDPE than Road Test Referrals who passed the knowledge test. This strongly indicates a need to modify current policy which

permits the hearing officer to decide whether or not to require a Road Test Referral *to pass* the knowledge test before taking a road test.

Recommendation #9

No temporary license should be issued to a DL62 Referral who does not first pass the knowledge test.

Rationale. Among Visual Acuity Referrals, poor performance on the knowledge test predicts failing the SDPE (Table 26, p. 134).

Recommendation #10

So that they may be accorded relevant safe-mobility interventions, require that if the proposed 3-Tier assessment system becomes operational, the Visual Acuity Referrals and those Road Test Referrals presently designated by CVC §12818 ("priority reexamination" cases reported by law enforcement pursuant to CVC §21061[37] and medical cases reported pursuant to HS §103900[38]), as well as referrals from other sources for whom a road test is indicated by DMV policy, be required to take the full battery of 3-Tier ATs, including an SDPE or a content-valid ADPE.

Part II: Procedural and Policy Changes Recommended for 3-Tier to be Effective

Part II is comprised of Recommendations 11- 16.

Recommendation #11

Background. The system that law enforcement uses to inform DMV of its reasons for considering any particular driver hazardous enough to warrant a reexamination (priority or regular reexamination request, DMV Form DS 427, Appendix J-1) has been greatly improved based on data collected in this study. Information from law enforcement previously consisted of

[37] Drivers referred by law enforcement for committing a traffic violation and giving evidence to the officer of a chronic incapacity to drive safely.

[38] This law provides for mandatory physician reporting of every patient aged at least 14 whom a physician has diagnosed as having a disorder characterized by lapses of consciousness. Reports of these cases are sent to DMV. The latter group includes many medical conditions, and the reporting law is explicitly written to include Alzheimer's disease and other dementias severe enough to be likely to limit a person's ability to operate a motor vehicle.

a brief ***narrative*** description, sometimes subjective (therefore possibly enabling age bias) and difficult to categorize. Using reexamination narratives from the 3-Tier database which had been collected from Road Test Referrals' files, 15 Critical Observed Driving Behaviors and 9 Critical Driver Conditions were identified. Appendix J-2 gives verbatim examples and the percent of 29 police narratives that cite the critical observed driving behaviors. Appendix J-3 gives verbatim examples and the percent of 51 police narratives that cite the critical driver condition. Most of the latter data is based on observations made after a collision. Two checklists for making and recording critical observations of driving behavior and driver condition were developed. These checklists were closely modeled, in their objectivity and ease of use, on the structured observations worksheet for making and recording observations of (mostly physical) limitations (p. 141). The two check lists were reviewed and approved by DMV policy staff and the Older Californian Traffic Safety Task Force's Law Enforcement work group (http://www.chp.ca.gov/community/pdf/OCTS_07_activity.pdf), in which the first author was the DMV representative. Also represented on the law enforcement work group were the California Highway Patrol, California Police Chiefs Association, California State Sheriffs' Association, California Peace Officer Standards and Training, Sacramento County Sheriff's Department, and the California Department of Transportation. The checklists were incorporated into DMV Form DS 427 and on May 2005, the revised DMV Form DS 427 (Appendix J-1) was distributed by DMV to law enforcement agencies throughout California.

Recommendation. *Law enforcement officers should continue using the DMV Form DS 427 checklists to refer a driver for a priority or regular re-examination.*

Recommendation #12

Background. The study results that are summarized in Figure 12 (p. 123) confirm this study's operationalization of "somewhat functionally limited."

As indicated in Table 1 the primary objective of identifying **somewhat functionally-limited drivers**, who were hypothesized to have the highest crash rate due to limitation-naivety, is to educate them about (1) their specific limitation(s)[39], (2) the types of driving conditions that are made more challenging for them by their limitation(s), and (3) ways of compensating for their respective limitation(s) that cannot be corrected or remediated. Figure 12 (p. 123) illustrates the substantially elevated crash rate of the somewhat functionally-limited elderly Renewals.

[39] Recall that some of the SFails have two marginally-limited abilities—Tier 1 SFail, Tier 2 SFail's.

Recommendation. *Administer education and training (for example, DVD-based presentations and/or behind-the-wheel refresher training) about (1) their specific limitation(s), (2) the types of driving conditions that are made more challenging for them by their limitation(s), and (3) ways of compensating for their respective limitation(s) to drivers who SFail.*

Recommendation #13

Background. The study results that are summarized in Figure 12 (p. 123) confirm this study's operationalization of "extremely functionally limited."

As indicated in Table 1 (p. 8), the **primary objective of identifying extremely functionally-limited drivers** is to follow-up the initiation of relevant safe mobility interventions with an *on-road assessment of whether they are driving fit.* These drivers should be given a choice between the DMV's SDPE (DMV *office-based* supplemental driving performance evaluation—meant to evaluate the driving abilities of experienced drivers who have acquired a driving-relevant limitation since their initial licensure) and a content-valid ADPE (area driving performance evaluation—the department's customized road test administered in a limited and familiar area around the driver's home). The ADPE is mainly, although not exclusively, administered to severely functionally-limited drivers whose compensating strategies likely already include restricting themselves to familiar and well-practiced routes and taking only necessary trips close to their home. By road testing extremely functionally-limited drivers when and where they customarily drive (this would include infrequent though important regular destinations), one can estimate whether they can consistently and adequately compensate for their limitations and, therefore, truly estimate whether their level of risk for making a critical driving error can be expected to be consistently small in their *customary* driving environments/conditions and for their customary driving practices. Requiring extremely functionally-limited drivers *who have already restricted themselves to familiar and well-practiced routes* to take the office-based SDPE, which is generally given in an area that is unfamiliar to the examinee, would *not* be a driving-centered estimate of whether such a driver is driving fit. The SDPE would *not* be appropriate for them—it would *not* be content valid.

Before administering an ADPE, the examiner would meet with the driver and determine the times, places (routes or areas), and conditions for a *content-valid* ADPE. As noted above, a content-valid ADPE must include infrequent though important regular destinations. With the implementation of a 3-Tier Assessment System, during this initial meeting with the driver and immediately after the ADPE, the examiner would be charged with initiating relevant safe-

mobility interventions (referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting [conditional licensure] and so on, see pp. 4-5 & p. 24). [40] Repeating a *failed* content-valid ADPE would be contingent on the applicant demonstrating or providing DMV with certification of s*uccessful* completion of the relevant interventions identified by the examiner (see description of Brainin's [1980] model licensing system on pp. 10-11). In order to be licensed, the extremely functionally-limited driver would be required to demonstrate the ability to *reliably* negotiate the routes or areas specified for the ADPE during the specified times and under the specified conditions without making any of the SDPE structured-CDEs[41] (Appendix G). As indicated in Table 13 (p. 105), the passing criterion, "without making any of the SDPE structured-CDEs," is consistent with failure of the SDPE which is almost always due to a structured-CDE. Drivers passing a content-valid ADPE would have their driving restricted appropriately to the specific times, places, and conditions under which they have demonstrated an acceptable level of driving fitness. Just as with the SDPE, in ADPE-based licensing there would be **no attempt to balance a driver's mobility needs with road/public safety** (cf. Arno & Boets, 2004, pgs. 7 & 41; Staplin & Hunt, 2004, p. 69)[42]. As noted earlier (p. 27), maintaining a low level of risk for making a real-world CDE, that is, driving safely, is integral to maintaining safe mobility. If functional limitations worsen (e.g., as indicated by DMV assessment results on future renewals or as reported by a physician before the end of the prescribed renewal term), and the driver continues to meet absolute standards (see footnote #5, p. 6), subsequent ADPEs would be necessary and the window of approved driving times, places, and conditions would diminish until, ideally, both the driver and DMV together realize that driving safely is no longer feasible.

Recommendation. Give *Renewals who XFail Tiers 1 and 2 a choice between an SDPE and a content-valid ADPE*.

[40] As indicated earlier, in initiating a safe-mobility intervention a DMV may or may not involve itself in actually administering the intervention.

[41] Making a large number of important, but *not* technically critical driving errors, would also indicate that the driver *cannot reliably* negotiate the routes or areas specified for the ADPE during the specified times and under the specified conditions without making any of the SDPE structured-CDEs.

[42] As indicated earlier, this is not to deny that in operationalizing 3-Tier there would be no subtle prioritizing of mobility over safety or vice-versa. For example, even though repeating a *failed* content-valid ADPE could be made contingent on the applicant demonstrating or providing DMV with certification of s*uccessful* completion of relevant interventions, one might ask: Should an applicant be limited in how many attempts they are permitted to pass an ADPE? If so, how many? The answers to these questions will be influenced by a prioritizing of mobility over safety or vice-versa.

Recommendation #14

The ADPE, how department staff are currently trained to administer the ADPE, and the circumstances under which an ADPE is offered should be formally evaluated by the department's Research and Development Branch as the first step in ensuring that an ADPE is reliable and content valid—evaluation and development of a reliable and content-valid ADPE should precede any changes to policy that would increase the use of the ADPE.

Rationale. The growing elderly population in California and 3-Tier Recommendation #13 are likely to lead to greater use of the ADPE. The current ADPE as specified in the California DMV Driver License Manual has not been formally evaluated and so its reliability and content validity have not been determined. Furthermore, anecdotal reports indicate that when and how the ADPE is currently administered varies greatly by field office and by Licensing/Registration Examiner. The evaluation and development of a content-valid ADPE should precede any changes to DMV policy that would increase the use of the ADPE.

Recommendation #15

Background. The results of this study suggest that the RBM program may be concealing a relatively large number of SFails among drivers aged 60 through 69 (Figure 8, p.115). That is, a large number of drivers SFail the first time they attempt to renew their drivers' licenses after they turn 70 years of age, and these drivers may be functioning at the SFail level while they are in their 60's.

Recommendation. *Distribute "Driving Safely While Aging Gracefully," (http://www.nhtsa.dot.gov/people/injury/olddrive/Driving Safely Aging Web/) to the RBM eligible drivers over 60. In the cover letter, explain why the following three commonly made assumptions are incorrect (see pp. 39-43):*

- *Older drivers are a functionally-unitary group.*
- *"Old age" causes driving-relevant functional limitations.*
- *"Older" can be used as a sign of diminished capacity for driving safely.*

The cover letter should also provide a link to the web-based module called "Road Map to Driving Wellness" at http://www.asaging.org/cdc/module4/home.cfm. This module presents a variety of ways for preserving and improving driving wellness.

Recommendation #16

Establish a task force to improve the training of DMV staff in field operations procedures.

A task force should be established to improve the training of DMV staff in field operations procedures. Desirable areas include: (1) test administration; (2) use of choreographed drives in training Licensing-Registration Examiners in how to administer departmental road tests; (3) using the DMV's Vision Conditions and Actions Chart, using the completed Report of Vision Examination (DL62), and using other relevant charts and completed forms; and (4) ongoing quality control procedures.

Part III: Complementary Recommendations that Make General Good Sense:

Part III is comprised of Recommendations 18 - 23.

Recommendation #17

Background. Memo DL 2004-10, allows "customers who have failed the written law test" (as the knowledge test is often called) to have "questions re-stated or re-phrased by a field office employee."

DL 2004-10 allows "field office employees discretion in determining whether the customer understands the laws and rules of the road." However, no guidance is provided to field office employees for doing this or for doing it in a consistent manner. This opens possibilities for gender-, age-, ethnicity-, and race-based or other forms of discrimination. The written knowledge test was carefully designed to provide an objective, reliable, and content-valid means of satisfying the examination requirements of CVC §12804.9(a)(1)(A)-(C), which are also stated on page 2 of Chapter 8 in the Driver Licensing Manual. Implementation of this new written test failure policy has made the written test a non-examination. In practice, there is no longer a

pass/fail cut score, and the unguided field office technician is solely responsible for determining whether a customer "passes" or "fails" the written knowledge test.
Table 26 (p. 134) shows the value of failing the knowledge test in predicting failing the SDPE.

