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ABSTRACT

Volume 1 of a study designed to conduct a state of the art review of driver problem assessment consists of a review of related literature. The purpose of the study is to identify diagnostic assessment techniques in isolating driver problems. The review was based on three levels of information sources: (1) information from primary sources--driver licensing file, (2) information from secondary sources--other agencies, and (3) information from direct driver measurement. Each level is further divided into the following conceptual areas: (1) driver performance and ability, (2) human condition and states, and (3) exposure variables. Level 1 data sources have the greatest current utility for diagnostic assessment in an operational setting, based on the relatively inexpensive means of data retrieval and the consistency of significant predictors found at this level. Level 2 data present several legal and logistical problems due to the privileged information requirements and a lack of coordination between agencies. Level 3 data usually require further research before their operational utility can be determined since they are currently not widely used for assessment in social control agencies. The discussion is supplemented by illustrations and tables. A list of references is given for each chapter, and an author index is included. (Author/EC)

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DIAGNOSTIC ASSESSMENT OF DRIVER PROBLEMS:

Volume 1. The State-of-the-Art in Driver Problem Diagnosis

Robin S. McBride
and
Kenneth W. Stroad, Jr.

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AUGUST 1975

FINAL REPORT

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16. Abstract

A review of the traffic safety literature was conducted to evaluate the potential of assessment techniques for identifying driver problems. The ultimate objective was to provide operational assessors with techniques which may be useful to identify specific driver problems. The state-of-the-art review was organized by levels of observation: Level I was defined as assessment variables primarily available from a driver licensing file; Level II included data from other agencies (e.g., mental health); and Level III contained information which was obtainable directly from the driver. Each of these levels of observation were further divided by conceptual area: Performance; Biographical; Psychological/Social/Attitude; Medical/Physiological; and Exposure. This structure was found useful to organize the research, as well as to identify "gaps" in research. In addition, the levels of observation were useful to specify the current data sources for assessment techniques or variables. A critical analysis of the research literature identified several inherent methodological issues which limit firm conclusions on the utility of various techniques. A prototype model based on an assimilation of the research reviewed was developed to provide guidelines for assessment in operational settings. Volume II of the Final Report describes this prototype diagnostic assessment system.

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PREFACE

The primary objective of this study was to conduct a state-of-the-art review of driver problem assessment to identify techniques suitable for current diagnostic application. The Final Report, Diagnostic Assessment of Driver Problems, is comprised of two volumes. Volume I, The State-of-the-Art in Driver Problem Diagnosis, is the result of the review of the literature pertaining to driver problem assessment. Volume II, Assessment Techniques for Operational Users, documents the development of a model diagnostic assessment system for operational users in the traffic enforcement/control system, based on the most useful techniques identified in the review.

The state-of-the-art review describes the utility of diagnostic assessment techniques in several human factor and condition areas. These techniques utilize Performance, Biographical, Psychological/Social/Attitude, Medical/Physiological, and Exposure measures. A critical review was conducted in each of the above areas, and recommendations for further research have been made.

Several libraries and data repositories were searched in performing this review. Activities and sources included: a computerized search of the National Highway Traffic Safety Administration Library; a Traffic Research Information Systems (TRIS) search of all on-going research in the area of diagnostic assessment of driver problems; a National Library of Medicine--Medline search of techniques described in the medical literature related to diagnostic assessment; bibliographic listings and quantitative evaluations of valuable documents in the field; a search of the American University Highway Safety Research Library; and, finally, the standard search-and-procurement of bibliographic references found in relevant articles and documents.

Due to the volume of research in the area, it was not possible to include all relevant documents in the review. However, an attempt was made to select as many representative studies as possible.

The work described here was performed by HumRRO's Eastern Division, Alexandria, Virginia, Dr. J. Daniel Lyons, Director, as prime contractor. This report has been designated HumRRO Final Report FR-ED-75-21. The project was sponsored by the National Highway Traffic Safety Administration, under Contract No. DOT-HS-4-01015. Acknowledgements for this project are made on the following page.

Meredith P. Crawford, President
Human Resources Research Organization

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Foremost, very special appreciation is extended to Ms. Marsha Michaels, whose editorial supervision greatly improved the quality of the report.

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We extend our gratitude to the consultants who provided constructive comments and critical reviews of sections of this report: Mr. Raymond C. Peck, Mr. William Marsh, Mr. William Epperson, and Mr. Richard Harano, all affiliated with the California Department of Motor Vehicles. Dr. Frank Haight, Pennsylvania State University, provided valuable advice during the planning stages of the project, and as editor of the Accident Analysis and Prevention Journal, provided aid in soliciting research reports and comments from the international research community. Dr. John Whittenburg provided valuable comments on the organization of the review. Richard Pain, URS MATRIX, provided draft materials for the performance measurement section of Chapter 3.

We also appreciate the efforts of the many HumRRO personnel associated with this project: Dr. J. Daniel Lyons and Dr. Joel M. Reaser provided general direction and support; Dr. George Brown, Mr. John D. Harris and Mrs. Deborah H. Bercini assisted in the collection and documentation of the research reviewed; Mrs. Lola Zook and Mrs. Ruth Gregory, Editorial and Production staff, produced the many complex tables and figures in the report. Special thanks are extended to Ms. Nedra Huff, Ms. Peggy Evans, Ms. Judy Pumphrey, and Ms. Elaine Goldberg for their patience in typing drafts and final copy, and to Ms. Krista McBride, who laboriously compiled and checked the references for the Final Report.

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INTRODUCTION

Motor vehicle crashes were responsible for 55,800 deaths in the United States in 1973, as reported by the National Safety Council (1974), making them the sixth leading cause of death in this country. Among individuals aged 44 and under, they were the leading cause of death. In addition to fatalities, 2 million personal injuries and $20.2 billion in costs were attributed to motor vehicle accidents, demonstrating the need for more effective efforts directed against the problem.

There have been numerous approaches to the reduction of the traffic safety problem. These have included control of highway design and environmental factors, improvement of vehicle design and performance characteristics, and programs directed toward the driver through licensing, problem identification, and post-licensing driver control. This review will focus on the driver to identify diagnostic assessment techniques which appear to have potential for isolating driver problems.

PERSPECTIVES ON DIAGNOSTIC ASSESSMENT

Diagnostic assessment can be viewed as a process of identifying problems and directing efforts toward providing solutions. It can be employed primarily in two operational stages: pre-license screening and post-license control.

Most researchers are in general agreement that diagnostic approaches in license screening have limited utility, due to low validity of prediction, or low ability to identify problems. In addition, since most applicants eventually drive, due to society's dependence on automobile transportation, alternatives for providing solutions are usually limited to some form of restricted license, special equipment, or supplemental driver training.

The assessment of driver problems appears more promising in the area of post-licensing control. Diagnostic assessment can have a broad impact on the traffic safety problem if high risk behaviors can be identified and effective countermeasures employed before driver involvement in a crash. From a research point of view, this identification/countermeasure approach involves several distinct phases. One task is to identify "types" of drivers most likely to have subsequent accidents. A separate process is the evaluation of the effectiveness of various treatment programs. Finally, assessment and treatment programs can be combined to permit the prediction of "types" of drivers least likely to recidivate once treatment has been administered, which is essential to the concept of tailored treatment programs (i.e., predicting success after treatment, rather than simply need for treatment).

Since the dimensions of the problem must be defined before countermeasures can be effectively developed and implemented, this review will not attempt to specify treatments and countermeasures for classes of drivers with a particular problem although the synthesis should provide guidelines for their development. In many cases, the identification of a problem leads directly to a suggested countermeasure.

The objective of the current review is to evaluate driver assessment procedures which are useful to predict individual accident risk potential (accident liability) within an operational setting such as a court or licensing agency-related driver improvement setting.

ACCIDENT PRONENESS

The concept that there are intrinsic human factors which predispose certain individual drivers to higher accident risk has been termed "accident proneness." This viewpoint has, for several decades, dominated research concerned with the relationship between personal characteristics and accident rates. Since the basis for diagnostic assessment of driver problems rests on the assumption that individual differences will be reflected in future accident rates, the concept of "accident proneness" should be examined. The most basic questions to be considered are these: "Do some people really have more accidents than others?" and "Are these differences too great to be attributable to chance?" (Shaw and Sichel, 1971). Shaw's own research provides a resounding "Yes" to both of these questions. Over a period of more than ten years, Shaw collected voluminous data on the accident rates of African bus drivers employed by a public transport company in South Africa. Correlating accident rates of individuals over two successive three-year periods, she obtained correlation coefficients in the range of .6 - .7. These correlations were sufficiently high that personality tests were found to be excellent predictors of high-risk driving. (It is worth noting that these drivers drove over controlled routes so that exposure was held relatively constant.)

Research studies conducted in the United States have failed to find such strong evidence of accident proneness, so that most American researchers tend to be dubious about the utility of the concept. A detailed series of studies conducted by the California Department of Motor Vehicles (1964) greatly illuminate this topic. Using the official accident records of 184,000 drivers in each of the years 1961-1963, correlations were computed between the accident records for different years. The highest coefficient obtained was only .06.[1] Correlations of this order of magnitude naturally raise doubts about the meaningfulness of the concept of accident proneness. It is apparent that accidents in America do not have nearly the degree of temporal stability of those in South Africa. As a result, liability prediction in American jurisdictions is correspondingly difficult.

A plausible explanation of cultural differences in accident proneness has been provided by Frank Haight in a review of Shaw's research:

> As non-motorized countries pass into mass motorization, and as the driving population expands from a few professionals to virtually every able bodied adult, there is a repeated sequence of experience: the driving school stage, with its fascination with steering and smooth gear changing; the long distance stage; the high speed stage, perhaps the drag racing stage. The final stage uses the motor car unemotionally as a transport means without pushing any capability to its limit. Anyone who has driven in a few dozen countries can see these stages at work, that is, can see a mass population absorbing the technical skills and developing the emotional outlook appropriate to

[1] The same data show that during the period of 1961 and 1962, only 11% of the state's drivers were involved in accidents. These same accident-involved drivers, however, were involved in only 20% of the subsequent (1963) accidents. Thus, 80% of the yearly accidents involved drivers who had <u>no</u> accidents in the preceding two years.

large scale road transport by private vehicles. Drivers gradually learn which of their abilities, personal habits and attitudes are inadequate for successful performance in a complex road system and, if they are to continue in the system, compensate for these deficiencies in the development of their driving style. It seems quite reasonable, therefore, that measurement of driver differences ... is more easily accomplished towards the primitive (or Jugoslav) end of the spectrum than towards the sophisticated (or Californian) end.
(Haight, 1972)

Thus, as individual variation is reduced in more sophisticated driving societies, and as accidents become increasingly rare events, the operational utility of a concept such as "accident proneness" is also reduced.

However, even in America, there is evidence that on an actuarial basis group liability is a function of previous driving history. For example, in the same California study, 86,726 male drivers were grouped on the basis of number of accidents sustained in 1961. For each group, a determination was made of how many accidents they incurred in the next one year period. Those who had had two accidents in 1961 sustained 1.9 times as many accidents in 1962 as did the group with no accidents in 1961. This relationship could be considered evidence of relatively stable personal characteristics which result in "accident proneness." However, since it may also stem from non-personal factors, such as quantity and quality of driving exposure,[2] or from relatively temporary factors such as situational stresses (e.g., marital problems, employment problems), we will employ a broader term, and label this concept "accident liability."

Overall, the positions presented here on "accident proneness" appear to be more a matter of semantics and emphasis than conceptual differences. American researchers (out of necessity) tend to emphasize the situational factors of the highway experience, such as exposure. At the other extreme, Shaw emphasizes more person-centered characteristics, a function of her research findings in a much different situation. Operationally the distinctions diminish since either may increase validity of driver problem assessment. This review, however, will be oriented primarily toward assessment in a more sophisticated and controlled driving environment, where variation among drivers is low, and temporal stability of criterion measures is reduced. The implication of this increasing driving sophistication is that to effect a large

2 It is essential, in examining accident proneness, to control for amount of exposure to the possibility of accidents (in terms of the amounts and kinds of driving). Adams (1970) adds that one must also control for variations in propensity to accept or reject hazards--what he calls "exposure proneness." He feels that exposure proneness may be a far more significant contributor to accident records than accident proneness.

reduction in the human factors area of traffic safety problems, diagnostic methods must be developed which will allow prediction of a broader range of problems, including a driver's first accident.

Operational systems often use point or entry criteria to define the driver with a history of accidents or violations as a "problem driver," but the identification and treatment of problem drivers alone can have only limited impact on the total accident picture. A broader application of assessment techniques is needed to identify problems among those drivers who have not yet exhibited a poor driving history. In addition, specific types of driving errors, not simply "problem driving," must be identified to select appropriate countermeasures. Thus, employing techniques at various intervention points in the traffic system will be useful to assess the presence of specific high risk behaviors and their determinants among a larger proportion of the population, regardless of driving history. The current review will therefore refer to the "problems of drivers," rather than the "problem drivers."