Recommendation. *Rescind procedural memo DL 2004-10.*

Recommendation #18

Background. Memo DL 2004-13 states: "a driving test is no longer mandatory for noncommercial Class C [auto] or M [motorcycle] renewal customers who fail the law test (as the knowledge test is often called) three times." Since three successive failures of the knowledge test may indicate a cognitive problem in the case of a renewal customer who presumably has taken and passed the test before, it is unwise to exempt these customers from a road test; specifically from the SDPE, which is relatively long and contains cognitive exercises. Table 26 (p. 134) shows the value of failing the knowledge test in predicting failing the SDPE.

Recommendation. *Rescind procedural memo DL 2004-13.*

Recommendation #19

Add to written departmental policy a provision that the following drivers be formally restricted from freeway driving: functionally-limited drivers who do not decline the freeway portion of the SDPE and then go on to fail the freeway portion.

Recommendation #20

Establish an inter-divisional task force within the department to:

- *Develop specific recommendations for encouraging customers to study the DMV Driver Handbook.*
- *Establish limits on the number of times the knowledge test may be taken during a specific period of time (perhaps six times in a month).*
- *Establish a minimum waiting period before the knowledge test can be retaken (at least one day).*

Recommendation #21

Restrict or impose a condition on 3-Tier XFails from using a cell phone (including hands-free use) while driving, and advise them to minimize conversational distractions in driving insofar as they can.

Rationale. Distractions, by definition, draw one's attention away from the task at hand, which here is driving. They are a problem for everyone, and likely are even more of a problem for extremely-limited drivers than for limitation-free ones. Distractions are in themselves a constraint on adequately and consistently compensating. One growing form of manageable distraction is use of a cell phone while driving. Studies have recently found that conversation on a *hands-free* telephone can disrupt a driver's ability to detect changes in natural traffic scenes; data also revealed a tendency for conversation to limit attentional-orienting responses in older adults. An attentive-listening task in which there was no need to reply verbally produced no such effects (McCarley, Vais, Pringle, Kramer, Irwin, & Strayer, 2004).

Recommendation #22

The DMV Research and Development Branch should draft plans for initiating work on:

- *Formalizing DMV field office procedures for initiating, if feasible, safe-mobility interventions (see Introduction and Rationale for details).*

- *Developing a formal means of screening drivers for the specific factors (barriers) that may keep them from adequately and consistently compensating after best improving their driving-relevant functioning.*

Part IV: Future Multi-Phase Pilot Study

This study was undertaken as the first step toward developing a system for DMV to make a 3-tiered driving-centered assessment of driving wellness (see Table 1, p. 8). The study results are consistent with the four hypotheses that were formulated for evaluating the validity of the three driving-wellness categories: driving well, somewhat functionally limited, and extremely functionally limited. The above 22 recommendations outline a 3-Tier driving-centered

assessment system that should answer the fundamental driving-centered question raised in the Introduction and Rationale:

> How can the DMV better *identify* and *assess* licensed drivers of any age who have acquired a driving-relevant functional limitation(s) (decrement(s) in driving wellness) so that the DMV, together with physicians, driving-rehabilitation specialists, and others can aid such drivers, if feasible, in driving safely by referring for physician-based evaluation and treatment, educating about driving-relevant limitation(s), recommending behind-the-wheel training, restricting (conditional licensure), and so on (see pp. 4-5 & p. 24)?

The 3-Tier driving-centered assessment system outlined above should be adopted on a pilot basis in order to further develop and evaluate such essential components as a reliable and content-valid ADPE and educational interventions for specific limitations.

The following three pilot study tasks should be undertaken:

- Determine current field office processes and outcomes (for example, road-test outcomes by age) to establish a baseline against which to measure 3-Tier system processes and outcomes.

- Evaluate 3-Tier system **processes** in a limited number of DMV field offices.

- Evaluate 3-Tier system **outcomes** (e.g., the crash rate of SFails as a group and XFails' safe driving years after initiating relevant safe-mobility interventions) in a limited number of DMV field offices.

Consideration of the statewide implementation of a 3-Tier driving-centered assessment system will be based on the outcomes of these three pilot study tasks.

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APPENDICES

Appendix A

Selected Items from the Driving Information Survey

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

Do you avoid driving at night?
□1 Never □2 Sometimes □3 Often □4 Always

Do you avoid driving when it's raining or foggy?
□1 Never □2 Sometimes □3 Often □4 Always

Do you avoid driving at sunrise or sunset?
□1 Never □2 Sometimes □3 Often □4 Always

Do you avoid driving alone?
□1 Never □2 Sometimes □3 Often □4 Always

Do you avoid making left-hand turns across oncoming traffic?
□1 Never □2 Sometimes □3 Often □4 Always

Do you avoid driving in heavy traffic?
□1 Never □2 Sometimes □3 Often □4 Always

Do you avoid driving on the freeway?
□1 Never □2 Sometimes □3 Often □4 Always

Do you avoid driving on unfamiliar routes?
□1 Never □2 Sometimes □3 Often □4 Always

Appendix B

Unobtrusive Structured Observations & Cognitive Screen

Discreetly observe the customers whom you handle for the failing criteria listed in the table below. Use the Observations Checklist (Appendix C). Record the numbers of the failed criteria on the 3-Tier score sheet where it says: Observed Failures. Authority to make and act on structured observations: California Vehicle Code 12814.

Ability	Observe Customer	Failing Criteria
1. Adequate lower body (below waist) strength, range of motion, mobility and coordination to use foot-operated vehicle controls	Walking to DMV service counter. You will need to be standing to make this observation.	1. Customer is unable to walk to DMV service counter if not aided physically by another person or significant support device (i.e., walker**,** wheel chair, breathing apparatus, or artificial limb), and license is not appropriately restricted or condition has not been noted on driver record, e.g., DL11. 2. Full or partial loss of use of a leg or foot and license is not appropriately restricted or condition has not been noted on driver record. 3. Obvious/Excessive shaking[a] and license is not appropriately restricted or condition has not been noted on driver record. 4. Obvious/Excessive stiffness or rigidity, and license is not appropriately restricted or condition has not been noted on driver record.
2. Adequate cognitive (remembering and thinking) functioning	Following directions in completing DL44[b] and any other forms. Recalling birth date and social security number.[c] (While you are still holding the customer's paper work.) Examining intersection problem.[d]	5. Customer made more than a minor error(s) in failing to follow directions. Having signed the DL44 is only a minor error. Failing to correctly complete DL44 after showing what the customer did wrong is more than a minor error in failing to follow directions. 6. Someone is assisting customer in completing forms and/or answering questions. 7. Customer failed to correctly recall from memory: 7A. Birth Date 7B. Social Security Number. 8. Intersection Problem: 8A. Customer failed to indicate "Turn right" on first response 8B. Was not responsive within the 1-minute time limit.

Appendix B (continued)

Ability	Observe Customer	Failing Criteria
3. Adequate upper body (above waist) strength, range of motion, mobility and coordination to use hand-operated vehicle controls.	Using arms and hands.	9. Full or partial loss of use of an arm or hand, and license is not appropriately restricted or condition has not been noted on driver record, e.g., DL11. 10. Obvious/Excessive shaking and license is not appropriately restricted or condition has not been noted on driver record. 11. Obvious/Excessive stiffness or rigidity, and license is not appropriately restricted or condition has not been noted on driver record.
4. Other possibly driving-relevant abilities that may be impaired.	Showing other obvious impairment of possibly driving-relevant abilities.	12. Describe signs of impairment on back of score sheet.

Note. These structured observations are largely based on screening procedures used in the Wisconsin and Florida DMV's.

[a] Severe and apparently uncontrollable.

[b] Driver License or Identification Card Application.

[c] After recording customer-identification information on the score sheet, and while you are still holding the customer's paper work, say: "I need to verify some of your driver-record information." Ask customer, "What is your birth date?", "What is your social security number?" If challenged in asking these questions, answer that you are piloting new screening procedures.

[d] Give customer the Intersection Problem, telling them, "This is a new question that we are trying out for the written test. What would you say is the right answer?" Start timing response.

Appendix C

Structured Observations Checklist and Worksheet

Start a new column for each customer you observe. Draw a line through the number for each passed item. Draw a circle around the number of each failed item.
Record the circled numbers on the 3-Tier score sheet where it says: Observed Failures. If no numbers are circled, record a '0'. Draw a line through the column you just finished using.

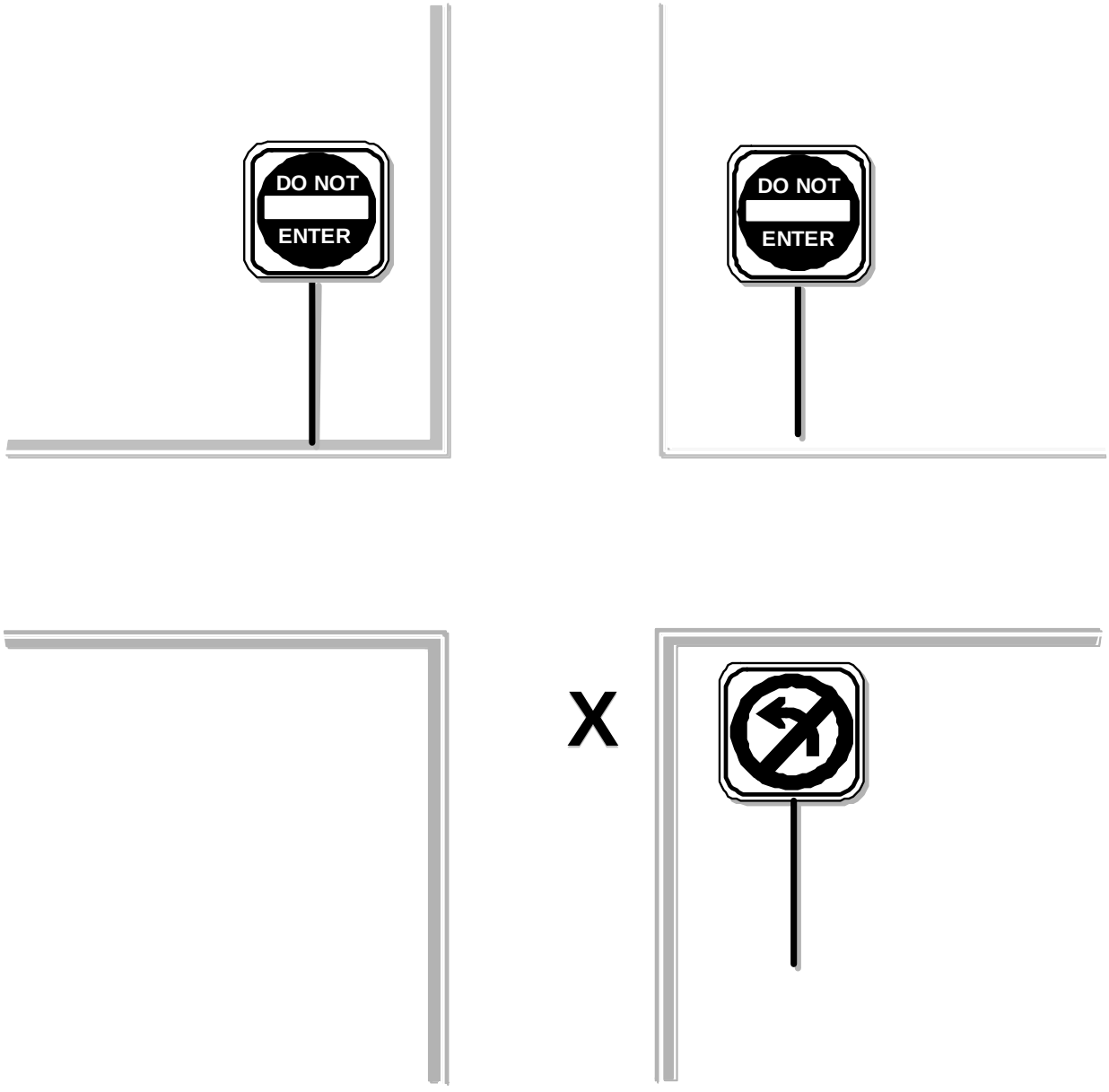
Unable to walk if not aided	1	1	1	1	1	1	1	1
Loss of use of leg or foot	2	2	2	2	2	2	2	2
Lower-Obvious/Excessive shaking	3	3	3	3	3	3	3	3
Lower-Obvious/Excessive stiffness	4	4	4	4	4	4	4	4
Failed to follow directions	5	5	5	5	5	5	5	5
Someone is assisting customer	6	6	6	6	6	6	6	6
Did not recall birth date	7A	7A	7A	7A	7A	7A	7A	7A
Did not recall social security number	7B	7B	7B	7B	7B	7B	7B	7B
Failed to indicate "Turn Right"	8A	8A	8A	8A	8A	8A	8A	8A
Was not responsive within 1 minute	8B	8B	8B	8B	8B	8B	8B	8B
Loss of use of arm or hand	9	9	9	9	9	9	9	9
Upper-Obvious/Excessive shaking	10	10	10	10	10	10	10	10
Upper-Obvious/Excessive stiffness	11	11	11	11	11	11	11	11
Other Impairment	12	12	12	12	12	12	12	12

Unable to walk if not aided	1	1	1	1	1	1	1	1
Loss of use of leg or foot	2	2	2	2	2	2	2	2
Lower-Obvious/Excessive shaking	3	3	3	3	3	3	3	3
Lower-Obvious/Excessive stiffness	4	4	4	4	4	4	4	4
Failed to follow directions	5	5	5	5	5	5	5	5
Someone is assisting customer	6	6	6	6	6	6	6	6
Did not recall birth date	7A	7A	7A	7A	7A	7A	7A	7A
Did not recall social security number	7B	7B	7B	7B	7B	7B	7B	7B
Failed to indicate "Turn Right"	8A	8A	8A	8A	8A	8A	8A	8A
Was not responsive within 1 minute	8B	8B	8B	8B	8B	8B	8B	8B
Loss of use of arm or hand	9	9	9	9	9	9	9	9
Upper-Obvious/Excessive shaking	10	10	10	10	10	10	10	10
Upper-Obvious/Excessive stiffness	11	11	11	11	11	11	11	11
Other Impairment	12	12	12	12	12	12	12	12

Appendix D

Intersection Problem

If you stopped at this intersection at X and saw these signs, what could you do?



(1) Go Straight (2) Turn Left (3) Turn Right (4) None Of These

Appendix E

California Vehicle Code

Authority to Make Study Participation Mandatory

Departmental Studies: Incompetent or Unqualified Drivers

12804.8. (a) Notwithstanding any other provision of law, the department may conduct studies to develop and identify examinations and tests, to more accurately identify persons who, due to physical or mental factors, or both, are not competent or qualified to safely operate a motor vehicle.

(b) In addition to any other tests or examinations required under this code, the department may require any person applying for an original driver's license or renewal of a driver's license, or any person subject to reexamination under Section 13801, to submit to one or more tests or examinations which are part of a study.

(c) The results and information obtained during the study, through the tests and examinations specified in subdivision (a), shall be used only to assess and evaluate the effectiveness of the tests and examinations and to select tests and examinations for use by the department, and for no other purpose. The results of the tests are confidential and shall not be disclosed to any person.

(d) No public entity or employee shall be liable for any loss, detriment, or injury resulting directly or indirectly from the department's acts or failure to act on information received through the studies.

Added Ch. 546, Stats. 1993. Effective January 1, 1994.

Appendix F

Exclusionary Criteria for Renewal By Mail

1. Driver has already had two successive RBMs. (After in-person renewal, the driver may again qualify for mail renewal in future years.)

2. Driver is age 70 or older.

3. Driver has accumulated more than 1 negligent operator point[43] in the 24 months prior to determining his or her eligibility for renewal by mail—usually 60 to 90 days before their current license expires (CVC §12814.5).

4. Driver was suspended under administrative license suspension law (CVC §13353.2).

5. Driver refused to submit to a chemical test of his or her blood alcohol content (CVC §13353 and §13353.1).

6. Diver failed to appear for a court date.

7. Driver was eligible to renew by mail but is trying to renew a year or more after license expiration.

[43] A negligent operator is any driver who accumulates four or more negligent operator points in 1 year, six or more points in 2 years, or eight or more points in 3 years (CVC §12810.5). Convictions of minor moving violations (e.g., speeding) and accidents for which the driver is considered at least partially responsible receive one point. Major convictions (e.g., drunk driving) receive two points (CVC §12810).

Appendix G

SDPE Structured-CDE Scoring Criteria

Structured-CDE	Scoring criteria
Intervention by evaluator	• Any action or inaction requiring physical or verbal intervention by the evaluator.
Strikes object	• Makes contact with another vehicle, object, pedestrian, or animal when it could have been safely avoided. • Drives over the curb or on the sidewalk.
Disobeys traffic sign or signal	• Goes through, at or exceeding a brisk walking speed (4 m.p.h.), a: —stop sign. —flashing red light. —right turn on a red light. • Does not stop and wait for a green signal at a: —red light (After making a full and complete stop at the red light, the customer may make a right turn if it is safe to do so.) —red freeway metered ramp signal. • Makes an unnecessary stop at a green light or on a freeway metered ramp. • Disobeys other traffic signs and/or lane markings, such as: —a lane drop. —painted arrows. —a painted island. —curb markings (red, blue, etc.) —traffic cones, etc.
Disobeys traffic safety personnel or safety vehicles	• Passes a school bus with flashing red lights. • Fails to pull over and stop for an emergency vehicle. • Disobeys any safety personnel, law enforcement officer, or fire fighter.
Dangerous maneuver	• Any action or inaction causing another driver or pedestrian to take evasive action. • Does not move head and eyes for traffic check at an uncontrolled intersection when a potential hazard is present.

Appendix G (continued)

CDE	Scoring Criteria
Dangerous maneuver (cont.)	• Makes an unnecessary stop on freeway merge lane while entering or exiting. • Blocks an intersection at any time with the vehicle so that it impedes cross traffic. • Neither looks in mirror(s) nor blind spot (over shoulder[s]) during: —a lane change, —a merge, —backing, or —when pulling from curb or side of road. • Kills the engine: —in an intersection. —three times due to poor clutch/gear use.
Speed	• Drives 10 m.p.h. —over the speed limit. —under the speed limit when road and/or traffic conditions do not warrant it. • Drives too: —fast for safety. —slow for safety. **NOTE:** For roadways with a posted speed limit of 55 m.p.h. or higher, *too slow* is driving less than 45 m.p.h. when road and/or traffic conditions do not warrant it.
Auxiliary equipment use	Fails to use windshield wipers, defroster, or headlights when weather conditions or darkness requires it.
Lane violation	• Drives: —further than 200 feet in a bike lane or two-way center left turn lane. —straight from a designated turn lane. —unnecessarily in the oncoming traffic lane at anytime. • Turns from a designated forward (straight) lane. • Makes a turn from the wrong lane. **EXCEPTION:** If improper turn is made without merging into bike lane: —do not mark a critical driving error as long as the blind spot is checked. —score under **Turns, Approach, Lane.**

Appendix H

Study Test Acceptability Ratings

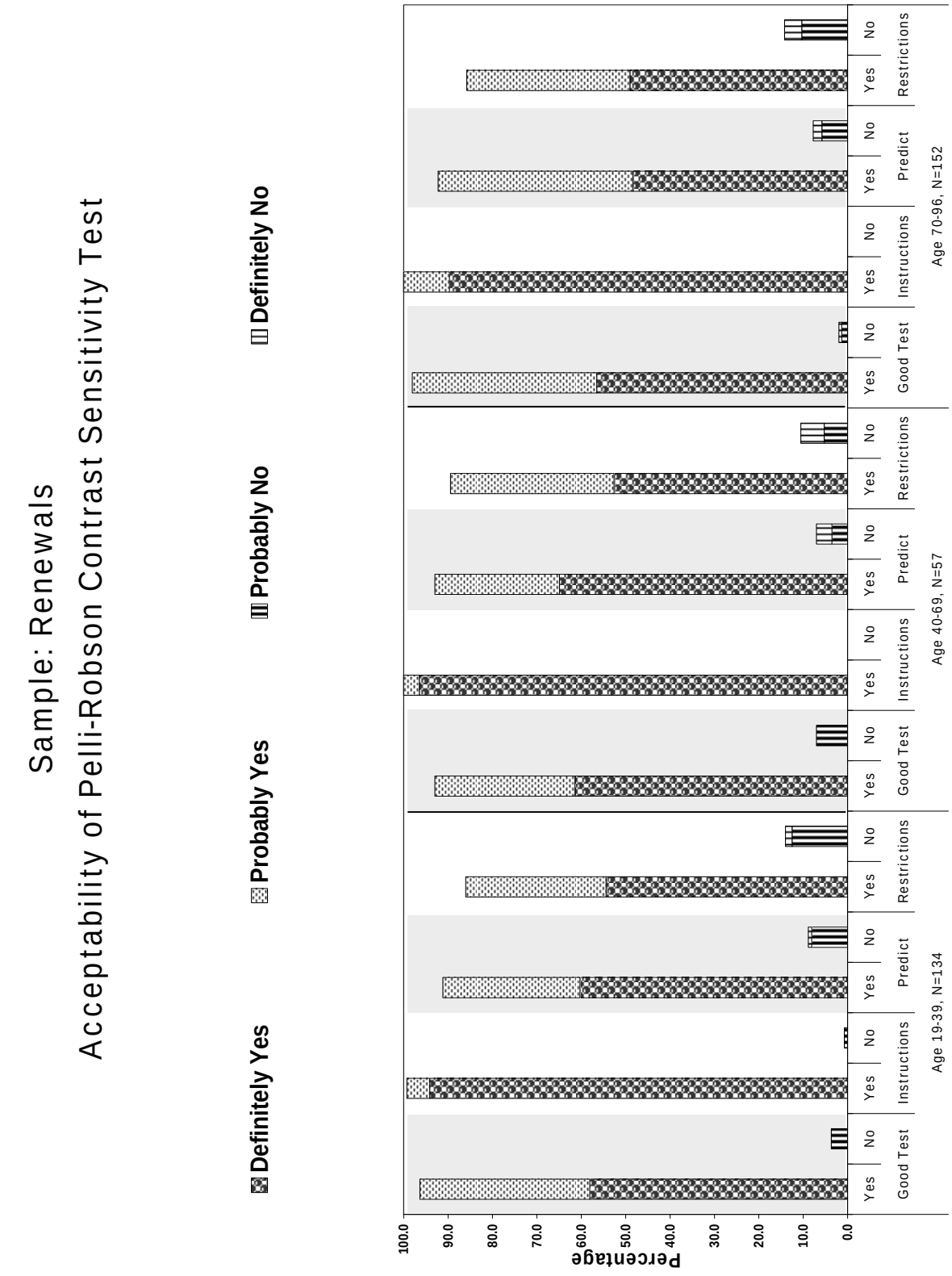
Appendices H-1A through H-4B summarize acceptability ratings of the Pelli-Robson Contrast Sensitivity Test and the Perceptual Response Time Test for the three study samples and staff.