The problems of drivers can be many. As early as 1949, the thesis was advanced that "a person drives as he lives" (Tillman and Hobbs, 1949), or, that those who have repeated difficulties in other areas of social adjustment will have similar problems with driving. Other researchers, notably McFarland, have more recently reached the same conclusion:

> "...the entire adjustment complex of the individual reflects the accident record of this person as a driver." (McFarland, restated by Lucas, 1970)

The implication of these statements is that assessment techniques which validly detect problems in any of the numerous areas of social adjustment might also be useful in driver assessment. Consequently, this review will discuss many broad areas of individual assessment, including some which are seldom included in driver assessment programs.

LIMITATIONS

Throughout the preceding discussion we have mentioned some of the limitations of diagnostic assessment in the field of traffic safety. These factors will also be discussed in depth in subsequent chapters, but will be summarized briefly here.

First, there are two major systematic errors which can bias the interpretation of most driving data. One is the problem of controlling for exposure. Although gross accident and conviction statistics are useful for administrators to define the magnitude of highway safety problems, exposure control is essential for individual diagnosis. To a very real extent, the number of accidents and traffic convictions is a function of the number of miles driven. An individual driver's contribution to highway risk must therefore be measured by "per-mile" accidents, not simply total accidents (amount of hazard per mile is equally relevant). The other major type of interpretation problem is the many forms of data reporting bias. Undetected driving errors are often not randomly distributed. Certain classes of drivers may be able to settle minor accidents amicably without police intervention. Others may be able to resolve traffic citations without a notation in the driver's record. Plea bargaining may systematically reduce or eliminate convictions. For example, persons represented by attorneys may be more likely to have severe charges reduced. Any driver data collection system must be examined for these and other reporting biases.

Another problem is that driving requirements are not static; they change with age, experience, jobs, marital status, economic status, and geographic location of one's residence. Research studies in this field seldom address the issues of effective "life-span" of predictor variables.

Another very limiting factor is the lack of a stable and valid criterion to measure driving errors. For the most part, diagnostic approaches in operational and driver licensing improvement systems have used driving records as the primary criteria for classifying deviant drivers into groups such as "negligent driver" or "problem driver." The use of these criteria represents at best a crude approximation of underlying factors which predispose one to high risk behaviors. As the discussion of accident proneness indicated, high relationships of predictor variables with total accident criteria will be difficult to demonstrate, since in this country accidents are relatively rare events, and on an individual basis, are usually an unstable criterion over time. This problem can only be partially remedied by using traffic convictions (which are about 3 or 4 times as frequent), since the relationship between accidents and convictions for individual drivers is not clear. Convictions could represent "accident proneness," or merely "getting caught proneness." Total accident or conviction statistics also provide little behavioral description of the driving errors involved, which is necessary for specific countermeasure assignment. Dividing convictions by types, or accident-related conviction types (e.g., an accident-related right-of-way violation) is a partial solution, but it aggravates the previous rare-event/temporal stability problem.

Finally, all programs aimed at increasing highway safety must be cost-effective. A reduction in total accidents means little unless the societal costs of the accidents avoided can be compared with the societal costs of the reduction effort. Predicting accident-cost liability would be more useful operationally than simply predicting accident liability.

The ideal diagnostic system then, should contain detailed information on driver errors so that problems can be diagnosed. In addition, severity data would allow countermeasures to be cost-effectively applied. Unfortunately, detailed descriptions are seldom available in an integrated fashion. Information often is scattered throughout research studies and in various agency files, in one form or another. To the extent possible, we will attempt to relate these factors to diagnostic systems, and identify areas which appear to be critical for further research. However, most research has suffered from one or more of these criterion-related disadvantages, so that conclusions must often be based upon inference rather than fact.

RESEARCH TRENDS

In recent years attempts have been made to overcome the criterion definition problem by conducting in-depth investigations of collisions, to evaluate the roles of interacting environmental, vehicular and human factors in accident causation. These investigations (some including over 800 variables) represent significant improvement in the attempt to understand the complex interactions among driving-related variables. Although the determination of causal factors is subject to error, since judgments must be made after-the-fact, these investigations do give a more complete view of the total system and point to areas in which change can be effected--the environment, the vehicle, or the driver. As a result, this review will frequently rely on the results of such investigations to help clarify causal relationships, and to provide supporting documentation for the role of the driver.

In driver licensing/improvement the quality of the research has improved substantially in recent years. Evaluation efforts have increasingly recognized the need for more comprehensive assessment of the driver, rather than limiting assessment to a particular problem. Batteries of psychometric tests and other devices are being used to isolate particular problems within the negligent driver population, and differential treatment programs are being initiated.

In the court setting, large scale efforts are underway to diagnose drivers with drinking problems. Diagnostic procedures are being applied on an experimental basis to young habitual violators to determine the relationship between personal characteristics and treatment effectiveness in reducing recidivism.

An attempt will be made to isolate approaches and areas of investigations which have practical utility. In doing so we will determine additional short- and long-term research requirements to improve assessment. At the same time, the need for instrument refinement will be identified. As appropriate, socio-legal issues will be addressed.

As in many areas of investigation, more questions are raised than answered. It is clear that many of the unresolved issues are a function of inadequate research methodologies, use of differing or poorly defined criteria, unclear delineation of contributing factors, or narrow research perspectives. In general, much of the research appears to have been conducted in isolation. Specific recommendations for more uniform approaches will be outlined in this review.

Through a systematic review of the literature we will attempt to "pull together" empirical findings and opinions of operational "assessors" in developing a prototype assessment model for use in operational settings. We shall also attempt to relate research findings to "target groups," or high accident liability classes of drivers, for whom the need for specialized diagnostic assessment is especially great.

APPROACH

To determine an appropriate framework which can relate assessment techniques, operational settings, psychometric properties, and "target groups," the inter-relationships of these concepts must be examined.

One of the assumptions underlying the development of diagnostic driver assessment techniques is that certain variables can be used to partition the driving population into a number of sub-populations. Among these sub-groups, those exhibiting high accident liability can be designated "target groups." As the number of (valid) variables used to partition the population increases, and probability estimates become more refined, the size of the resultant "target groups" decreases.[3]

For operational purposes, not every variable can be collected for every driver. Some variables may be cost-effectively (or even appropriately) collected only for certain sub-populations. Thus, target groups have often been considered preliminary divisions of the driver population. The designation of particular sub-populations as a target group is an administrative decision based on cost-effectiveness, political implications, and other considerations. Within the highest of these preliminary liability classes, it is hoped that further refinement of potential accident liability can be made using assessment techniques.

Assessment techniques are any methods used for collecting information (variables) which can partition the driving population into target groups. Asking a license applicant to write down his age, or issuance of a traffic citation are both assessment techniques, although the data collection methods may vary.

The selection of the variables (techniques) to be collected (used) for every driver to determine accident liability class remains with the individual licensing agency, which must weigh potential gains vs. increased cost. This review will attempt to demonstrate the relative gains in predictive potential using increasingly descriptive assessment techniques.

[3] Extending this assumption further, perfectly reliable and valid assessment techniques (ignoring, for the moment, transitory characteristics) would allow the total driver population to be divided into sub-groups, each containing only one driver. The exact future driving record of each individual could thus be predicted. Since presently available assessment techniques are far from being perfected, we are forced to settle for "target groups."

OPERATIONAL REQUIREMENTS

To be useful for diagnostic assessment, every technique must be reliable, i.e., capable of consistently producing the same result on different occasions. This is not always the case with, for example, psychological tests. There is one other essential psychometric requirement which a predictor variable must meet. A variable must exhibit a demonstrated relationship with future driving criteria to be useful in creating meaningful driver "target groups." The degree of this relationship, or predictive validity, varies widely among the currently available diagnostic assessment techniques. Finally, variables must also be "true" predictors--obtainable prior to the event being predicted.

In addition to psychometric requirements, there are some other operational requirements which must be considered in variable selection for target group definition. One important constraint is amount of difficulty, time, and expense required to collect the data. Another is the possible controversial nature of the data. In some cases, the data collection process may also be subject to legal constraints.[4]

ORGANIZATION OF REVIEW

Diagnostic assessment techniques have often been classified by conceptual areas such as measures of "alcohol problems," "attitude problems," "medical problems," etc. Although this approach may appear to provide a clear organizational structure, it suffers from a certain lack of comprehensiveness, since driver problems are seldom confined to one area and patterns of problems often exist.

In addition, it does not address a most important operational consideration--sources of data. To be sensitive to operational issues as well as conceptual, we have attempted to group techniques by the apparent degree of difficulty involved in obtaining the data, as well as by conceptual area. The following were arbitrarily chosen as our levels of difficulty. They are also the titles of our first three chapters.

Chapter 1 INFORMATION FROM PRIMARY SOURCES (Level I)

Data available at a driver licensing agency (not all of the information referred to in this chapter will be available at all such agencies). In most instances, other driver control agencies such as court systems will have (or should have) access to licensing agency files.

[4] See McGuire (1969)

Chapter 2 INFORMATION FROM SECONDARY SOURCES (Level II)

Data already collected and obtainable from sources other than the driver. This includes any information not available directly at a licensing agency, but which is potentially easy to obtain, often by a phone call. Examples include hospital records, criminal records, mental health treatment records, etc.

Chapter 3 INFORMATION FROM DIRECT DRIVER MEASUREMENT (Level III)

Data for which the driver must be located to complete a test, interview, or questionnaire. Physically locating a driver must be considered more difficult than simply finding his records. This chapter includes telephone surveys, interviews, psychological tests, etc.

Throughout the text, these types of sources will be referred to as Level I sources, Level II sources, etc. As we have stated, the levels have been somewhat arbitrarily chosen. A variable available at a driver licensing agency in one state (e.g., marital status), might be available only from a secondary source (another agency) in another state, and might require interviewing the driver in a third state. Thus, our review represents a generalized conception of a current driver control system. It is not intended to be a static model. Any technique can be moved from one level to another, if such a change appears warranted. To illustrate a change from Level III to Level I, the administration of a particularly useful psychological attitude test, which now requires locating an individual driver, could instead be performed routinely as an adjunct to all license and renewal applications, with the scores retained in every driver's file. These scores could then be easily used as a "first-cut" to determine accident liability class.

The majority of current research is being conducted using Levels I and III as data sources. Level I (licensing agency records) offers for the most part, descriptive data on accidents and violations, as well as various biographical information such as age, sex, and marital status. Since these data sources are usually quite accessible, a substantial body of research will be reviewed in Chapter 1. Although Level II (other agency) data sources are numerous, this area represents the largest gap in research. This gap is due, in part, to the difficulty within research programs of coordinating the efforts of several agencies with different orientations, and in part to the obligation incumbent upon these other agencies (e.g., mental health, medical) to protect certain information obtained from clients. Level III sources (direct driver measurement) are almost by definition areas of research. These sources are not yet operational, yet through their use, techniques may be developed for inclusion at Levels I and II.

Additionally, Level III sources can also provide some verification and integration of Levels I and II.

Since our levels of information sources have been operationally defined (by amount of difficulty in data collection), they are not necessarily research levels. Research findings at one level may be useful to explain variables which are operationally employed at another level. Thus, some research results, notably the multi-disciplinary accident investigations, may be found throughout our chapters, wherever they might be useful to explain information from more conventional sources.

In summary, we have attempted to classify assessment techniques by the level of difficulty currently involved in using them in operational settings. Within each level we have then addressed conceptual areas and psychometric properties. Our distinctions have been arbitrary, but hopefully will illustrate the degree to which increasingly difficult to obtain information increases the overall knowledge of the driver.

To maintain continuity, we have further divided each of our "levels of difficulty" chapters into the following conceptual areas:

- Driver Performance Variables
- Human Conditions and States

  Biographical Variables

  Psychological/Social/Attitude Variables

  Medical/Physiological Variables
- Exposure Variables

These distinctions have been made since the human condition variables are useful in accident liability prediction only as predictors, while the driver performance measures which are available in various forms at various levels can be used not only as predictors, but also as subsequent criteria. Under the second section, "Human Conditions and States," it should be noted that the three sub-headings are also extremely arbitrary. Many variables could have been discussed under several headings. Marital status is discussed under "Biographical" variables, while "Divorce," considered a stress factor, is included under the "Psychological/Social/Attitude" heading. The third section, "Exposure Variables," discusses any variables which qualitatively and quantitatively describe the driving environment (e.g., area of residence, annual mileage, etc.). Although these variables do not directly describe the driver, they have been shown useful in interpreting the other driver descriptions.