Survey Items:

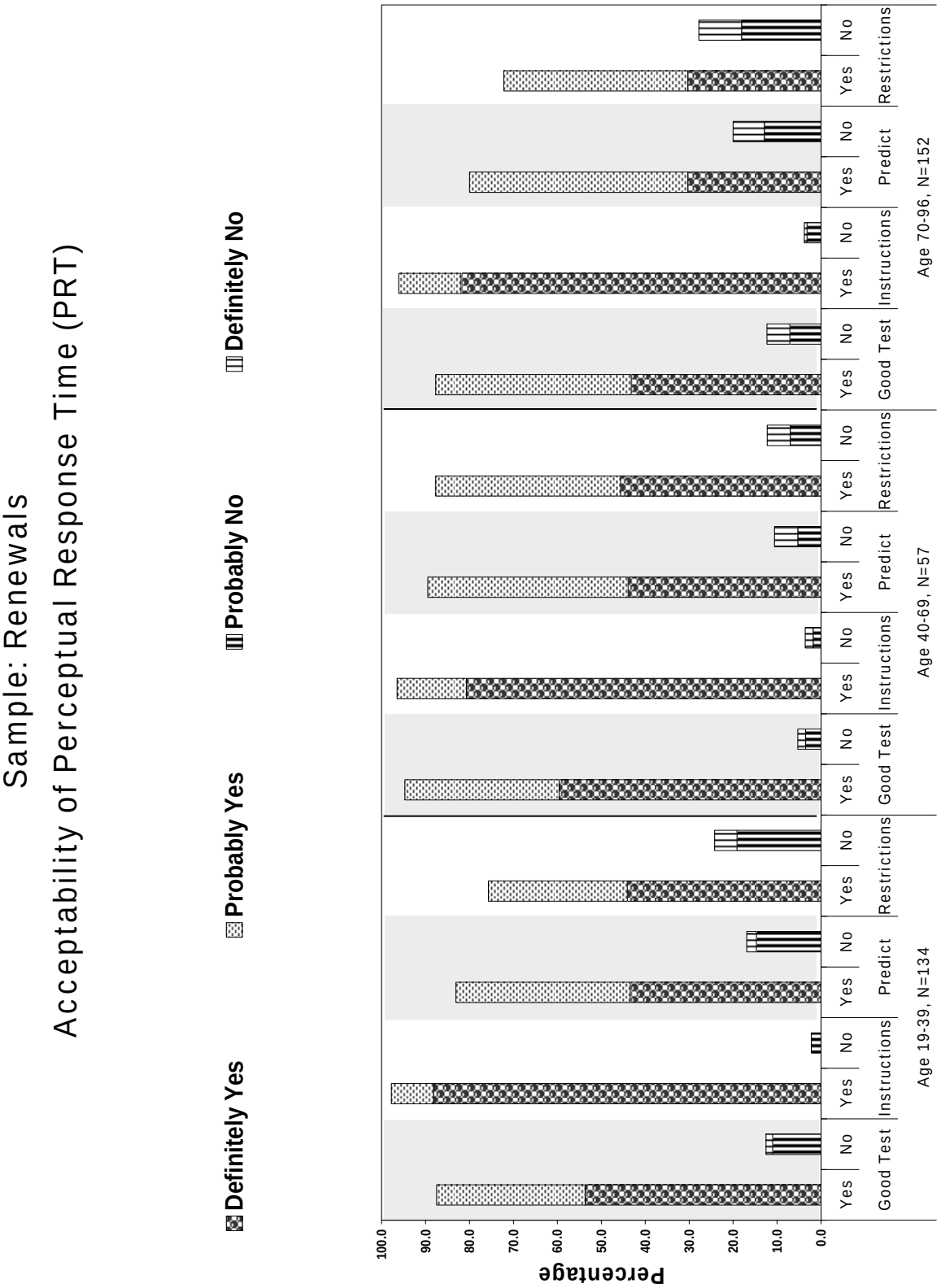
- In your opinion is this a good test?
- Were the instructions easy to understand?
- Do you think that this test would help DMV predict which people might have trouble driving?
- Do you think it would be fair to give drivers this kind of test to see if they should get restrictions on their license?

The answer choices for each acceptability question were "Definitely No," "Probably No," "Probably Yes," and "Definitely Yes."

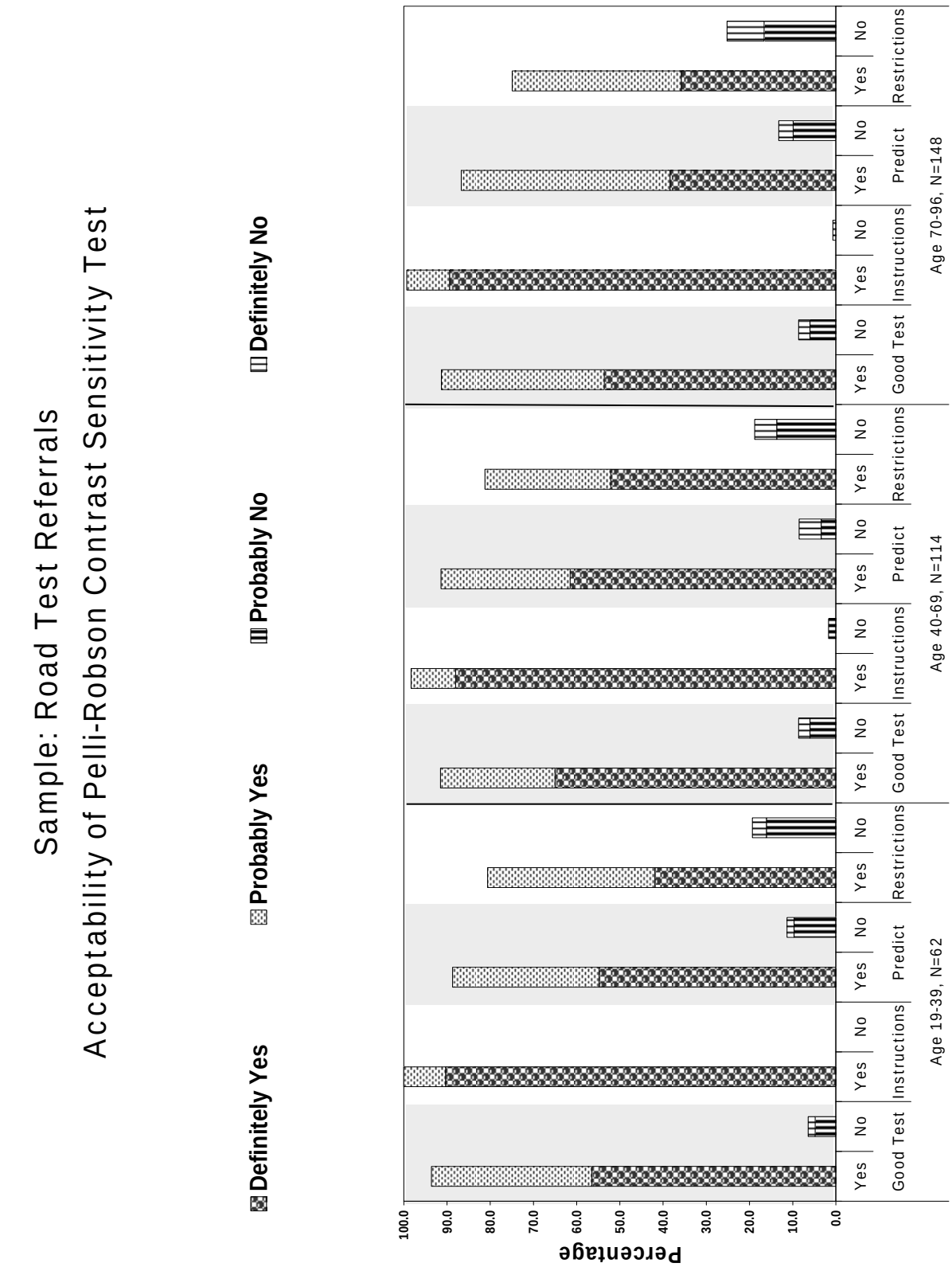
Appendix H-1A



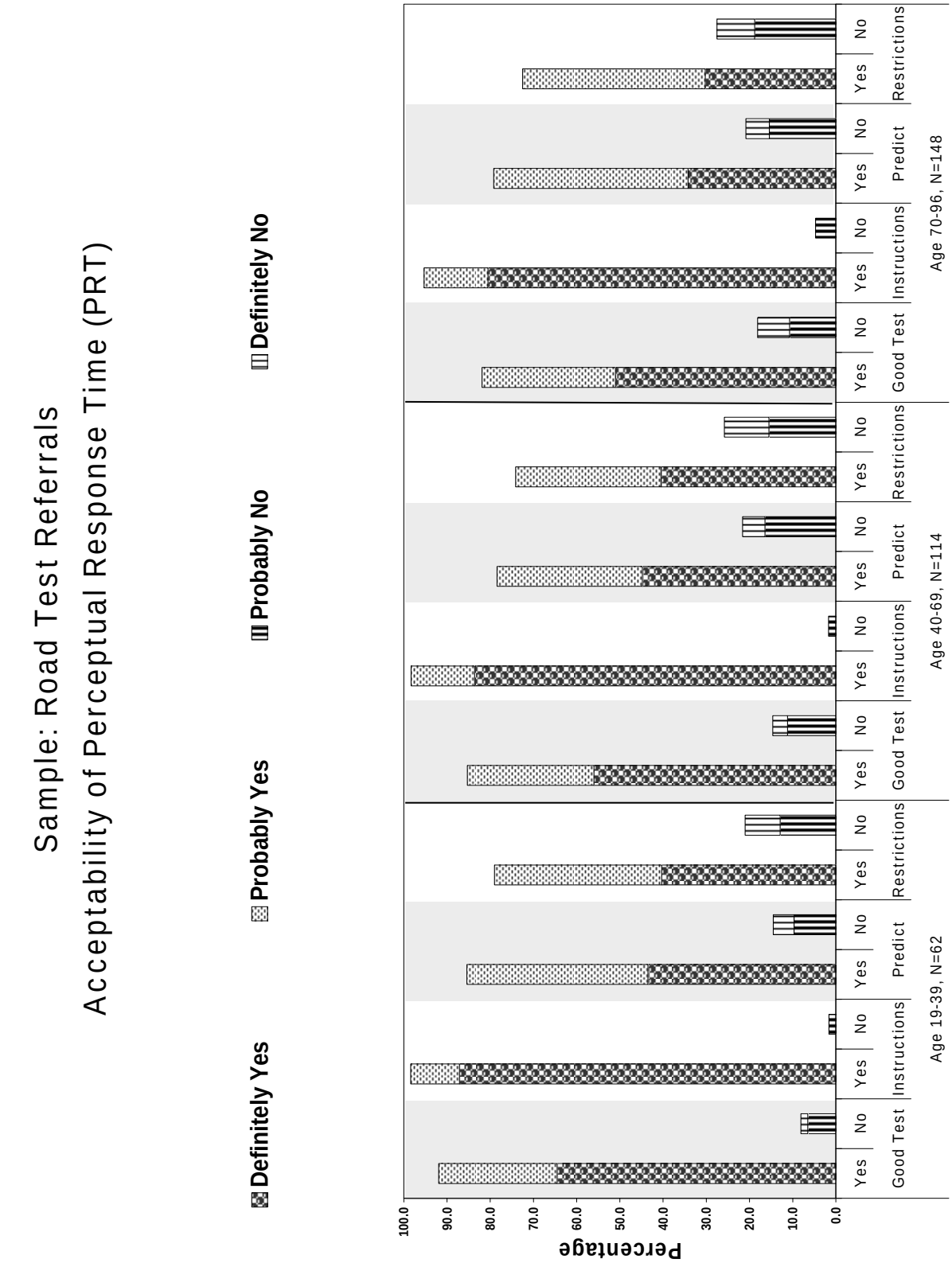
Appendix H-1B



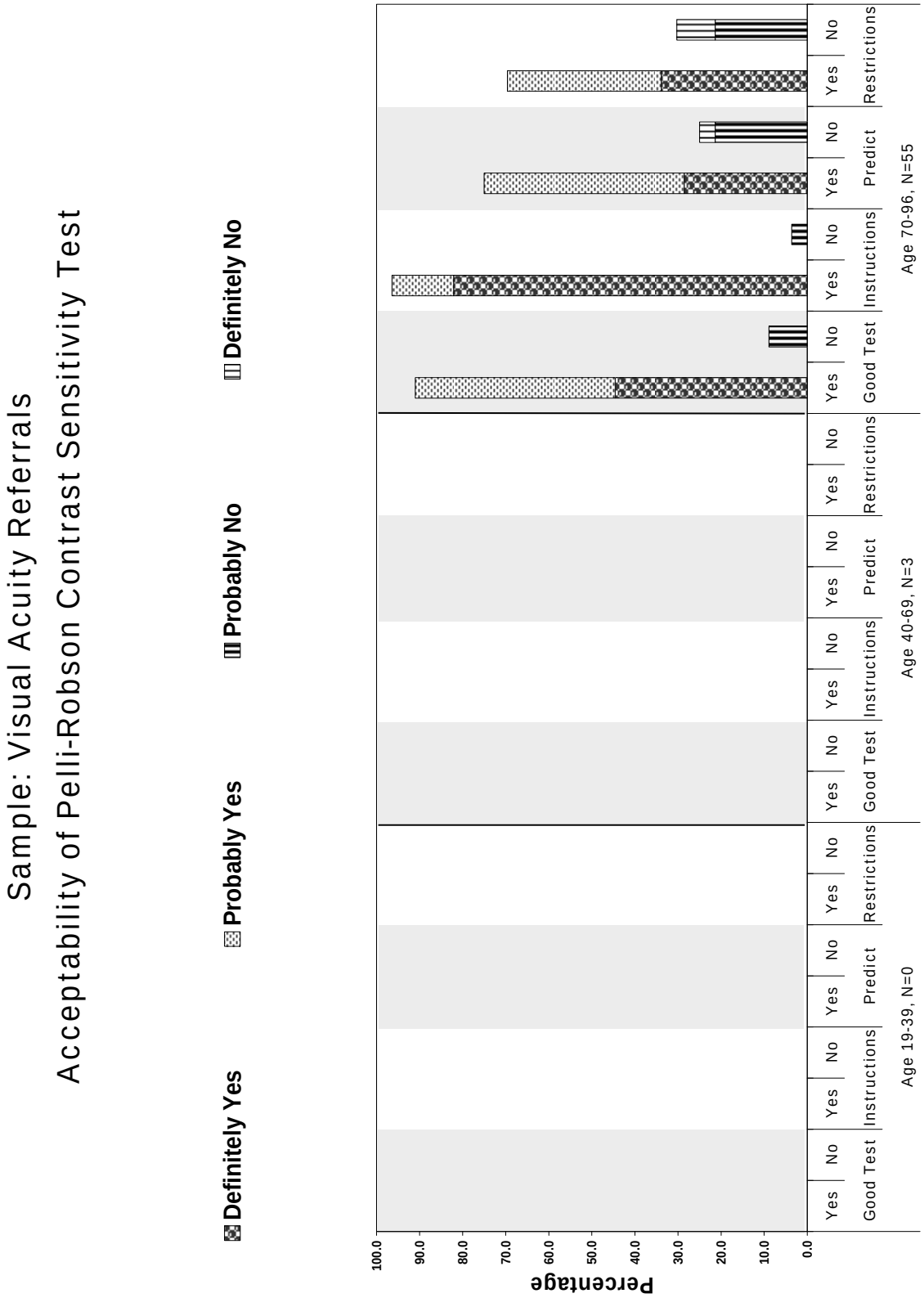
Appendix H-2A



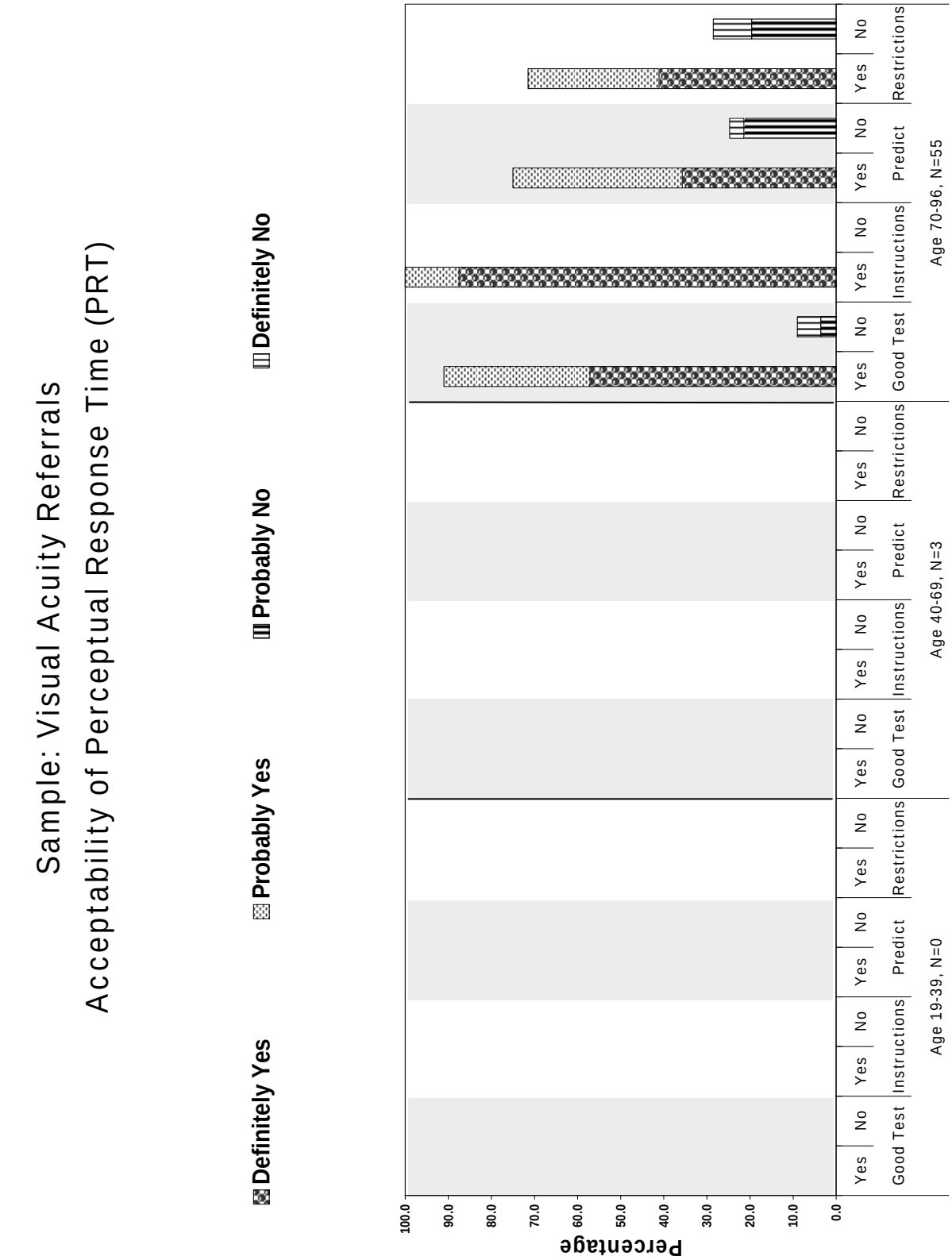
Appendix H-2B



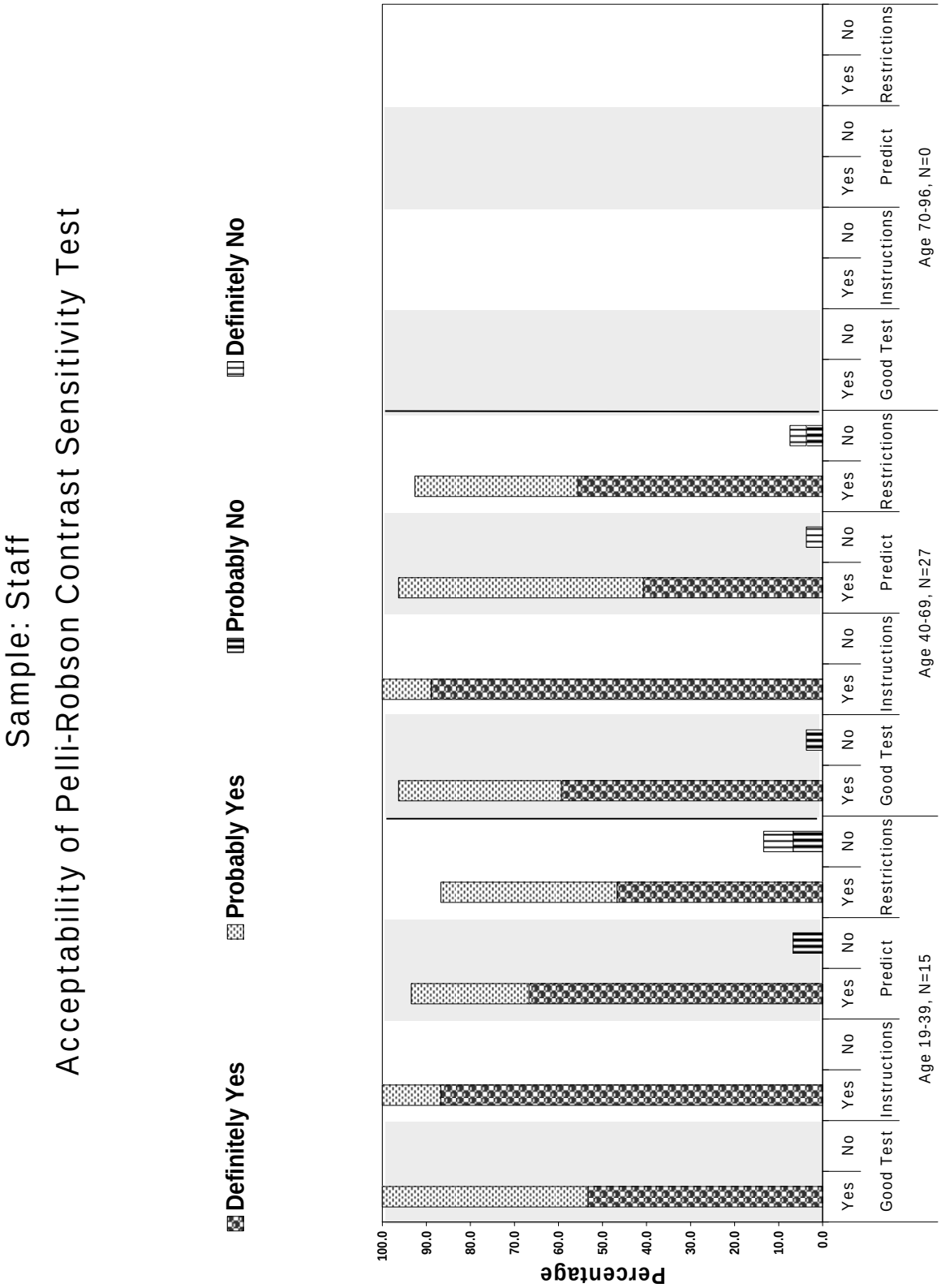
Appendix H-3A



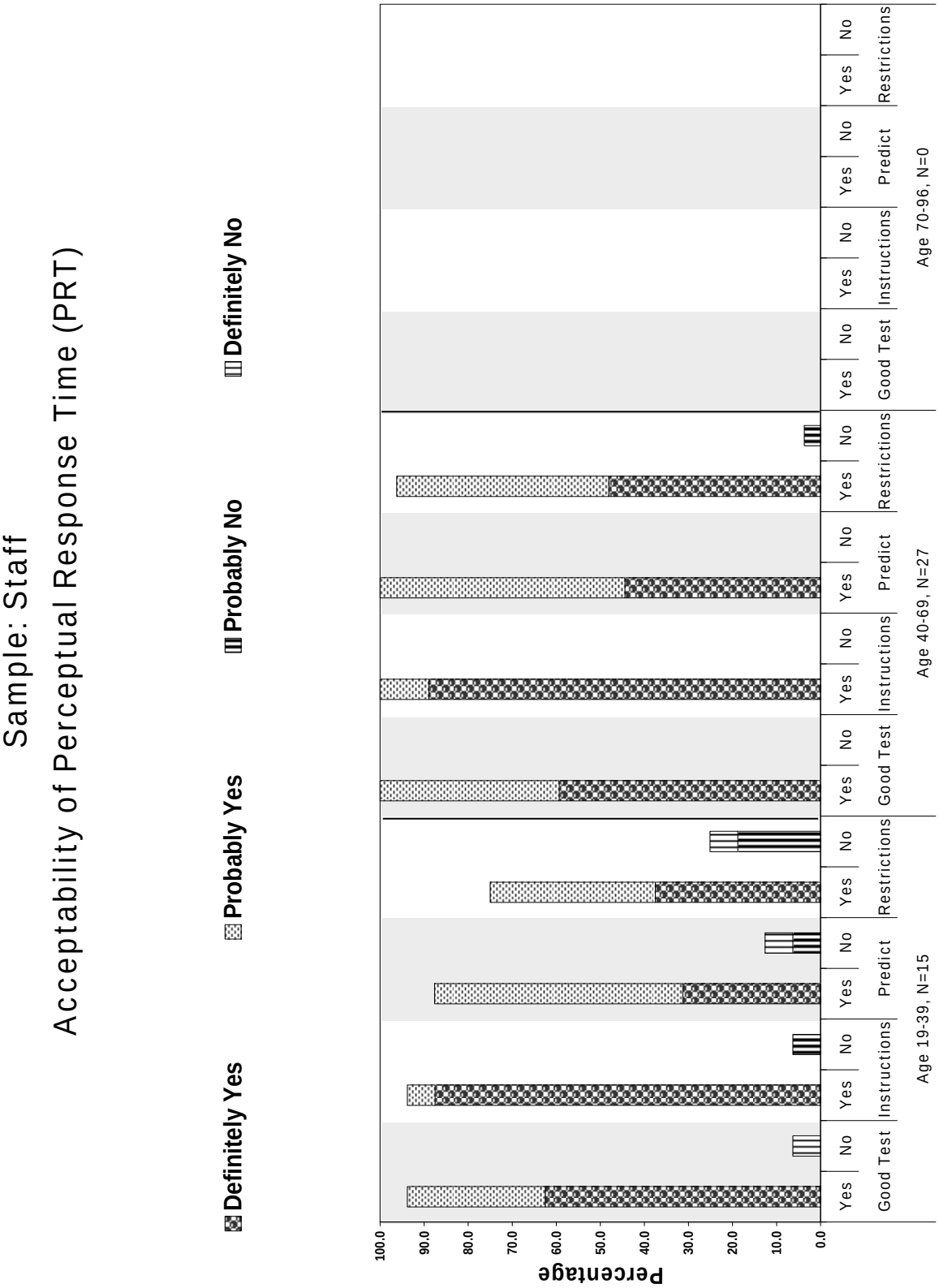
Appendix H-3B



Appendix H-4A



Appendix H-4B



Appendix I

Additional Screening Characteristics

Appendices I-1 through I-17 summarize additional screening characteristic information for the assessment tools (ATs) shown in Tables 14-17 and for the written knowledge test. These ATs include:

I-1 Written Knowledge Test
I-2 Physical Limitation (Physical)
I-3 Recall SSN
I-4 Intersection Problem
I-5 Pelli-Robson Contrast Sensitivity
I-6 SKILL Card, Dark Letters Correct
I-7 SKILL Card, Light – Dark Letters Correct
I-8 FACT Row 2
I-9 Tier 1 (Physical, SSN, Pelli-Robson Contrast Sensitivity)
I-10 Tier 1 (Physical, Intersection, Pelli-Robson Contrast Sensitivity)
I-11 Tier 1 (Physical, SSN, Intersection, P-R Contrast Sensitivity)
I-12 Tier 1 (Physical, SSN, FACT Row 2)
I-13 Tier 1 (Physical, SSN, SKILL Card-Dark Letters)
I-14 PRT
I-15 Tier 1 (Physical, SSN, Pelli-Robson Chart) & Tier 2 (PRT)
I-16 Tier 1 (Physical, SSN, FACT Row 2) & Tier 2 (PRT)
I-17 Tier 1 (Physical, SSN, SKILL Card-Dark Letters) & Tier 2 (PRT)

Appendix I-1

Assessment tool: Written knowledge test				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	27.8%	.541
	Road Test Referrals	62	39.0%	.010
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	25.0%	N/A
	Road Test Referrals	114	37.4%	.010
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	25.5%	.000
	Road Test Referrals	148	36.1%	.065
	Visual Acuity Referrals	55	40.4%	.009

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	69	40
AT fail	11	28
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.863	CI: 0.773 to 0.922
AT sensitivity: proportion of SDPE fails who failed AT	.412	CI: 0.303 to 0.530
Odds ratio for SDPE failure, AT fail vs. AT pass	4.391	CI: 1.975 to 9.761[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.956	CI: 1.427 to 2.682[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-2

Assessment tool: physical limitation (physical)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	0%	N/A
	Road Test Referrals	62	6.5%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	5.3%	N/A
	Road Test Referrals	114	14.5%	N/A
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	16.8%	.008
	Road Test Referrals	148	25.8%	.190
	Visual Acuity Referrals	55	30.4%	.808

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	73	51
AT fail	7	17
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.913	CI: 0.832 to 0.957
AT sensitivity: proportion of SDPE fails who failed AT	.250	CI: 0.162 to 0.364
Odds ratio for SDPE failure, AT fail vs. AT pass	3.476	CI: 1.342 to 8.989[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.722	CI: 1.236 to 2.400[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-3

Assessment tool: recall SSN				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	2.9%	N/A
	Road Test Referrals	62	4.8%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	1.8%	N/A
	Road Test Referrals	114	9.4%	N/A
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	17.4%	.079
	Road Test Referrals	148	14.6%	.714
	Visual Acuity Referrals	55	12.5%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	70	52
AT fail	10	16
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.875	CI: 0.785 to 0.931
AT sensitivity: proportion of SDPE fails who failed AT	.235	CI: 0.150 to 0.349
Odds ratio for SDPE failure, AT fail vs. AT pass	2.154	CI: 0.904 to 5.129[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.444	CI: 1.000 to 2.084[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-4

Assessment tool: intersection problem				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	1.5%	N/A
	Road Test Referrals	62	11.3%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	7.0%	N/A
	Road Test Referrals	114	19.7%	.867
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	23.2%	.086
	Road Test Referrals	148	32.5%	.794
	Visual Acuity Referrals	55	39.3%	.072

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	66	48
AT fail	14	20
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.825	CI: 0.727 to 0.893
AT sensitivity: proportion of SDPE fails who failed AT	.294	CI: 0.199 to 0.411
Odds ratio for SDPE failure, AT fail vs. AT pass	1.964	CI: 0.903 to 4.275[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.397	CI: 0.980 to 1.991[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-5

Assessment tool: Pelli-Robson contrast sensitivity				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	2.9%	N/A
	Road Test Referrals	62	11.3%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	10.5%	N/A
	Road Test Referrals	114	26.5%	.056
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	54.2%	.283
	Road Test Referrals	148	80.1%	.975
	Visual Acuity Referrals	55	98.2%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	40	28
AT fail	40	40
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.500	CI: 0.393 to 0.607
AT sensitivity: proportion of SDPE fails who failed AT	.588	CI: 0.467 to 0.697
Odds ratio for SDPE failure, AT fail vs. AT pass	1.429	CI: 0.744 to 2.742[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.214	CI: 0.848 to 1.738[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-6

Assessment tool: SKILL card, dark letters correct				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	0.8%	N/A
	Road Test Referrals	62	3.3%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	19.2%	N/A
	Road Test Referrals	114	34.5%	.103
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	52.0%	.063
	Road Test Referrals	148	70.5%	.305
	Visual Acuity Referrals	55	94.5%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	44	27
AT fail	36	41