Table I-1 presents a summary of the kinds of variables included

TABLE I-1. ORGANIZATION OF REVIEW

		HUMAN CONDITIONS AND STATES			
LEVEL OF OBSERVATION	PERFORMANCE	BIOGRAPHICAL	PSYCHOLIGICAL/ SOCIAL/ATTITUDE	MEDICAL/ PHYSIOLOGICAL	EXPOSURE
I	Convictions Accidents Knowledge Testing Driving Ability Testing Driver Improvement Actions and Sanctions	Age Sex Marital Status Race Driver Education Height Weight	Type of Motor Vehicle	Medical Impairments Vision Testing	Class Mileage Estimates Class of License Motor Vehicle Ownership Local Accident and Conviction Rates Area of Residence
II	Police Accident Reports	Socio-Economic Status ● Occupation ● Education ● Credit Rating	Divorce Criminal Convictions Unemployment Mental Health Reports	Alcoholism Treatment Drug Usage	Time of Day Induced Exposure
III	Search Detect Identify Situation Diagnosis Action Selection Action Execution ● Simulator ● Observation ● Road	Family Relationships Socio-Economic Status Lifestyle ● Activities	Situational Stress General Personality Characteristics Driver-Specific Personality and Attitude Measurement	Alcohol Related Problems Fatigue Effects	Estimated Mileage Qualitative Exposure Variables

within each conceptual area at each level of observation (or difficulty). The first three chapters of this review will proceed across a row of this model. Within each of these sections, we will attempt to describe variables by their psychometric utility and describe any applicable operational constraints. Each chapter will conclude with a brief summary. A summary of the "state-of-the-art" of driver problem diagnostic assessment (Chapters 1-3), as well as recommendations for the future, comprise Chapter 4.

Chapter 1

INFORMATION FROM PRIMARY SOURCES

Most studies of accident prediction conclude that certain variables from the motor vehicle operator's prior driving history, found in state driver control agency files, are among the best of the numerous available predictors of crash liability. State driver licensing and improvement agencies, for purposes of this review, have been defined as the primary source of such driver information. We shall discuss information which is currently available within most of these agencies (all will not be available in all states) which appears to have some utility for accident liability prediction. (It is presumed that other driver control agencies, such as traffic courts, will have access to the licensing agency's records.) Almost all of the primary source data can be obtained from state driver licensing records.

In 1967, NHTSA (then NHSB) established minimum requirements for state driver record files. A summary of these requirements is presented as Table 1-1 (Jordan and Wilson, 1971). Driver record data is divided into two sections, Identification and History. Very little of the identification information has been shown to be useful for accident liability prediction except age and sex of the driver, although all of the prior driving history variables have shown at least some utility.

This chapter will review any useful information in the required state driver license files, as well as other information, not required of all states, which has shown some utility in the jurisdictions where it is available. In addition, some useful information which can be found in separate records, such as medical or accident files, and certain demographic information which often can be obtained within the licensing agency, will be discussed.

Finally, since many variables, such as past citations, accidents, court actions, DMV actions, etc., are subject to numerous statistical, methodological, and data collection problems, yet are still useful to the extent that these problems can be controlled, these and other limitations will be discussed for each variable as operational constraints.

TABLE 1-1. MINIMUM DRIVER DATA ELEMENTS THAT SHOULD BE COLLECTED, STORED AND RETRIEVABLE.

1. Identification

   Name--last, first and middle

   Address--house number, street, city, state, zip code

   Identification number

   Date and place of birth

   Sex

   Height

2. History

   Driver education

   - Program type
   - Performance
   - Year of completion

   Licensing

   - Date of examination
   - Results
   - Restrictions

   Medical

   - Physical deficiencies
   - Mental or nervous impediments

   Driving performance

   - Accident involvements
   - Traffic violation convictions
   - Department actions
   - Driving exposure

Source: Jordan and Wilson (1971)

DRIVER PERFORMANCE AND ABILITY

The data found in most driver licensing files commonly emphasizes various aspects of past driver performance. These data are often divided into several general types of information, including:

- Traffic Accidents and Convictions
- Licensing Knowledge and Performance Testing
- Driver Improvement History

Although each of these types of information is of some utility for prediction of future problems, the first category is the best available measure of actual, on-road performance, and therefore is also useful as a criterion measure. The second type of data, licensing knowledge and driving ability testing, is often used as an intermediate criterion when actual on-road performance criteria are unavailable (e.g., in short-term evaluation of training programs or for new license applicants). The driver improvement history information is useful both for prediction and for program evaluation, but is of little value as a driving criterion, except as it reflects past accidents and convictions. This review will therefore discuss each of these three types of performance measures separately.

Although this performance information is available in all licensing agencies, a recurring problem for accident liability prediction is the very general level of data reporting. Specific details of accidents, convictions, and licensing tests are often missing. As a result, when these data are used as criterion measures, the conclusions drawn must often be very general in nature. The following sections will describe the utility and the problems in using these types of data, both as criterion measures and as predictors of subsequent criteria.

TRAFFIC ACCIDENTS AND CONVICTIONS

Traffic safety research has historically been directed toward reduction of accident rates. As a result, accident frequency has been a logical criterion measure for measuring program effectiveness in the conduct of experimental studies. Traffic convictions have also held intuitive appeal as indicators of driver errors. The availability of traffic accident and conviction data has further encouraged such research. Unfortunately, there are a number of statistical disadvantages which limit the effectiveness of both of these as driving criteria. These problems are discussed below.

The Rare Event Problem

The largest problem in the statistical use of accident data is the fact that accidents are rare events. California data has shown that 89% of all drivers are accident free over a two-year period. (California Department of Motor Vehicles, 1965.) Consequently, very large sample sizes and extended time frames are needed to conduct meaningful research. Since convictions occur about three times as frequently as accidents, they are much less subject to this problem.

Accident and Conviction Distributions

There is some question whether the distribution of these events differs at all from distributions of random events. Peck, McBride, and Coppin (1971) reported that accident and conviction frequencies differed significantly from theoretical random Poisson distributions, indicating that some non-random factors are involved. These authors did not, however, control for exposure of individual drivers.

Lack of Temporal Stability

Another significant problem is the lack of stability of accident and conviction data over time. Peck, McBride, and Coppin (1971) computed stability coefficients for accident data over various time intervals. All correlations were significant, but very low, and generally higher for males than females.[1] The correlations among conviction data (Table 1-2) are much higher than those for accident data (Table 1-3), suggesting one advantage to employing conviction data as a criterion.

The Relationship of Convictions and Accidents

Despite low temporal stability, numerous studies have shown that past accident and conviction data are still among the best available predictors of future accident liability.

There is a wide range of literature which examines the relationship between past and future accidents and convictions. Prior convictions have often been associated with current accidents. For example, Baker (1970) reports that 42% of fatally injured drivers studied had two or

[1] The authors point out that these correlations are measures of temporal stability only, and not measures of reliability, since the concept of reliability rests on the assumption that all other conditions remain constant over time, which is definitely not the case.

TABLE 1-2. CONVICTION-CONVICTION CORRELATIONS OVER TIME*

Years Correlated	Males	Females
1961 by 1962	0.252	0.142
1962 by 1963	0.239	0.153
1961 by 1963	0.217	0.137

Source: Peck, McBride, and Coppin (1971).

*All correlations are significant at beyond 0.01 level of confidence.

TABLE 1-3. ACCIDENT-ACCIDENT CORRELATIONS OVER TIME*

Years Correlated	Males	Females
1961 by 1962	0.054	0.028
1961 by 1963	0.036	0.041
1961, 1962 by 1963	0.060	0.041
1962 by 1963	0.050	0.028

Source: Peck, McBride, and Coppin (1971).

more traffic convictions in the previous three years, while Peck et al., (1971) report only 6.7% with two or more convictions in the general driving population. Similarly, prior accidents have been associated with current convictions. Perrine et al. (1971) report that 22% of their recent DWI arrest sample had two or more accidents in the previous five years, compared to 9% for their roadblock control group.

Of these two common performance measures, convictions have been consistently shown to be the more useful predictor. Peck et al., (1971) have shown that correlations between convictions and accidents over time (Table 1-4) are greater than correlations of accidents with themselves. The authors provide the explanation that "convictions probably contain some of the same behavioral elements as accidents, and are more stable, sensitive measures of individual differences in driving behavior."

Many reported relationships between convictions and accidents are contaminated by the inclusion of "spurious convictions" (convictions resulting directly from accidents). Including these convictions when examining concurrent convictions and accidents can yield misleadingly high relationships. Such statements as "40 percent of the drivers involved in one accident had at least one citation" (O'Neall, 1967) can be very misleading, since that "one citation" may often have resulted from the accident in question. By removing these spurious convictions, a more accurate description can be found.

Table 1-5 (from the California Department of Motor Vehicles, 1965) indicates the accident rate for each level of convictions with spurious convictions excluded. The results indicate increasing accident rates for increasing numbers of convictions. Drivers with 9 or more convictions in a three-year period were involved in 6.5 times as many accidents as those with no convictions. Although these data reflect a dramatic increase of accidents associated with convictions, the magnitude of the relationship is somewhat misleading. Using statistics based on individual variation, the relationship appears somewhat lower. Translating the same data to a correlation coefficient, the equation $r = 0.23$ results, i.e., approximately 4% of the variability is explained. While accidents do tend to increase as a function of convictions, a large proportion of drivers remain accident-free. The relatively small number of drivers at the extremes (e.g., six or more convictions) have high accident rates, but their contribution to the overall relationship between convictions and accidents is small. These data are shown in Figure 1-1, which also depicts the effect of including spurious (accident-related) convictions.

Many authors, using multivariate methods, have found that total number of traffic convictions (or moving violations) is the best single predictor of accident involvement (McGuire, 1969; Harano et al., 1973). Peck, McBride, and Coppin (1971), using multiple regression to predict accidents by driving records, also found total convictions to be the

TABLE 1-4. CORRELATION BETWEEN ACCIDENTS AND CONVICTIONS*

Conviction Year	Accident Year	Males	Females
1961	1961	0.116	0.072
1961	1962	0.089	0.066
1961	1963	0.075	0.048
1962	1962	0.115	0.073
1962	1963	0.083	0.057
1963	1963	0.100	0.069

Source: Peck, McBride, and Coppin (1971).

*All correlations are significant at beyond 0.01 level of confidence.

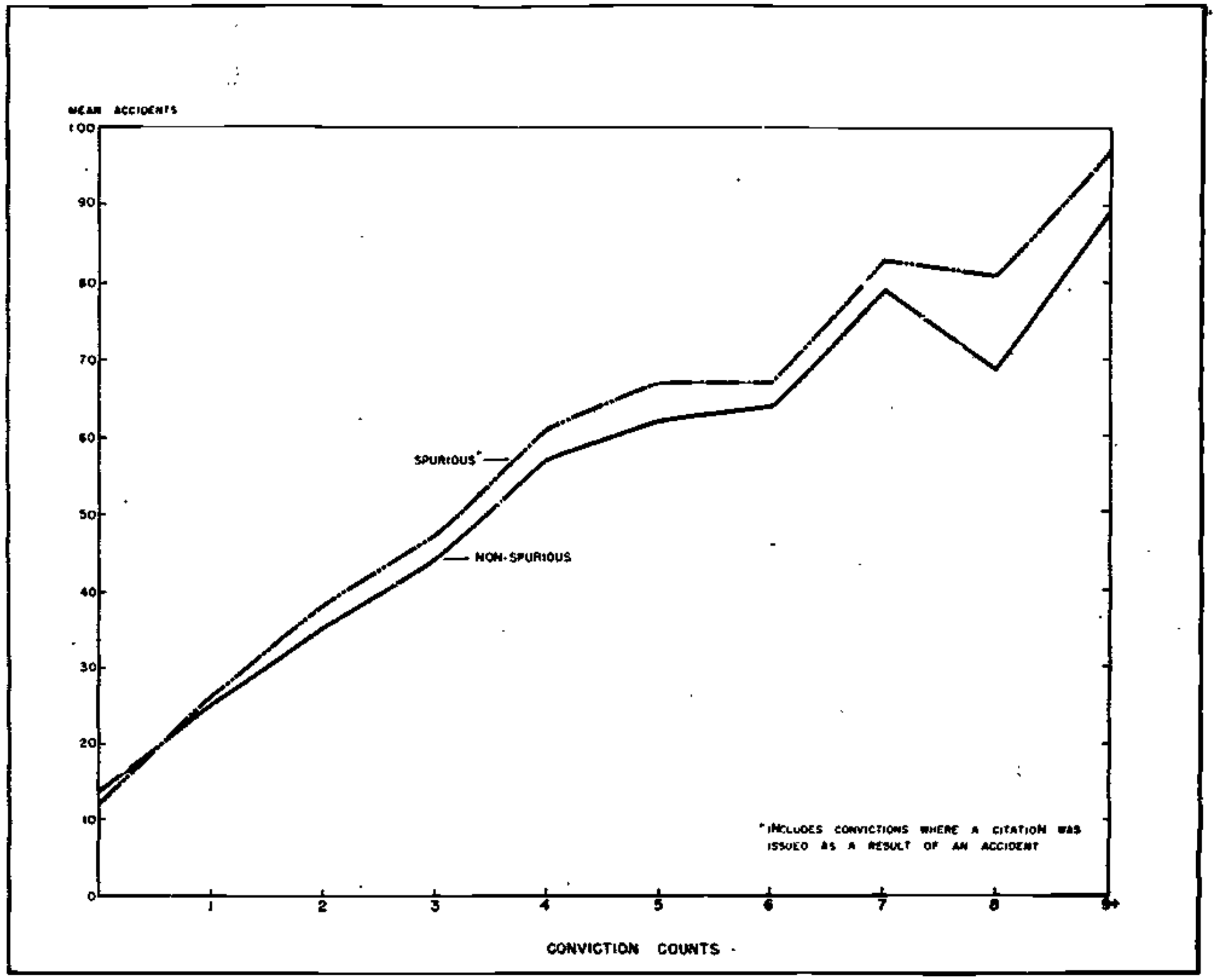
TABLE 1-5. DIFFERENTIAL ACCIDENT RATES BY NUMBER OF COUNTABLE CONVICTIONS

(Three-year period)