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.550	CI: 0.441 to 0.654
AT sensitivity: proportion of SDPE fails who failed AT	.603	CI: 0.484 to 0.711
Odds ratio for SDPE failure, AT fail vs. AT pass	1.856	CI: 0.963 to 3.576[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.400	CI: 0.974 to 2.014[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-7

Assessment tool: SKILL card, light – dark letters correct				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	3.1%	N/A
	Road Test Referrals	62	3.3%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	9.6%	N/A
	Road Test Referrals	114	29.3%	.574
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	52.7%	.088
	Road Test Referrals	148	71.1%	.744
	Visual Acuity Referrals	55	78.2%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	43 vs. 44	27 same
AT fail	37 vs. 36	41 same
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Appendix I-8

Assessment tool: FACT row 2				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	8.8%	N/A
	Road Test Referrals	62	9.7%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	15.8%	N/A
	Road Test Referrals	114	34.2%	.079
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	62.6%	.003
	Road Test Referrals	148	64.2%	.151
	Visual Acuity Referrals	55	89.3%	.377

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	39	17
AT fail	41	51
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.488	CI: 0.381 to 0.595
AT sensitivity: proportion of SDPE fails who failed AT	.750	CI: 0.636 to 0.838
Odds ratio for SDPE failure, AT fail vs. AT pass	2.854	CI: 1.414 to 5.76[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.826	CI: 1.18 to 2.827[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-9

Assessment tool: Tier 1 (physical, SSN, Pelli-Robson contrast sensitivity)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	5.9%	N/A
	Road Test Referrals	62	21.0%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	14.0%	N/A
	Road Test Referrals	114	40.2%	.036
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	63.9%	.011
	Road Test Referrals	148	85.4%	.592
	Visual Acuity Referrals	55	98.2%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	36	17
AT fail	44	51
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.450	CI: 0.3468 to 0.559
AT sensitivity: proportion of SDPE fails who failed AT	.750	CI: 0.636 to 0.838
Odds ratio for SDPE failure, AT fail vs. AT pass	2.455	CI: 1.214 to 4.962[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.674	CI: 1.084 to 2.583[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-10

Assessment tool: Tier 1 (physical, intersection, Pelli-Robson contrast sensitivity)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	4.4%	N/A
	Road Test Referrals	62	27.4%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	19.3%	N/A
	Road Test Referrals	114	45.3%	.018
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	65.8%	.005
	Road Test Referrals	148	87.4%	.616
	Visual Acuity Referrals	55	98.2%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	35	15
AT fail	45	53
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.438	CI: 0.334 to 0.547
AT sensitivity: proportion of SDPE fails who failed AT	.779	CI: 0.667 to 0.862
Odds ratio for SDPE failure, AT fail vs. AT pass	2.748	CI: 1.333 to 5.667[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.803	CI: 1.137 to 2.859[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-11

Assessment tool: Tier 1 (physical, SSN, intersection, P-R contrast sensitivity)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	5.9%	N/A
	Road Test Referrals	62	29.0%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	19.3%	N/A
	Road Test Referrals	114	48.7%	.055
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	69.0%	.006
	Road Test Referrals	148	88.1%	.853
	Visual Acuity Referrals	55	98.2%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	32	13
AT fail	48	55
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.400	CI: 0.300 to 0.510
AT sensitivity: proportion of SDPE fails who failed AT	.809	CI: 0.700 to 0.885
Odds ratio for SDPE failure, AT fail vs. AT pass	2.821	CI: 1.330 to 5.983[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.848	CI: 1.129 to 3.025[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-12

Assessment tool: Tier 1 (physical, SSN, FACT row 2)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	10.7%	N/A
	Road Test Referrals	62	18.3%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	21.2%	N/A
	Road Test Referrals	114	44.0%	.104
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	70.3%	.001
	Road Test Referrals	148	71.8%	.187
	Visual Acuity Referrals	55	89.1%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	33	11
AT fail	47	57
SDPE total	80	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.413	CI: 0.311 to 0.522
AT sensitivity: proportion of SDPE fails who failed AT	.838	CI: 0.733 to 0.907
Odds ratio for SDPE failure, AT fail vs. AT pass	3.638	CI: 1.661 to 7.969[b]
Relative risk of failing SDPE, AT fail vs. AT pass	2.19	CI: 1.277 to 3.765[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-13

Assessment tool: Tier 1 (physical, SSN, SKILL card-dark letters)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	3.1%	N/A
	Road Test Referrals	62	13.3%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	23.1%	N/A
	Road Test Referrals	114	40.5%	.097
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	62.6%	.004
	Road Test Referrals	148	75.0%	.202
	Visual Acuity Referrals	55	94.5%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	38	17
AT fail	41	51
SDPE total	79	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.481	CI: 0.374 to 0.590
AT sensitivity: proportion of SDPE fails who failed AT	.750	CI: 0.636 to 0.838
Odds ratio for SDPE failure, AT fail vs. AT pass	2.780	CI: 1.375 to 5.623[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.793	CI: 1.160 to 2.772[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-14