Countable convictions**	Number of drivers (N = 148,006)	Number of accidents	Accidents per 100 drivers	"Times as many"*
0...........	94,117	12,835	14	1.00
1...........	31,623	7,829	25	1.81
2...........	12,048	4,211	35	2.56
3...........	5,229	2,286	44	3.21
4...........	2,385	1,348	57	4.14
5...........	1,273	790	62	4.55
6...........	659	422	64	4.70
7...........	334	263	79	5.77
8...........	157	108	69	5.04
9+..........	181	161	89	6.52

*This number represents the relative increase in accident rate over the "0 countable convictions" group.
**Excludes all "spurious" convictions-that is, those which have resulted from a reported accident.

Source: The California Department of Motor Vehicles (1965)



Source: California Department of Motor Vehicles (1965)

FIGURE 1-1. MEAN ACCIDENTS BY SPURIOUS AND NON-SPURIOUS CONVICTION COUNTS (3 Year Record) best predictor of accidents. Very little overall prediction was gained by adding to the equation other variables such as violations by type, or violations by point count, as predictors. Marsh and Hubert (1974), and Harano (1974) found that multiple regression equations developed to predict convictions, predicted accidents in a cross-validation sample better than equations developed to predict accidents. Carlson and Klein (1970) found that the traffic conviction records of students are even significantly related to their parents' traffic histories, suggesting that not only do drivers "drive as they live," but that they drive as their parents drive.[2] Schuster (1968) reports that previous driving history (accidents and violations), combined with various attitude scales (Chapter III) were found to be the best predictors of future accidents. Class of license (Operator vs. Chauffeur) and total speeding convictions were also significant.

Tables 1-6 & 1-7 demonstrate some representative findings of research studies employing past convictions and accidents as predictors of driving errors. The correlations using total convictions are relatively high compared to other potential driver record variables. In general, as the criterion measure becomes less frequent, the correlations become somewhat lower, due to increased instability. This applies to total accidents, accident types, and conviction types. (Although unstable, accident and conviction types are currently among the best indicators of specific driver problems.)

In summary, it would appear that gross accident or conviction statistics alone are insufficient evidence on which to base an estimate of accident liability. Nevertheless, they are still the best available single predictors, and should be included in any diagnostic assessment system.

Accident and Conviction Types

The analysis of traffic convictions by type of violation has provided useful information on the types of errors made by various classes of drivers (e.g., Harrington and McBride, 1970; Peck, McBride, Coppin, 1971; and Marsh and Hubert, 1974). However, this level of information can be considered only a very gross measure of the types of errors that actually occur. In addition, the use of any particular violation type as a criterion greatly increases the rare-event problem.

Although specific accident descriptions or even accident summaries are seldom included in driver licensing files, a similar degree of accident description can often be obtained from the types of convictions

[2] Wallace (1969) also found a significant relationship between an individual's driving record and the number of people in his family with poor driving records.

Table 1-6. Selected Studies Using Convictions as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Peck, McBride and Coppin (1971)	Driver Records	Reviewed Records of a 2% random sample of California Drivers	Traffic Convictions in 1961	Traffic Convictions in 1962				Accidents in 1962			
				Males	.232	.01	86,726	Males	.089	.01	86,726
				Females	.142	.01	61,280	Females	.066	.01	61,280
				Traffic Convictions in 1963				Accidents in 1963			
				Males	.217	.01	86,726	Males	.075	.01	86,726
				Females	.137	.01	61,280	Females	.048	.01	61,280
			Traffic Convictions in 1962	Traffic Convictions in 1963				Accidents in 1963			
				Males	.239	.01	86,726	Males	.083	.01	86,726
				Females	.153	.01	61,280	Females	.057	.01	61,280
F.L. McGuire (1969;1972)	Questionnaire	Correlated test and questionnaire items with self-reported accident frequency for young drivers (ages 17-20) with two years driving experience (males - random sample)	Self-reported Moving Violation Citations (2 yr.)					Self-reported accidents (2 Yrs.)	.24	.05	1,481
								Cross Validation	.32	.05	1,481
M.W. Perrine (1974)	Questionnaire	Questionnaire administered to learner applicants, applicants for junior operator's license, applicants for operator's license, fleet safety group, DWIs (Contrasted Sample)	Number of MV convictions per cent reporting 2 or more (3 yrs)	Operator							
				Pass	10%	NR	185				
				Fail	10%	NR	64				
				Fleet	8%	NR	79				
				DWI	35%	NR	78				
Harano (1974)	Driver Records	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (cluster analysis, and data collection reported in earlier study Finkelstein and McGuire 1971)		Total Convictions (Subsequent (1 Yr.)				Total Collisions (Subsequent 1 Yr.)			
			FTAs & FTPs		.093	.01	850		–.001	NS	850
			Non-countable convictions		.154	.01	850		–.017	NS	850
			Other two-count convictions		.022	NS	850		–.043	NS	850

NR Not Reported
NS Not Significant

r [illegible] unless otherwise specified. Occasionally mean values reported in r column
P Probability of significance [illegible]

Table 1-7. Selected Studies Using Accidents as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	p	Sample Size	Validity: Accidents Type	r	p	Sample Size
Peck, McBride, and Coppin (1971)	Driver Records	Reviewed records of a 2% random sample of California drivers.	Accidents in 1961					Accidents in 1962 Males Females	.034 .028	.01 .01	86,726 61,280
								Accidents in 1963 Males Females	.036 .041	.01 .01	86,726 61,280
			Accidents in 1961 and 1962					Accidents in 1963 Males Females	.060 .041	.01 .01	86,726 61,280
			Accidents in 1962					Accidents in 1963 Males Females	.050 .028	.01 .01	86,726 61,280
Harano (1974)	Driver Records	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting <u>future</u> errors. (cluster analysis, and data collection reported in earlier study Finkelstein and McGuire 1971)	Collisions	Total Convictions (Subsequent 1 Yr)	−.010	NS	850	Total Collisions (Subsequent 1 Yr)	.046	NS	850
			Responsible collisions		.056	NS	850		−.009	NS	850
Marsh, W.C. and Hubert, D.M. (1974)	Driver Record Questionnaire Interview	Post-contact driving records of 13,594 male negligent drivers using three data sources: prior driving record, interview by driver improvement analyst.	Accidents (1 year prior)	Hazardous Driving Convictions (20 month post-contact)	−.022	.10	6,795	Total accidents (20 month post-contact)	.021	.10	6,795
			Responsible accidents (1 year prior)	Hazardous Driving Convictions (20 month post-contact)	−.068	.001	6,795	Total accidents (20 month post-contact)	.001	NS	6,795
			Accident Responsibility Score (3 year prior)	Hazardous Driving Convictions (20 month post-contact)	−.026	.05	6,795	Total accidents (20 month post-contact)	.031	.05	6,795
			Days From Last Prior Accident	Hazardous Driving Convictions (20 month post-contact)	.032	.01	6,795	Total accidents (20 month post-contact)	−.023	.10	6,795

NR Not Reported
NS Not Significant

r [illegible]
P [illegible]

which resulted from accidents. Since many accident-involved drivers are not convicted of any violation, even the use of total number of accident-related convictions as a criterion significantly increases the rare event problem. Examining only one type of accident-related conviction further exacerbates the problem. For example, the prediction of accidents involving "Right-of-Way" violations would require an extremely large sample size. Despite this problem, a breakdown of accidents by conviction type is among the few practical techniques for examining differences among driver errors. As we shall see, there is considerable evidence that drivers do vary by types of errors which lead to accidents. Predicting only total accidents will mask these variations, inhibiting both specific diagnosis and specific countermeasure assignment.

The following sections discuss some of the common violation and accident-associated violation types. (Table 1-8 presents some representative research findings.) We have arbitrarily divided such convictions into the following types of driver errors:

- Alcohol-Related Errors
- Risk-Taking Behavior Errors
- Recognition Errors

This a priori "clustering" of conviction types has not, to our knowledge, been experimentally verified. It is merely our best estimate of the communalities among driver errors, as represented by traffic violations.[3] There may, of course, be some overlap among these factors.

Alcohol-Related Errors

The driver problem which appears a most prominent contributor to the highway death toll is alcohol usage. Statistical evidence has identified alcohol as the most frequent factor in all automobile accidents. Generally, association of alcohol with automobile accidents seems to increase proportionately with severity of accidents. Minor accidents show unclear or very low degree of alcohol involvement; more severe accidents show a more pronounced association with alcohol. The National Safety Council estimated that alcohol was a factor in 800,000 of the 14 million minor auto accidents in 1969, and in half of that year's 55,000 highway fatalities.

[3] A factor analysis of driver record variables was conducted by Harrington (1968), but his data included relatively few categories of moving violations, some non-moving violations, and biographical data (age, marital status, height, and weight). Analyses were conducted separately by sex. Resultant factors (same for each sex) were labelled--moving violations, non-moving violations, age, weight, and height. The analysis was somewhat confused by the inclusion of different types of variables, so that factors of moving violation types were not possible. A replication of this study, using only moving violations broken into specific types (and using grouped data, if necessary), would be highly desirable.

Table 1-8. Selected Studies Using Conviction Types as Assessment Variables.

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Marsh, W. C. and Hubert, D. M. (1974)	Driver Record	Post-contact driving records of 13,594 male negligent drivers using three data sources: prior driving record, questionnaires and interview by driver improvement analyst.	Hazardous Driving Convictions (1 Year Prior)	Hazardous Driving Convictions (20 month post-contact)	.157	.001	6,795	Total Accidents (20 month post-contact)	.023	.10	6,795
			Non-Hazardous Convictions (1 Year Prior)		.120	.001	6,795		.035	.01	6,795
			Non-Driving Convictions on Driving Record (1 Year Prior)		.102	.001	6,795		.026	.05	6,795
			Weekend/Holiday Convictions (1 Year Prior)		.090	.001	6,795		.027	.01	6,795
			Days From Last Conviction (violation date)		–.032	.001	6,795		.005	NS	6,795
			Speed (unsafe) Convictions		.087	.001	6,795		.032	.01	6,795
			Speed (limit) Convictions		.047	.001	6,795		–.004	NS	6,795
			Driving Without License		.081	.001	6,795		.031	.05	6,795
			Technical Equipment Conviction		.121	.001	6,795		.034	.01	6,795
			Right-of-Way Conviction		–.031	.05	6,795		–.030	.05	6,795
Peck, McBride, and Coppin (1971)	Driver Records	Reviewed Records of a 2% random sample of California Drivers	Right-of-Way Convictions						.060	.05	42,228
			Turning, Stopping, Signalling Convictions						.077	.05	42,228
			Speed Convictions						.145	.05	42,228
			Equipment Convictions						.088	.05	42,228
			Sign/Signal Convictions						.122	.05	42,228
			Passing Convictions						.098	.05	42,228
			Major Convictions						.033	.05	42,228
			License Restrictions Convictions						–.005	NS	42,228
			Misc. Tech. Convictions						.097	.05	42,228

—Continued—

NR Not Reported
NS Not Significant

r [illegible] mean values [illegible]
P [illegible]

Table 1-8. Selected Studies Using Conviction Types as Assessment Variables *(Cont.)*

Study	Type of Instruments	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Harano (1974)	Driver Records	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Speeding convictions	Total Convictions (Subsequent 1 Yr)	.033	NS	850	Total Collisions (Subsequent 1 Yr)	.062	NS	850
			Other one-count convictions	Total Convictions (Subsequent 1 Yr)	.051	NS	850	Total Collisions (Subsequent 1 Yr)	−.037	NS	850
			Drunk driving convictions	Total Convictions (Subsequent 1 Yr)	−.015	NS	850	Total Collisions (Subsequent 1 Yr)	−.036	NS	850
			Other two-count convictions	Total Convictions (Subsequent 1 Yr)	.022	NS	850	Total Collisions (Subsequent 1 Yr)	−.043	NS	850

NR Not Reported
NS Not Significant

r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P Probability of significance (P" has been dropped)

There is, however, considerable controversy surrounding the accuracy and interpretation of statistics such as these. According to Zylman (1973), these statistics are not only misleading, but also cannot be substantiated by any reliable data. By applying the most reliable data and taking into account passengers and pedestrians, Zylman concludes that the number of "alcohol-involved traffic deaths" is reduced from the more-than-half figure to 39%, and the number of fatality victims found to be drunken drivers can be reduced from a range of 28,000-35,000 to less than 13,000. However, Zylman's recomputed fatal accident statistics are also misleading. By using data which examine blood alcohol concentrations (BAC's) of individual victims, appropriately including passengers and pedestrians, but which also examine each fatality as an independent event, a significant source of bias is introduced. Non-drinking drivers who are killed by drunken drivers appear as non-alcohol related victims in Zylman's statistics.[4] His figures do reflect the absolute numbers of intoxicated individuals who are killed (drivers, passengers, and pedestrians), but clearly underestimate the issue raised by the Safety Council statistics--the number of automobile deaths in which alcohol was a factor, which Zylman's figures do not even address.

Other researchers have argued, more convincingly, that statistics on alcohol as a factor in vehicle accidents tend to underestimate the problem. For example, in accidents involving fatalities, many coroners do not routinely perform blood alcohol analyses--an omission that allows alcohol involvement to go undetected. Unless there has been a dangerous traffic violation, police officers do not always detect low to moderate concentrations of alcohol. Some officers tend to be reluctant to charge drivers with alcohol violations because alcohol convictions often carry severe penalties; others are reluctant to issue citations for alcohol involvement because offenders are often convicted of less serious violations, such as reckless driving or speeding, rather than of the original charge involving alcohol.[5] Finally, some jurisdictions purge (or refuse to disclose) alcohol-related conviction data after the driver has completed an alcohol rehabilitation program, to enable the driver to retain his automobile insurance. In each of these instances, alcohol statistics become underestimates. Since the evidence for the possibility of statistical underestimates in alcohol-related accident data is impressive, we are inclined to believe that the alcohol-related traffic

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[4] One estimate of the number of innocent drivers killed by intoxicated drivers places this figure at 44% (Committee on Public Works, 1968).

[5] One survey (Perrine et al., 1971) has shown that 81% of all DWI arrests involved individuals with blood alcohol concentrations of 0.15% or more. This is well above presumptive limits for intoxication, which usually range from 0.08% to 0.10% in this country, implying that many drivers who are legally "intoxicated" never appear in driving-while-intoxicated statistics.

safety problem is at least as great as indicated in current statistical estimates, if not greater.[6]

The only information on alcohol-related driving errors generally available from Level I sources is alcohol-related conviction data. These types of convictions include "Driving While Intoxicated" (DWI), "Driving Under the Influence" (DUI), and various other designations. During the adjudication process, alcohol-related charges are often reduced to Reckless Driving. As a results, Reckless Driving convictions (with local variations) may also be indicative of alcohol-related driving errors.

Although alcohol is a major highway safety problem, alcohol-related convictions are extremely rare events. One California study (Peck et al., 1971) grouped all serious non-spurious traffic violations, including alcohol offenses, reckless driving, etc. into one category labelled "Major Violations" (to offset the above effects of reduction of charges), and found that this category comprised only 2.4% of the convictions for males, and less than 1% of the convictions for females. Thus, prediction of such a rare criterion will necessarily be limited.

Risk-Taking Behavior Errors

In most jurisdictions, the most frequently cited violation type is the speeding violation, which is representative of what we have termed "risk-taking" errors. The relation of speed to accident severity has been widely documented. The National Safety Council (1974) statistics implicated speeding errors in 25.2% of all fatal accidents, 17.5% of all injury accidents, and 13.4% of the total United States traffic accident problem. Thus, speeding errors were the largest identifiable problem (other than alcohol) in fatal accidents, although not for injury or total accidents.

Speeding citations, however, are seldom employed singly as a predictor of future driving behavior. Among the few studies which have been conducted (e.g., Peck et al., 1971), speeding convictions are generally found to be useful predictors in regression models, although strongly correlated with (and thus overlapping in predictive utility with) total convictions.

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[6] We note that the latest edition of National Safety Council's Accident Facts (1974) no longer lists alcohol-related accident statistics, mentioning only that "it is believed that such reports understate the frequency" of the problem.

Recognition Errors

The final cluster of violations is comprised of problems relating to recognition. These include turning violations, some sign violations, and some passing violations. (Sign and passing violations, in some cases, are also related to risk-taking behaviors.) Although violations of this kind can have numerous causes, including perceptual, physical, or driving experience factors, the use of Level I (Primary Sources) information limits description to a general discussion of recognition problems.

The involvement of "recognition" type human errors in the traffic safety problem has been shown to be extensive. The National Safety Council (1974) groups driving errors of this type into "right of way" errors, including "Yield," "Sign," and "Signal" errors. Grouped in this manner, they find the "Right-of-Way" errors are implicated in 13.8% of fatal accidents, 21.1% of injury accidents, and 20.2% of all accidents. California data reported by Harrington and McBride (1970) indicate that 54% of all accident-related citations are issued for "Sign," "Turning," "Passing," and "Right-of-Way" violations. Thus, it is clear that recognition-related driving errors are a major contributor to the traffic safety problem.

At this point, however, the causes of the recognition errors themselves remain unclear. Within the Biographical section of this chapter, some interesting subdivisions of the recognition error problem, particularly by age and sex, will be discussed. Subsequent chapters will examine the physical, psychological, and situational aspects of the problem.

Operational Constraints of Accident and Conviction Data

The most significant constraint in the use of accident and conviction data is systematic bias within the data collection process. An excellent review of the data collection problems which often cloud the utility of these data as highway safety criteria is presented by Zylman (1972). The following points summarize Zylman's conclusions:

1. Standards of measurement vary from one jurisdiction to the next. Not only do areas from which statistics are reported vary widely by demographic characteristics, but also "diverse practices, policies, interpretations, terminologies, and standards of training and discipline within reporting agencies" make comparisons across jurisdictions "totally invalid."

2. "Accidents" and variations in reporting are widespread. "It would seem that everyone knows what a traffic accident is. However, the questions as to whether such an event should be reported to a police department, whether a policeman will

appear at the scene to write a report, whether a police agency will report it to the DMV, whether such a report should be limited to fatal and injury crashes or include collisions resulting in a specified amount of damage, or whether all collisions should be reported--these questions have almost as many answers as there are police agencies."[7]

As Zylman points out, this is not only an interstate problem, but intrastate as well, varying with local jurisdictions.

3. In some jurisdications, a minor complaint of pain is considered an injury. In others, the victim must be taken to a hospital. In still others, the victim must be admitted to the hospital.

4. Traffic law enforcement varies widely by local jurisdiction, allowing drivers in low enforcement jurisdictions greater opportunity to avoid becoming a bad or negligent operator. (Enforcement varies not only by number of citations, but also by popularity of certain types of citations.)

5. Arrests for DWI also fluctuate by local jurisdictions. In some areas, police cannot cite a driver for DWI unless the officer witnessed the offense. In other places, police, judges, or prosecutors routinely reduce DWI's to lesser charges to avoid court backlogs, or penalties they feel are excessive.

6. Data do not exist to compare judicial activity across jurisdictions.

This list represents many of the biases which can affect assessment using accidents and convictions as predictors. Zylman concluded that, even if the above data problems could be solved, driving record variables would still be of little value without accurate exposure information.[8] Another significant limitation to the use of accident or conviction variables as predictors is the relatively short periods for which such records are kept in license files. Ferreira (1970) suggests that "the number of years of observation needed to characterize a driver's accident history is at least as long as the over-all average

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[7] Selzer and Vinokur (1974), attempting to use previous accident data as the basis for further prediction, also encountered the accident reporting problem. One of their samples reported a mean accident frequency of .47 accidents per driver, while an audit of their records revealed only .18 accidents per driver.

[8] Klein (1966) discusses in detail the problems of exposure and differential reporting as they affect the young driver.

time-period between accidents--roughly 10 years." Many jurisdictions periodically "purge" records at considerably shorter intervals, limiting predictive capability.

Discussion of Traffic Accident and Conviction Data

The broadest goal of highway research has been to reduce accidents. Thus the frequency of occurrence of accidents has been a logical criterion to evaluate both highway problems and solutions. The use of driving record variables as criteria is subject to statistical difficulties since the events which they measure are extremely rare, necessitating very large sample sizes to draw meaningful conclusions. The statistical aspect of this problem can be partially remedied by using convictions, which are more numerous. However, the relationship between convictions and accidents is, at best, unclear. Correlations between convictions and accidents are low, approximately .05 - .11 for one year samples. (Of course, even a high correlation would not imply causality. Thus, a program which reduced convictions might have no effect on accidents). These low correlations, plus many deficiencies in reporting of conviction data, argue against their use for strong punitive actions such as license withdrawal. In addition, such statistical problems force many program evaluations to be conducted with intermediate criteria such as knowledge tests, rather than with actual subsequent driving performance. A second disadvantage involves the previously mentioned data-collection problems, which can invalidate many of the conclusions drawn from both accidents and convictions, although the more severe accidents are fairly immune to this problem (since most all are reported). Also, gross accident or citation measures are not sufficiently descriptive of types of driver errors. More specific criteria such as detailed accident reports discussed in Chapter 2 would be useful for appropriate countermeasure assignment.

The multidisciplinary accident investigations which are being conducted throughout the United States may provide sufficient detail to determine the severity and causal factors (human, vehicular, environmental) of accident involvement. The results of these investigations have potential for identifying variables for future diagnostic assessment. At the present driver record level of observation, the only available criterion, type of citation, appears to lack sufficient behavioral description, and is subject to numerous systematic reporting biases. Finally, employing accident frequency as a sole criterion does little to reflect the societal costs of accidents. Numerous studies (e.g., Institute for Research in Public Safety, 1973) have shown that various classes of drivers tend to have substantially different types of accidents, which in turn reflect substantially different societal impact. Younger drivers may have more high speed accidents, while older drivers may have more sign-recognition related accidents. Thus predictive methods of the type which equate a minor recognition error "fender bender" with a multi-fatality high speed crash, are necessarily limited as means of societal cost reduction. There is therefore a need, as a supplement to numerical counting of accidents, to obtain data using an accident-severity index, based on accident costs (e.g., Wilbur Smith and Associates, 1966).

For diagnostic purposes driver record variables may have more utility. Driving records are currently employed as accident liability predictors in every state, most using a simple point or entry system. Both accident and conviction frequencies have been demonstrated to be significant but of low utility when used alone. Prediction can be significantly increased by the addition of other variables, as will be seen later. J. H. Reese (1971) has summarized the disadvantages of current point systems:

> "Point systems are often assumed to be a more effective means of identification of errant driver behavior that justifies license withdrawal. However, research has shown that there is a poor correlation between the traffic violations on which point systems are based and future accident involvement. Thus, point systems may predict poorly or not at all. However, they have a salutary legal effect in the sense that they quantify the decision criteria and contribute to procedural due process and equal protection for licensees. The critical element in a respectable point system is the assignment of point weights on the basis of the statistical relationship to accident records rather than on the basis of personal opinion as to the seriousness of various offenses. It is this relative weighting of offenses that establishes the predictive validity of any point system. Even so, several authorities have suggested that respectable point systems and other license withdrawal criteria should be used for diagnostic purposes only to identify drivers in need of further training or rehabilitation. Because they are such poor predictors, current criteria should not be used to withdraw licenses."

An additional disadvantage of all driving history variables is that they cannot be used for new license applicants. Thus performance measurements and standards with predictive capability should be established for those drivers entering the system. These will be discussed in the following pages.

DRIVER LICENSING KNOWLEDGE AND PERFORMANCE TESTING

Driver licensing files often contain some record of an individual's performance during his initial licensing examinations. Such examinations usually contain both written, oral, or automated knowledge testing, and range or on-road driving ability testing. These variables are of particular importance for diagnostic prediction of the future accident liability of the newly licensed driver, since no information about his past driving performance is available. In fact, many motor vehicle administrators (see Jackson, 1971) believe that major improvements in highway safety will be possible only by improved driver licensing. Unfortunately, driver record files seldom contain the item or even total scores on these examinations. The common practice is to infer the outcomes from other variables, such as pass/fail of overall license examination.