Assessment tool: PRT				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	1.5%	N/A
	Road Test Referrals	62	3.2%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	7.0%	N/A
	Road Test Referrals	114	20.2%	.932
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	34.2%	.016
	Road Test Referrals	148	52.0%	.001
	Visual Acuity Referrals	55	50.9%	.377

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	59	38
AT fail	20	30
SDPE total	79	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.747	CI: 0.676 to 0.813
AT sensitivity: proportion of SDPE fails who failed AT	.441	CI: 0.359 to 0.518
Odds ratio for SDPE failure, AT fail vs. AT pass	2.329	CI: 1.165 to 4.656[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.532	CI: 1.084 to 2.082[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-15

Assessment tool: Tier 1 (physical, SSN, Pelli-Robson chart) & Tier 2 (PRT)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	0%	N/A
	Road Test Referrals	62	3.2%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	3.5%	N/A
	Road Test Referrals	114	23.9%	.172
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	37.9%	.001
	Road Test Referrals	148	63.3%	.008
	Visual Acuity Referrals	55	78.6%	N/A

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	59	32
AT fail	20	36
SDPE total	79	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.747	CI: 0.641 to 0.830
AT sensitivity: proportion of SDPE fails who failed AT	.529	CI: 0.445 to 0.605
Odds ratio for SDPE failure, AT fail vs. AT pass	3.319	CI: 1.662 to 6.626[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.828	CI: 1.304 to 2.491[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-16

Assessment tool: Tier 1 (physical, SSN, FACT row 2) & Tier 2 (PRT)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	0%	N/A
	Road Test Referrals	62	1.6%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	3.5%	N/A
	Road Test Referrals	114	28.4%	.084
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	41.6%	.000
	Road Test Referrals	148	57.3%	.000
	Visual Acuity Referrals	55	75.0%	.800

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	61	25
AT fail	18	43
SDPE total	79	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.772	CI: 0.668 to 0.851
AT sensitivity: proportion of SDPE fails who failed AT	.632	CI: 0.514 to 0.737
Odds ratio for SDPE failure, AT fail vs. AT pass	5.829	CI: 2.835 to 11.983[b]
Relative risk of failing SDPE, AT fail vs. AT pass	2.425	CI: 1.678 to 3.503[b]

[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix I-17

Assessment tool: Tier 1 (physical, SSN, SKILL card-dark letters) & Tier 2 (PRT)				
Age group	Participant status	*N*	Percentage who failed AT	'*p*-value' for 2x2 Chi Square: AT(P,F) x SDPE(P,F)
19-39	Renewals	134	0%	N/A
	Road Test Referrals	62	1.7%	N/A
	Visual Acuity Referrals	0	N/A	N/A
40-69	Renewals	57	3.8%	N/A
	Road Test Referrals	114	19.8%	.275
	Visual Acuity Referrals	3	N/A	N/A
70-96	Renewals	152	39.5%	.002
	Road Test Referrals	148	54.7%	.001
	Visual Acuity Referrals	55	67.3%	.639

Note. N/A: one or more cells have an expected count of less than 5.

Renewals aged 70- to 96-year old, N=148[a]		
	SDPE pass	SDPE fail
AT pass	57	32
AT fail	22	36
SDPE total	79	68

[a] Due to such matters as a lack of insurance, the brake lights did not work, or other related matters, the SDPE was not administered to four of the elderly Renewals.

Specificity, sensitivity, odds ratio, and relative risk		95% confidence interval
AT specificity: proportion of SDPE passes who passed AT	.722	CI: 0.614 to 0.808
AT sensitivity: proportion of SDPE fails who failed AT	.529	CI: 0.412 to 0.643
Odds ratio for SDPE failure, AT fail vs. AT pass	2.915	CI: 1.47 to 5.78[b]
Relative risk of failing SDPE, AT fail vs. AT pass	1.726	CI: 1.226 to 2.432[b]

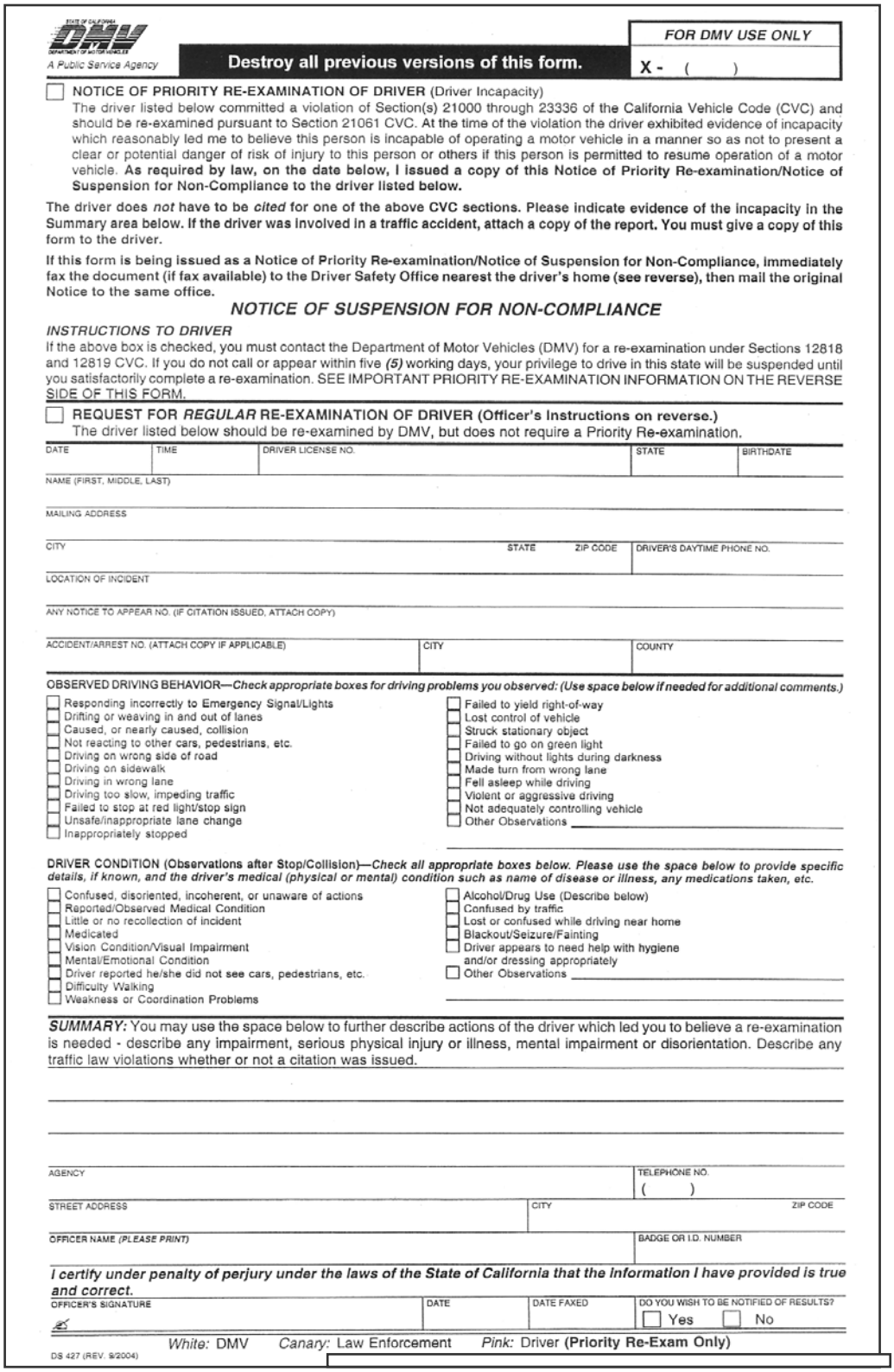
[b] A 95% CI that does not include the null value, 1, is equivalent to rejecting the null hypothesis at the .05 level.

Appendix J

Appendices J-1 through J-3 show the DMV Form DS 427, Law Enforcement Request for Re-Examination of Driver, and examples of the data used to construct the Form DS 427 checklists: Observed Driving Behavior and Driver Condition.

Appendix J-1

Law Enforcement Request for Re-Examination of Driver



STATE OF CALIFORNIA
DMV
DEPARTMENT OF MOTOR VEHICLES
A Public Service Agency

Destroy all previous versions of this form.

FOR DMV USE ONLY
X - ( )

☐ **NOTICE OF PRIORITY RE-EXAMINATION OF DRIVER** (Driver Incapacity)
The driver listed below committed a violation of Section(s) 21000 through 23336 of the California Vehicle Code (CVC) and should be re-examined pursuant to Section 21061 CVC. At the time of the violation the driver exhibited evidence of incapacity which reasonably led me to believe this person is incapable of operating a motor vehicle in a manner so as not to present a clear or potential danger of risk of injury to this person or others if this person is permitted to resume operation of a motor vehicle. **As required by law, on the date below, I issued a copy of this Notice of Priority Re-examination/Notice of Suspension for Non-Compliance to the driver listed below.**

The driver does *not* have to be *cited* for one of the above CVC sections. Please indicate evidence of the incapacity in the Summary area below. If the driver was involved in a traffic accident, attach a copy of the report. You must give a copy of this form to the driver.

If this form is being issued as a Notice of Priority Re-examination/Notice of Suspension for Non-Compliance, immediately fax the document (if fax available) to the Driver Safety Office nearest the driver's home (see reverse), then mail the original Notice to the same office.

NOTICE OF SUSPENSION FOR NON-COMPLIANCE

INSTRUCTIONS TO DRIVER
If the above box is checked, you must contact the Department of Motor Vehicles (DMV) for a re-examination under Sections 12818 and 12819 CVC. If you do not call or appear within five ***(5)*** working days, your privilege to drive in this state will be suspended until you satisfactorily complete a re-examination. SEE IMPORTANT PRIORITY RE-EXAMINATION INFORMATION ON THE REVERSE SIDE OF THIS FORM.

☐ **REQUEST FOR *REGULAR* RE-EXAMINATION OF DRIVER (Officer's Instructions on reverse.)**
The driver listed below should be re-examined by DMV, but does not require a Priority Re-examination.

DATE | TIME | DRIVER LICENSE NO. | STATE | BIRTHDATE

NAME (FIRST, MIDDLE, LAST)

MAILING ADDRESS

CITY | STATE | ZIP CODE | DRIVER'S DAYTIME PHONE NO.

LOCATION OF INCIDENT

ANY NOTICE TO APPEAR NO. (IF CITATION ISSUED, ATTACH COPY)

ACCIDENT/ARREST NO. (ATTACH COPY IF APPLICABLE) | CITY | COUNTY

OBSERVED DRIVING BEHAVIOR—*Check appropriate boxes for driving problems you observed: (Use space below if needed for additional comments.)*

- ☐ Responding incorrectly to Emergency Signal/Lights
- ☐ Drifting or weaving in and out of lanes
- ☐ Caused, or nearly caused, collision
- ☐ Not reacting to other cars, pedestrians, etc.
- ☐ Driving on wrong side of road
- ☐ Driving on sidewalk
- ☐ Driving in wrong lane
- ☐ Driving too slow, impeding traffic
- ☐ Failed to stop at red light/stop sign
- ☐ Unsafe/inappropriate lane change
- ☐ Inappropriately stopped
- ☐ Failed to yield right-of-way
- ☐ Lost control of vehicle
- ☐ Struck stationary object
- ☐ Failed to go on green light
- ☐ Driving without lights during darkness
- ☐ Made turn from wrong lane
- ☐ Fell asleep while driving
- ☐ Violent or aggressive driving
- ☐ Not adequately controlling vehicle
- ☐ Other Observations _____

DRIVER CONDITION (Observations after Stop/Collision)—*Check all appropriate boxes below. Please use the space below to provide specific details, if known, and the driver's medical (physical or mental) condition such as name of disease or illness, any medications taken, etc.*

- ☐ Confused, disoriented, incoherent, or unaware of actions
- ☐ Reported/Observed Medical Condition
- ☐ Little or no recollection of incident
- ☐ Medicated
- ☐ Vision Condition/Visual Impairment
- ☐ Mental/Emotional Condition
- ☐ Driver reported he/she did not see cars, pedestrians, etc.
- ☐ Difficulty Walking
- ☐ Weakness or Coordination Problems
- ☐ Alcohol/Drug Use (Describe below)
- ☐ Confused by traffic
- ☐ Lost or confused while driving near home
- ☐ Blackout/Seizure/Fainting
- ☐ Driver appears to need help with hygiene and/or dressing appropriately
- ☐ Other Observations _____

SUMMARY: You may use the space below to further describe actions of the driver which led you to believe a re-examination is needed - describe any impairment, serious physical injury or illness, mental impairment or disorientation. Describe any traffic law violations whether or not a citation was issued.