This section will review the diagnostic utility of each of these types of licensing examinations, and, where applicable, the individual test scores, since these are available to the licensing agency during licensing examination, and could be saved in the driver's records if their utilization is warranted.

Knowledge Testing

Some form of driver knowledge testing, either oral, written, or mechanized, is included in the licensing process within all American licensing and control agencies. The justification for including most of these tests in driver licensing rests solely on face validity -- i.e., the items appear to be relevant to the driving task. Most controlled research evaluations of these tests have failed to demonstrate any more substantial forms of validity.

An evaluation of the Washington State driver licensing examinations was conducted by Wallace and Crancer (1969). By relating the written licensing scores of a sample of license applicants who passed the test with their subsequent driving records, the authors found that correlations were not only non-significant, but also in the wrong direction (low scores indicating better driving record.) The authors conclude that "the observed correlations are slight, of no practical significance, and do not justify the use of the testing procedures as the basis for a practical decision." A subsequent individual-item analysis of a 40 item test proved equally disappointing. Very few of the items could significantly distinguish between high-citation and citation-free drivers at license renewal. The authors again conclude that "the results of the two studies indicate that the ability of the present written licensing examination to achieve its stated purpose is questionable." Such conclusions, based on this data, are also questionable. In the first evaluation, no drivers who failed the written examination were included in the sample (since they were not granted a license at that time).[9] If those who failed the test had been licensed anyway, their resultant driving errors may have increased the test score - driving error correlations to higher levels of significance. The second evaluation, comparing "good" vs. "problem" drivers, all of whom were already licensed, has little apparent relationship to initial driver licensing. The

[9] Such inclusion is essential to a proper evaluation of license examinations. Since no state appears likely to risk the inherent dangers of such a project, effective evaluation of licensing examination appears unlikely to ever be conducted.

problems of experienced "problem" drivers may be unrelated to the problems of beginning drivers, who have relatively little driving experience. The Washington State data do, however, suggest that while little is known about the utility of written license examinations for initial license screening, the tests appear to be of little value in diagnosis of drivers who are already licensed.

Other evaluations of licensing knowledge tests suffer from essentially the same limitations. Freeberg and Creech (1971) have conducted an extensive analysis of North Carolina's driver licensing written examination. A factor analysis of initial licensing exams yielded only one dominant factor, reflecting many subject areas, which the authors labelled "general knowledge." The authors conclude that any test of verbal proficiency might perform equally well in ranking driver applicants. This conclusion, although certainly possible, cannot be verified by the available data. Although validity studies were not conducted on the initial licensing exams, renewal exams were studied in greater detail. The authors report that despite psychometric limitations of the test they studied, there is evidence that license renewal exam scores may be useful predictors if used in conjunction with other types of variables such as vision, prior driving record and background information.

Recently, various mechanical alternatives to the traditional paper and pencil or oral examinations have been implemented. For example, closed circuit television has been introduced to improve driver licensing examinations by the Iowa Department of Public Safety (AAMVA, 1971). Various driving situations are presented to the examinee on an individual television console. From several alternatives the driver must then select the response appropriate for the situation. Potential advantages of the system include faster and less expensive examination processing enabling more frequent driver re-examinations, and possibly teaching drivers as well as testing them. Similar systems are currently being employed in a number of jurisdictions (e.g., Virginia, District of Columbia). At present, however, few have been evaluated to any greater extent than have written examinations.

An evaluation of one such mechanized system was conducted by the State of Washington (1971). Both group and individualized testing machines were employed, although only one evaluation was conducted because content materials for the two systems were similar. The individualized system did prove to have far fewer operational difficulties. Subjects, selected from renewal applicants, were volunteers (although none refused to volunteer). They were then classified as "good" and "poor" drivers by their past driving records. The evaluation was conducted on a relatively small sample, since much data was lost due to hardware failure. Using regression analysis on the remaining sample, 21 of the 25 items were found to be significantly related to driving record class. However, 11 of these 21 results were in an unexpected direction - correct response predicting poor driving record. The authors conclude that of these 11 items, the better drivers tended to select an overcautious response to some, and demonstrated a lack of knowledge of correct freeway procedures on others. Although many operational advantages of the examination hardware are cited, the authors do not speculate about the potential utility of the renewal test.

Discussion of Driver Knowledge Testing

The only major operational constraint for using knowledge testing scores is that, while these scores are immediately available at driver licensing and control agencies at least during the initial driver licensing process, the scores themselves are seldom retained in the driver's file. As a result, such scores are commonly unavailable for predictive purposes.

There are numerous other limitations. Few, if any, licensing knowledge tests have demonstrated the minimum psychometric properties which are required of tests in other applications and settings. Seldom have licensing agencies bothered to conduct any sort of reliability evaluation. Validity is also generally limited to face validity. Of the few evaluations that have been made, none have shown acceptable levels of either reliability or validity. Thus, the tests have no predictive utility, except possibly for initial screening (where validity cannot be fully evaluated). Additional factors may also reduce utility. The tests apparently measure primarily verbal ability (that is, measure how well the applicant reads the licensing manual, not how much he knows or uses traffic safety rules). Also, the opportunity to re-take the test after failing minimizes the number of license denials, reducing even screening capability. The examinations then merely force applicants to study the rules of the road. Whether this has any effect on subsequent performance has not been demonstrated. At present, however, no claims can be made for diagnostic capability.

In a current NHTSA-sponsored project, the utility of tailoring knowledge manuals to sub-populations is now under evaluation. The results of this study should provide further insight into knowledge testing.

Driving Ability Testing

On-road performance measurement began as part of the driver licensing process, in which drivers are rated by human observers. While various refinements and modifications have been made in procedures, test lengths, etc. over the years, the use of examiners to rate drivers has remained relatively unchanged.

For diagnosis of an individual driver's performance, the state-of-the-art of this performance measurement appears to be in a relatively early developmental stage. Many tests, e.g., Neyhart (1955), claim diagnostic capability but do not have an empirically established relationship with any useful driving performance criterion (which is similar to the problem found in knowledge testing). To reduce this problem, innovative procedures, including complex instrumented vehicles, sophisticated rating systems, and multi-variate approaches to describing and measuring driver behavior, have been developed. Since these methods are not currently operational, they will be described in Chapter 3. Data that are available on performance testing in a licensing setting will be discussed in this section.

On-Road License Testing Evaluation

In the driver licensing area, some attempts have been made to relate scores obtained on on-road tests to subsequent actual driving behavior. Findings indicate that performance of individuals on basic skill maneuvers has some relationship to accident and violation experiences. Campbell (1958) used subsequent driving records of a group of 1000 drivers involved in fatal accidents and of 1000 drivers randomly selected from the North Carolina files. The road test used for screening applicants for driving licenses was composed primarily of basic skill maneuvers: starting, stopping, turning, backing, 3-point turning, slowing, braking, quick and hard stopping, and starting and stopping on grade. Applicants were also rated on posture, clutch, attention, distraction, keeping in lane, following, overtaking, being overtaken, right-of-way, and use of horn. The comparison groups (fatality and random) could be differentiated on the basis of several of the road test items as well as total score. (The groups also differed by age and sex).

McRae (1968),using a sample of 1,319 licensed North Carolina drivers and state license road test results, was also able to differentiate accident and violation groups from non-accident groups. Certain classes of driving skill (i.e., physical handling of the automobile and interaction with traffic), differentiated between groups. However, cross-validation findings did not substantiate the predictive power of the total test scores.

Harrington (1971) correlated drive test scores for young drivers obtained on original licensing test with follow-up accident convictions. The relationships were non-significant for accidents and significant, but very low, for predicting convictions. ($r = -.03$). The results, however, only include drivers who eventually passed the test, which may underestimate the predictive validity of the drive test score. (Drivers may make several attempts before passing).

In another study, Harrington (1973) studied the discriminative power of the standard DMV road test for previously licensed out-of-state drivers applying for a license in California. Over fifteen-thousand applicants took the test as usual while twenty-three thousand had the test waived. After a six month follow-up of accident and violation reports, there was no significant difference between groups on number of accidents, fatal and injury accidents, or convictions.

It does not appear that current DMV behind-the-wheel testing has been adequately refined to warrant a firm conclusion. However, the evidence indicates that no useful relationship exists between the DMV road test and accident experience, among applicants who pass. Evaluation is again not currently possible for those who fail.[10] Intrarater and interrater reliability might also be problems of on-road testing.

Driver Range Performance Evaluation

Since many of the observer performance rating assessment techniques previously discussed have been employed on driver ranges as well as in on-road settings, it may be worthwhile to consider some of the differences between these settings.

Since predictive utility of licensing performance examinations has historically been low, a number of licensing agencies have attempted to improve prediction by using driver ranges to further standardize their performance testing. However, there is little if any hard evidence that range conditions significantly improve prediction of subsequent driving record criteria.[11]

There are very early references in the driver performance literature to the use of driver ranges for testing in a driver licensing context. (See Lauer, 1936). Numerous advantages have been cited for this use of driver ranges:

-- improves reliability by standardizing driving situations encountered.

-- insures a variety of driving situations encountered.

-- complex visual situations will identify recognition problems.

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10 Previous failures on either knowledge or performance license testing do not seem to be relevant to subsequent driving performance of those drivers who eventually pass. McGuire (1969, 1972) studied Air Force enlisted men, ages 17-20, and found no significant difference in the driving histories of those men who had previously failed one of these tests, and those who had passed on their first attempt. It should be noted, however, that he did not obtain data from a licensing agency, but rather from questionnaires administered to the subjects themselves. He also did not attempt to assess failures on knowledge and performance testing separately.

11 Brazell (1961) and Bishop (1965) both reported no differences in training effectiveness between on-road and range training conditions. We know of no studies, at present, in which these have been compared as testing conditions.

-- elapsed time for completion of total course (compared to the mean) will identify both overcautious and impatient drivers.

-- for poor drivers, range is less hazardous.

Range tests are also being developed for use as intermediate criteria in driver training programs. The Ohio Department of Education, (1974) in evaluating driver education curricula, reported that certain maneuvers on a range test could demonstrate a clear distinction between novice and experienced drivers, as well as differentiate between different skill levels of novice drivers.

Whittenburg et al. (1973), developed an objectively scored observer checklist, measuring quality and speed of various driving maneuvers, to serve as a driver range test. They reported that significant differences existed between test scores of accident and accident-free groups of drivers, "but in an unexpected direction--higher scores were associated with accident involvement." Since the subjects were all young males (Coast Guard recruits), and all were relatively experienced, higher scores may have simply reflected higher driving exposure (which increases accident risk), or more frequent risk-taking (if for this age group better drivers take more frequent risks). Findings such as these demonstrate the need to evaluate the usefulness of assessment techniques for specific sub-populations.

The advantages of a driver range test were cited by Riley and McBride (1974). They employed a basic skills range test and an evasive range test to evaluate driver training curricula. Both tests used the instructor/observer rating method, and after lengthy instructor training, the reliabilities were reported moderately high. However, no attempts at predictive validity have yet been made. These authors cite as the two main advantages of range training and testing:

1. Economy--less instructors/raters needed per student/examinee.

2. Control of traffic patterns--highway problems can be pre-selected. They also point out that hazardous maneuvers such as evasive action must be conducted on a driving range for safety reasons.

Whittenburg et al. (1972), have summarized both the advantages and limitations of range training and testing:

"The driving range provides an opportunity to maintain controlled conditions for observing driving maneuvers. However, certain compromises/trade-offs must be accepted:

- The dynamic, ever changing conditions of real-world driving are minimized;

- only a limited number of real-world conditions can be simulated on the range;

- actual driving must be a simulation of the real world in terms of speed and distances covered; that is, the range imposes a pressed time and space format; and

- because of slow speeds and external constraints (in the form of an instructor or evaluator) imposed on the driver, the threat of serious accident or injury is greatly reduced. Also, the driver is probably motivated to "do his best" since other drivers and instructors are watching and commenting on his performance."

In summary, it would appear that for maximum accident liability prediction the advantages of driving range performance testing are probably counterbalanced by the disadvantages. Administrative considerations such as reduced hazards appear to be their greatest proven asset.

Driving Simulator Performance Evaluation

Although there have been attempts to utilize driving simulators as a driver licensing criteria, the use of such devices is usually limited to training and research purposes. As a result, we shall postpone a discussion of driving simulator performance until Chapter 3, which includes many assessment techniques whose current state of development is primarily appropriate for research.

Summary - Licensing Knowledge and Performance Testing

All forms of knowledge and performance licensing examinations for initial license applicants lack sufficient validity to be of predictive utility in an operational setting. Several studies have shown small, but significant differences among driving records between groups of drivers with low and high mean scores on performance testing (Campbell, 1958; McRae, 1968). Other studies have been less conclusive (Waller and Goo, 1968; Harrington, 1973). Some representative research results are presented in Table 1-9. Generally, minimum standards for psychometric properties, essential to other applications of testing, have not been met. Thus these examinations presently cannot demonstrate any capability to differentiate among those applicants who pass (either initial licensing or renewal).

The use of these tests as a screening procedure to eliminate the poorest of applicants may be justifiable on face validity alone, despite the fact that this function of licensing performance testing may never be fully evaluated. However, predictive uses of the tests among passing

Table 1-9. Selected Studies Using Licensing Tests as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions — Type	r	P	Sample Size	Validity: Accidents — Type	r	P	Sample Size
F. L. McGuire (1969; 1972)	Question-naire	Correlated test and questionnaire items with self-reported accident frequency for young male (Air Force) drivers (ages 17-20) having a two-year driving history. (Random Sample)	Previous failure to pass written and/or driving part of driver's license test					Self-Reported Accidents (2 Yr)	.02	NS	1,481
Harrington (1971)	Driver Record	From large random young driver sample interviewed and collected School data. Correlational study predicting driving record.	Drive Test Score (Licensing Agency)	Subsequent Convictions (Males) 1 Year 2 Year (Females) 1 Year 2 Year	 −.03 −.03 −.01 −.03	 .01 .01 NS .05	 8,121 8,121 5,794 5,794	Subsequent Accidents (Males) 1 Year 2 Year (Females) 1 Year 2 Year	 −.02 −.02 −.01 −.01	 NS NS NS NS	 8,121 8,121 5,794 5,794
Wallace, J. E. & Crancer, A. (1969)	Driver Record	A written exam and road test scores were correlated with driving record. A sample of 235 Washington drivers were examined at the licensing agency. Another sample comparison of "good & bad" licensed drivers was also made using an experimental knowledge test (N=779)	Written Exam Score	4 year concurrent convictions	.144	NS	235				
			Road Test Score	4 year concurrent convictions	.151	NS	235				
			Combined Exam Score	4 year concurrent convictions	.172	NS	235				
			Experimental Knowledge Test (40 items):	Group Comparison of good & bad driver. (means)	(mean number correct)						
			Rules of the Road	good bad	13.4 13.7	.05	533 246				
			Defensive Driving	good bad	12.7 12.5	.05	533 246				
			Total	good bad	26.1 26.3	.01	533 246				
Freeberg and Creech (1971)	Driver Record	A Correlational study to develop a reliable & valid renewal licensing rules test. Five versions were evaluated. One representative version (Form A) is presented here. Total sample 4,474 males & females.	Rules Test Form A	Total Convictions (prior 4 year period) Males Females	 .12 .03	 .01 NS	 522 368	Total Accidents (prior 4 year period) Males Females	 −.02 .04	 NS NS	 522 368

NR Not Reported
NS Not Significant

r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P Probability of significance (. has been dropped)

applicants cannot be justified, since little or no predictive validity has been demonstrated. They apparently measure ability to perform "as expected" in a testing situation, but do not account for exposure, motivation, or situational factors. It is possible, however, that further refinement could eventually provide diagnostic capability among initial license applicants, which would be extremely useful since these drivers usually have little if any previous driving history upon which to base diagnosis. Thus, among those who meet minimum standards for licensing, performance testing is perhaps the best opportunity to isolate potential "high-risk" groups at that time. Additionally, since none of these have demonstrated high validity, there is currently no valid means to assess target populations on performance criteria. Thus, many questions remain to be answered. Do performance measures mean anything for experienced drivers? Are they useful only for the inexperienced drivers or the physically impaired drivers? Can they supply, for the new licensee, the predictive utility that accidents and violations provide for the experienced driver? Are they more useful for certain biographical groups? Occupational classes? These questions cannot be resolved until performance measures can be more fully validated.

DRIVER IMPROVEMENT AND DRIVER SANCTIONS

Previous contacts with a driver improvement program (e.g., warning letter, group meeting, or hearing), or previous sanction levied against the driver, can conceivably be employed as Level I assessment variables. Driver improvement and sanction variables are obviously related to previous accidents and convictions. If these programs are effective deterrents to future driving errors, however, they may provide predictive capability above that of simply past driving problems. To the extent that countermeasure program evaluations have been conducted, and probabilities for subsequent success can be accurately determined, assignment to a driver improvement program can be used as an assessment variable to predict changes in future performance (see Schuster, 1971).

It should be recognized that driver improvement variables may also be crude measures of previous assessment, since differential criteria may have been used in assigning drivers to a program. Regardless of the source of variance, these variables may be useful in projecting base expectancy rates. The question of concern is therefore, "Does attendance at a program or administration of some form of countermeasure or sanction predict future success?" More specifically, "Does a record of attendance at a court school, a driver improvement meeting, hearing, etc. result in valid criteria for classifying his subsequent accident potential?" Since a number of program evaluations are currently being (or have been) evaluated, such questions can partially be answered.

Other variables associated with driver improvement may also be indicators of driving liability, perhaps reflecting an individual's attitude or social deviance. Failure to appear for a hearing or failure to pay fines probably measure to some extent these psycho-social dimensions.

For example, Harano (1974) found prior failure to appear and failure to pay fines to be significant predictors of subsequent convictions among negligent drivers, in combination with other variables in a multiple regression equation.

One example of the differential utility of driver improvement assignment is the Didenko et al. (1972) study, in which drivers convicted of alcohol-related offenses were randomly assigned to different treatment modalities. Their subsequent driving records were found to vary from one treatment to the next, although relatively few of the differences were significant, as shown in Figure 1-2.

Harano and Peck (1971) evaluated the effectiveness of court traffic school (Uniform Driver Improvement School) and found significant interactions of prior driving record and treatment combinations. They report that:

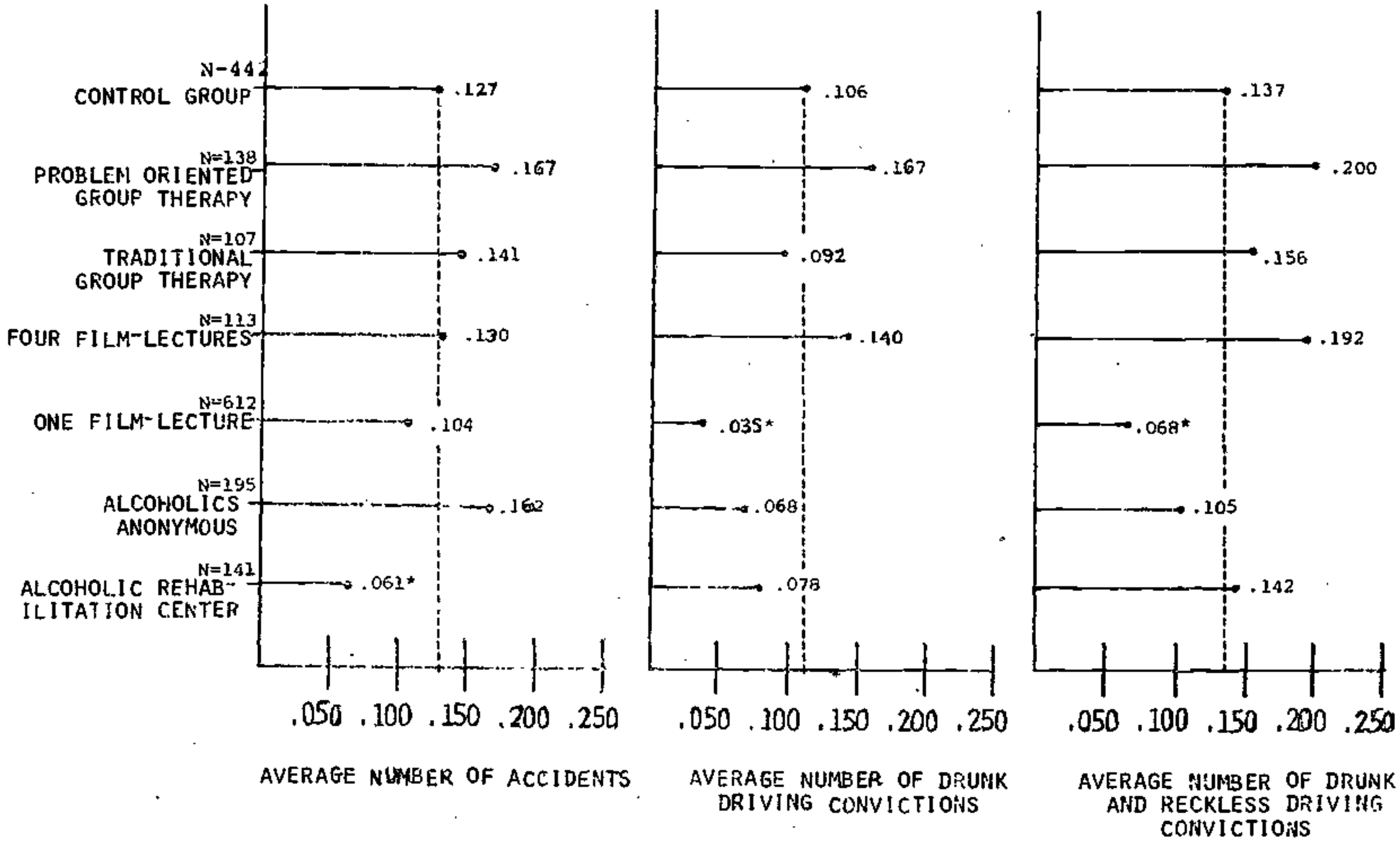
> "The marginal results of the Treatment x Prior Driver Record interaction suggested that treatment effects were influenced by the subject's prior driving record. The form of this interaction can be seen by comparing the post accident means for the High violator/Accident-free subjects and the High violator/Accident-involved subjects across treatments. Both traffic schools had directionally lower accident means than the Control for the High violator/Accident-free subjects. For the High violator/Accident-involved subjects, however, the Control had lower accident means. The t-tests indicated that the majority of these differences were statistically significant at the $p < .10$ level. These results suggest that the negative effects found for UDIS subjects with prior accidents also occurred for Regular School subjects with prior accidents."
> (Harano and Peck, 1971)

This study illustrates the need to examine combinations of prior driving records and subsequent treatment programs, as well as simply employing "treatment" as a predictor variable.

Recent state-of-the-art reviews by Goldstein (1974) and Peck et al. (1975) indicate that a number of controlled evaluations of driver improvement programs have generally demonstrated low utility for reducing collisions but somewhat greater utility for reducing convictions. These results could be explained several ways. Convictions may be more sensitive measures of program effectiveness since they occur more frequently than accidents. Alternatively, the elements of the programs may relate to violation-producing behaviors, but not to accident behaviors.

The Peck et al. (1975) review reports relatively few studies of warning letters or group meetings demonstrating significant treatment

TOTAL SAMPLE



Source: Didenko et al. (1972)

FIGURE 1-2. COMPARISON OF INDIVIDUAL TREATMENT GROUPS AND THE COMBINED CONTROL GROUPS ON THREE VARIABLES effectiveness, while a substantial percentage of individual hearing evaluations produced a statistically significant reduction in accidents, and more so for convictions. Beside demonstrating an overall increasing effectiveness with more extensive treatments, some utility of the type of driver improvement as a predictor variable is also suggested. For an individual, a history of several driver improvement efforts may further increase prediction.

Judicial sanctions have also been shown to be related to future driving performance. Finkelstein and McGuire (1971) employed several driver sanction and driver improvement variables to predict accidents. Among these variables, the amount of fine was the highest predictor of accident involvement followed by jail, traffic school attendance, suspension and revocation, classification as a negligent operator, attendance at a hearing, and a license restriction. Fines greater than $40.00 resulted in a degradation in performance while fines below $40.00 showed improvement. Poor performance was also related to the combination of prior fine and attendance at a traffic school. Finkelstein and McGuire speculate this combination of treatment creates resentment. Findings such as these demonstrate the need to examine the apparently complex interactions between sanctions, driver improvement programs, and driver characteristics.

Another study of driver sanctions (Buikhuisen et al. 1972) was conducted in the Netherlands, examining that country's steady increase in the number of drivers convicted for DWI since 1955, and the corresponding increase in the severity of sentences for such violations. In 1960, 47% of DWI cases were sentenced to prison; in 1968, the percentage was 70%. The study was designed to determine the influence of varying sentences on DWI recidivism.