AGENCY | TELEPHONE NO. ( )

STREET ADDRESS | CITY | ZIP CODE

OFFICER NAME *(PLEASE PRINT)* | BADGE OR I.D. NUMBER

I certify under penalty of perjury under the laws of the State of California that the information I have provided is true and correct.

OFFICER'S SIGNATURE | DATE | DATE FAXED | DO YOU WISH TO BE NOTIFIED OF RESULTS? ☐ Yes ☐ No

White: DMV *Canary:* Law Enforcement *Pink:* Driver **(Priority Re-Exam Only)**

DS 427 (REV. 9/2004)

Appendix J-1 (continued)

INSTRUCTIONS TO THE OFFICER

Use this form to refer drivers to the Department of Motor Vehicles (DMV) for re-examination. All drivers referred by a law enforcement officer will be scheduled for a re-examination or, if appropriate, an immediate suspension or revocation will be imposed. Drivers who meet the criteria of 21061 CVC should be referred for an immediate, priority re-examination. Drivers who do not meet this criteria, but you believe should still be seen by DMV, should be referred for a regular re-examination.

Priority Re-examination

If the driver is being referred for a priority re-examination in accordance with Sections 12818 and 21061 of the California Vehicle Code (CVC), you must:

- Check the box for Priority Re-examination.
- Describe or list any violation of Section(s) 21000 - 23336 CVC. An actual citation or arrest is not required. (If the driver was involved in an accident or arrested, the information should be listed, or a copy of the accident report attached.)
- Describe actions of the driver, *including a description of the serious physical injury or illness, mental impairment or disorientation* that led you to reasonably believe the person is incapable of operating a motor vehicle without danger of risk of injury.
- Check one of the boxes below for the location of the Driver Safety Office nearest the driver's home.
- Sign the front of this form where indicated.
- Give a copy of this form to the driver.

If possible, fax the Notice of Priority Re-examination/Notice of Suspension for Non-Compliance to the Driver Safety Office nearest the driver's home (see list below), then mail the original copy of the Notice to the same office.

Regular Re-examination

Requests for a "regular" re-examination of a driver should be mailed (not faxed) to the Driver Safety Office nearest the driver's home.

INSTRUCTIONS TO THE DRIVER FOR PRIORITY RE-EXAMINATIONS

This Notice of Priority Re-examination/Notice of Suspension for Non-Compliance requires you to contact the DMV (in person or by telephone) within five (5) working days or your driving privilege will be suspended on the sixth day. Contact the DMV Driver Safety Office checked below for an appointment to talk to a hearing officer as soon as possible to make arrangements for reexamination before the suspension goes into effect. The hearing officer will schedule you for all required tests. At the time of your appointment for the reexamination, bring this form with you. You may be required to take a written, vision and driving test. You should be prepared to take any of these tests. ***Please have a licensed driver accompany you.*** Before a driving test is conducted, you must show evidence of financial responsibility (proof of auto insurance) for the vehicle you will drive during the test.

IMMEDIATE SUSPENSION OR REVOCATION POSSIBLE

In the event the Department of Motor Vehicles determines that your safety, or the safety of other persons upon the highways, requires suspension or revocation of your driving privilege, the Department of Motor Vehicles may, upon receipt and investigation of this Notice of Priority Re-examination/Notice of Suspension for Non-Compliance, suspend or revoke your driving privilege immediately in accordance with Section 13953 of the California Vehicle Code.

DEPARTMENT OF MOTOR VEHICLES—DRIVER SAFETY DISTRICT OFFICES

LOCATION	TELEPHONE	FAX	ADDRESS
☐ City of Commerce	(323) 724-4000	(323) 724-9262	5801 E. Slauson Ave., 2nd Flr., Ste. 250, 90040
☐ El Segundo	(310) 615-3500	(310) 615-3581/82/83	390 N. Sepulveda Blvd., Ste. 2075, 90245
☐ Fresno	(559) 445-6399	(559) 445-6379	2510 S. East Avenue, Ste. 310, 93706
☐ Irvine	(949) 440-4416	(949) 440-4424	16735 Von Karman Ave., Ste. 110, 92606
TDD:	(949) 440-4455		
☐ Oakland	(510) 563-8900	(510) 563-8950/8951	303 Hegenberger Rd., 4th Flr., Ste. 400, 94621
☐ Oxnard	(805) 488-0863	(805) 488-3219	4050 S. Saviers Rd., 93033
☐ Sacramento	(916) 227-2970	(916) 227-0174/2901	4700 Broadway, 2nd Flr., 95820
☐ San Bernardino	(909) 383-7413	(909) 383-7439	1845 Business Center Dr., Ste. 212, 92408
☐ San Diego	(858) 627-3901	(858) 627-3925	9174 Sky Park Court, Ste. 200, 92123
☐ San Francisco	(415) 557-1170	(415) 557-7375	1377 Fell Street, 2nd Flr., 94117
☐ San Jose	(408) 229-7100	(408) 229-7128	90 Great Oaks Blvd., Ste. 104, 95119
☐ Van Nuys	(818) 376-4217	(818) 376-4215	6150 Van Nuys Blvd., Ste. 205, 91401

DS 427 (REV. 9/2004)

Appendix J-2

Verbatim Examples and Percent of Police Narratives (N=29) that Cite the Critical Observed Driving Behavior

Critical observed driving behavior	Verbatim examples of observed driving behavior	Percent
1. Responding incorrectly to emergency signals/lights	"…veh came to complete stop in #3 of 5 lanes when emerg. lts. activated." "…when I initiated an enforcement stop on D-1, he came almost to a complete stop in the #1 LN of the S/B SR-14…" "The driver failed to yield for the P/V's lights & sirens for approx. 5 miles…"	37.9%
2. Drifting or weaving in and out of lanes	"While S/B on S. Oak Park Blvd, P. crossed over into oncoming traffic lane after drifting across the center divider lane…" "…veh was drifting into HOV LN & #2 LN & returning to #1. Veh came to complete stop in #3 of 5 lanes when emerg. Lts. Activated. "Driver B. in left turn lane and drove straight, weaving, nearly hit another vehicle and weaved into opposite lane when turning…" "Driver weaving all over road bumping into curbs…"	34.4%
3. Driving too slow, impeding traffic	"Driving at 5-8 mph in a 35 mph zone…" "…driver moved forward at 35 mph in 65 mph zone"	27.6%
4. Caused or nearly caused a collision	"…traffic from behind had to break to avoid a collision…" "…he nearly caused 2 collis in a small distance"	24.1%
5. Driving over speed limit	"Subject stopped for speed (87 in a 70 mph zone) and weaving (4 feet onto shoulder)…" "S/V observed speeding 76 mph…" "D-1 was paced at 78 to 80 mph, S/B SR-14 N/of San Fernando road…"	17.2%
6. Driving on wrong side of the road	"Driver made a left turn in front of incoming traffic. Drove on wrong side of road at oncoming traffic" "S. was observed driving northbound in the southbound lane of Mission Dr. Mission Dr. is clearly marked with one lane in each direction, separated by a solid double yellow line…" "As I was approaching the intersection of Harbor St. and Morro Bay Blvd. I saw V. turn W/B into a E/B one way only section of Harbor St…"	17.2%

Appendix J-2 (continued)

Verbatim Examples and Percent of Police Narratives (N=29) that Cite the Critical Observed Driving Behavior

Critical observed driving behavior	Verbatim examples of observed driving behavior	Percent
7. Failed to stop at red light/stop sign	"…running through a red light signal." "Driver failed to stop for 3 consecutive stop signs…" "I witnessed M., driving W/B on Monterey Rd. go through a full phase red light at the cross street of Meridian Ave, nearly missing a major traffic collision…"	13.8%
8. Unsafe/inappropriate lane change	"Veh was paced at approx. 110 mph & veh was observed making several unsafe lane changes" "I observed Mr. P. make a right turn from E/B Edinger to S/B Beach blvd. He cut a P/U truck in doing so, He then made a left turn onto E/B Stark Ave from Beach & cut another car off in doing so…"	13.8%
9. Inappropriately stopped	"…obs driver/D. parked across 2 lanes of traffic." "…turning wide left onto Charlotte Av and stopping on the wrong side of street…"	10.3%
10. Failed to yield right of way	"I observed Ms. C. driver from a stop sign into heavy traffic despite signs indicating such traffic had the right of way…" "Driver made a left turn in front of incoming traffic…"	6.9%
11. Lost control of vehicle	"…I noticed the driver (O.) appearing to be out of control and unsafely turned across the roadway edge and nearly struck me…." "…driver pulled into center divider almost losing control of s/v…"	6.9%
12. Struck stationary object	"…P. struck the west curb …"	6.9%
13. Failed to go on green	"…fail to go on green…"	3.4%
14. Failed to wear a seat belt	"I attempted to stop him for this violation and a seatbelt violation…"	3.4%
15. Driving without lights	"Obs. B. driving w/out lights during darkness…"	3.4%

Appendix J-3

Verbatim Examples and Percent of Police Narratives (N=51) that Cite the Critical Driver Condition

(Most of this data is based on observations made after a collision.)

Critical driver condition	Verbatim examples of critical driver condition	Percent
1. Confused, disoriented, incoherent, or unaware of actions	"…D. could not say where he was. Very disoriented" "…other party described above as vacant and not in touch with reality…" "S. said he did not see the yellow line and did not know what he did wrong"	60.8%
2. Driver reported or officer observed medical condition(s)	"S. experienced some type of seizure while driving…" "…as a result of the diabetes the driver had low blood and sugar while driving. She was involved in a collision and has no memory of it." "…it was determined that her blood sugar was #30 & she suffered a diabetic seizure."	17.6%
3. Little or no recollection of incident	"…could not tell me where collision occurred." "Driver does not know how accident happened & only remembers that he wasn't feeling well earlier in the day." "V. told reporting officer that he didn't remember anything…"	17.6%
4. Medicated	"B. stated she is on multiple medications and was suffering double vision and semi-aware of…" "…takes 400 mg Dilantin daily to control seizures…" "Driver is taking over 11 medications."	9.8%
5. Vision condition	"…suffering from double vision…has had problems for several days" "…not wearing glasses as reqd."	9.8%
6. Lacks knowledge of rules of the road	"…when asked why he did this Mr. N. stated 'I thought that is what I am supposed to do'" "Driver apparently did not know what to do when being pulled over" "Driver has no knowledge of driving laws and is very unsafe"	9.8%

Appendix J-3 (continued)

Verbatim Examples and Percent of Police Narratives (N=51) that Cite the Critical Driver Conditions

Critical driver condition	Verbatim examples of critical driver condition	Percent
7. Driver reported he/she did not see cars, pedestrians, etc.	"turned in front of on-coming traf resulting in severed t/c. Drvr stated he did not see approaching veh." "Driver while on Wood Canyon struck a pedestrian on the roadway jogging. She related she never saw him…" "S. said he did not see the yellow line…"	7.8%
8. Alcohol/drug Use	"Driver fell asleep behind running vehicle in drive due to .26 Blood Alcohol Content" "Driver involved in a traffic collision while under the influence of alcohol & drugs…" "Subject determined to be under the influence of a drug upon completion of a drug recognition evaluation. Subject determined to be under the influence of a CNS depressant" "Driver involved in a traffic collision while under the influence of alcohol & drugs…"	7.8%
9. Unsteady, difficulty walking	"The damage appeared to be caused by hitting the parking structure wall. He was also unsteady in walking…" "M.'s hands were unsteady and appears to be suffering from some ailment due to age (76 yrs.)…" "Mr. A. also displayed a total lack of balance and coordination and was unable to stand without assistance."	5.9%