An analysis of criminal records of subjects who had been convicted of DWI was conducted for all male subjects who had been convicted of this offense between 1960 and 1964 (N = 1674). The criminal records of these subjects were examined for information about age, profession, social status, number and kind of offenses committed before and after the DWI conviction which caused them to be included in the sample. As validity measures, certain background factors had a multiple correlation of .51 with severity of sentencing for DWI, although only .37 with recidivism (explaining only 13% of variance). Severity of sentence correlated -.16 with recidivism, which is described as "neglectable," and when background factors were partialled out, the correlation dropped to -.03. As a result, severity of sentence appeared to be of little importance.

Summary of Driver Improvement and Driver Sanctions

Several of the studies reviewed show that driver improvement variables and sanctions predict future driver behavior to a limited extent. They of course reflect the driver's prior convictions and accidents. However, as several of the studies have shown, they do often add explained variance beyond simply past convictions and accidents, which could be measures of effectiveness of the program or sanction.

Although evaluations of driver improvement programs have produced inconsistent results, there is some evidence that effectiveness increases with more extensive treatments. Rigorous evaluations will be required to assess the utility of each specific driver improvement (or sanction) action as a predictor in a given setting. There are so many intervening variables that complex multi-variable analyses will be necessary. As such evaluations become commonplace, and as driver improvement efforts (and diagnostic programs) become more effective, the predictive value of such variables should increase proportionately. At present, their value is low, except in settings where evaluations have been conducted. Even in those cases, however, there is the additional problem of recency of driver improvement or sanction, which must also be evaluated. It would appear unlikely that any of these variables would have high effective "life-span" as a predictor.

Judicial sanctions have also been shown to be related to subsequent driving behavior. It has often been noted that severe penalties are not generally effective in reducing recidivism. This conclusion becomes circular when it is recognized that the more deviant drivers, who receive the higher fines, also have a higher base expectancy for future problems. Controlled research (by varying fines) is needed to fully determine the "pure" effect of deterrence.

In addition to reflecting severity of driving errors, fines might also reflect, in part, an underlying risk dimension. Approximately 60% of citations are for speed. In turn, the amount of fine is generally correlated with deviations from the legal speed limit. Thus, it may also be useful in future research to isolate the effects of fines for each violation type.

HUMAN CONDITIONS AND STATES

BIOGRAPHICAL DATA

Highway safety researchers have often attempted to predict accident liability classes by searching for correlations between various biographical (identification) variables, and driver performance. Such attempts are usually motivated by longstanding and often unsubstantiated notions concerning "types" of drivers who are subject to "accident proneness." Further encouragement has been provided by the availability of large institutional data files to test such hypotheses, as well as the fact that such biographical performance predictors would be extremely valuable in both driver licensing and insurance applications.

Age

The biographical factor most frequently associated with highway accident liability is age of the driver. Many research studies have shown that violations and accidents are disproportionately distributed among the various age groups within the driver population. In addition, these age groups can be further differentiated by the types of driving problems which are more likely to occur.

There are, however, two major sources of bias which can limit the interpretation of any type of biograpl il data, particularly age-related data. (See Klein, 1966)

- Exposure

Both convictions and accidents are directly related to quantity and quality of miles driven. Hence, failure to accurately control for mileage could cause a relatively high ability group of drivers, who also drive a large amount or under hazardous conditions, to appear as "poor" drivers. Similarly, a relatively "poor" group of drivers could appear to have no problems.

- Reporting Bias

Both convictions and accidents can be differentially reported in many ways. A police officer may issue citations more frequently to the very young or very old driver, for offenses for which the middle-age drivers might receive no citation or a lesser charge. Similarly, a judge may convict certain age classes less frequently, or of reduced charges. Drivers of certain age groups may be more able to resolve citations without a notation in the driver record. For accident data, it is clear that many incidents never come to the attention of the appropriate authorities. These unreported accidents may be spread unevenly across the age distribution, since it is possible that certain age groups may be better able to settle minor accident claims without involving any enforcement personnel. If enforcement personnel do become involved, they might also be more likely to issue citations or assign culpability to certain age classes of drivers. Even "unbiased" research investigators can be subject to potential data reporting biases. As a result, the most applicable estimates of driving errors by age class can be found in fatal accident data, since very few if any of these accidents are unreported. However, even in descriptions of fatal accidents, assignment of crash "culpability" is still subject to reporting bias. In addition, there is little basis to assume that even an accurate description of the fatal accident problem will generalize to less severe accidents.

General Driving Errors By Age

Numerous studies have demonstrated that violation and accident rates per driver are disproportionately high for the youngest age group of drivers. (Harrington and McBride, 1970; Peck et al., 1971; Bailey et al., 1969; Burg, 1970; O'Neall, 1967) The 1966 review of traffic safety literature, by A. D. Little, discusses New York, California, and National Safety Council statistics which demonstrate high accident liability for the younger driver age groups, although correction for total mileage suggests that the per-mile accident rate of older (age 55 and up) drivers may be even higher than that of young drivers.

More recent studies have produced similar results. Harrington and McBride (1970) showed that as age increases, violations and accidents decline rapidly, the curve leveling at about age 25-30, as shown in Figure 1-3, for violations.[12] Although this simple graph of accidents or violations plotted vs. age does not indicate any significant problems among older drivers, when average mileage per age group is controlled (calculating accidents or violations per mile) the curve again rises at about age 55. (See Figure 1-4) These "per-mile" figures indicate that older drivers have increased driving problems, which are not reflected in gross accident or conviction statistics, since this group drives relatively few miles.[12a]

The magnitude of the problem appears similar with fatal accidents, except that fatalities do not reach their highest levels until about age 20. (See Schuman et al, 1967) The California Highway Patrol (1973) report shows that the 20-24 age group has the highest automobile-related fatality rate of any age group--54 deaths per 100,000 population.

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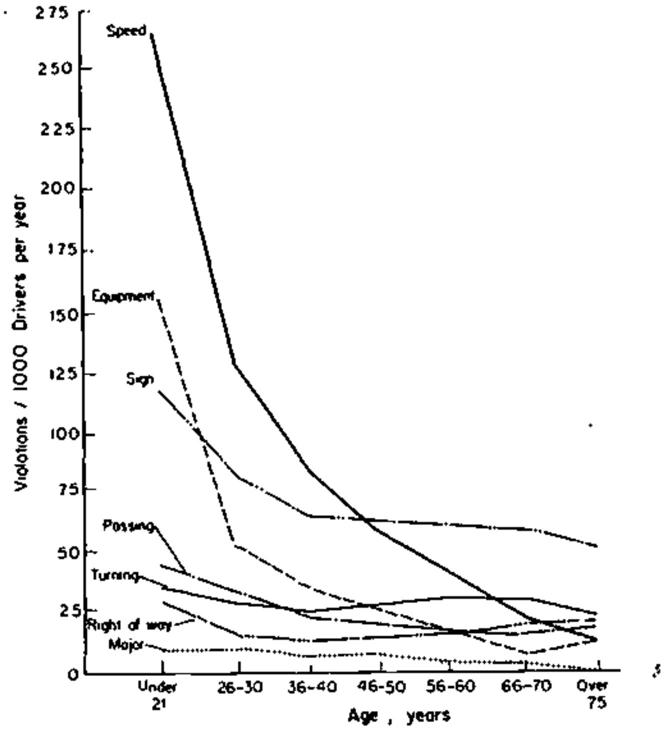
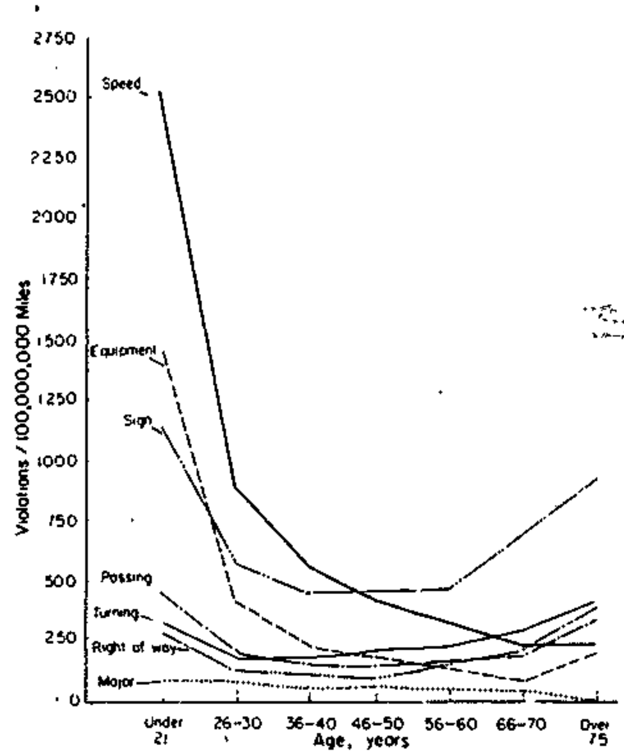
[12] Habitual accident repeaters have also been shown to be younger than randomly selected controls. (Goodson, 1972)

[12a] This U-shaped function has been confirmed by Cerrelli (1972), for total accidents by age.



Source: Harrington and McBride (1970)

FIGURE 1-3. VIOLATIONS PER 1000 DRIVERS PER YEAR BY TYPE AND AGE



Source: Harrington and McBride (1970)

FIGURE 1-4. VIOLATIONS PER 100,000,000 MILES BY TYPE AND AGE

The second highest fatality rate - 46 deaths per 100,000 population - was found for the 75 and over age group.[13] The average for the total population was only 25 fatalities per 100,000 population. The A. D. Little review (1966) suggests that the high fatality and injury rate among elderly drivers may be in part a result of their lesser physical ability to survive an automobile accident. This finding has been more recently discussed by Baker (1970) who reports "the possibility that most of the fatally injured drivers age 60 or over died following crashes which might not have proved fatal to younger drivers." This may, however, be offset in part by the finding of Epstein and O'Day (1972) that older drivers tend to own larger cars, which are presumably safer.

Perchonok (1972), studying fatal accidents, found that the under-21 age group had an excessively high proportion of drivers who were judged "culpable" for their accident. Perchonok also reports that in fatal accident cases, an abnormally high percentage of drivers in the over-56 age group were found "culpable".

Table 1-10, from Baker (1970), demonstrates that the percent of fatally injured drivers judged "at fault" decreases with age above age 24, until it again increases at age 60. The 20-24 age group had the highest percent at fault. Ages 50-59 had the lowest. Similarly, Perchonok (1972) reports that in 56% of the two-vehicle crashes studied, the younger of the two drivers was judged culpable.

Other studies have applied more direct means of controlling for exposure when examining age differences. Borkenstein, et al. (1964) randomly selected and questioned drivers of passing cars, at the same place, time, and day of week that accidents had occurred, to compare accident drivers vs. non-accident controls. This roadblock method provides accurate group exposure information for comparison. Examining the age distributions, Borkenstein et al. found 22.5% of all drivers in the control sample were less than age 25, yet this age group accounted for 33.3% of all the recorded accidents.

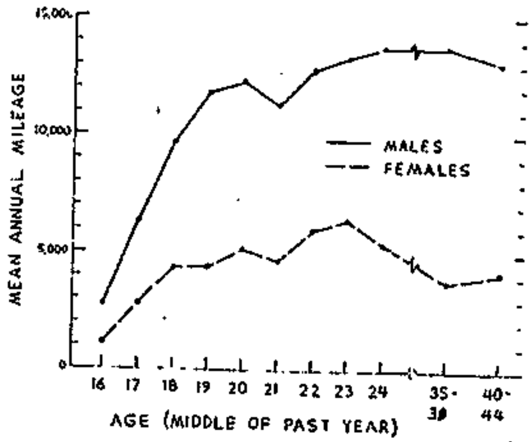
Pelz and Schuman (1971a) have demonstrated that annual mileage driven is not greater for the youngest drivers. Using relatively sophisticated techniques for mileage estimation, involving statistical combinations of assessments of number of daily trips, average mileage per trip, time spent driving for different purposes, etc., they found that average annual mileage for 16 year-old males was only 3,000 miles (Figure 1-5). The average mileage curve then rises sharply with each

[13] Other sections of the present review discuss underlying problems of older drivers such as medical conditions, vision, and decision-making.

TABLE 1-10. AGE AND RESPONSIBILITY AMONG FATALLY INJURED DRIVERS

Age	Number Of Drivers	% Single Vehicles	% Not At Fault
14-19	26	73%	12%
20-24	65	63%	6%
25-39	102	54%	18%
40-49	55	40%	27%
50-59	35	40%	31%
60-69	24	46%	13%
70 +	21	10%	14%
Total	328	50%	17%

Source: Baker (1970)



Source: Pelz and Schuman (1971a)

FIGURE 1-5. MEAN ANNUAL MILEAGE vs. AGE

year's increase in age, leveling at about 13,000 miles at age 22 or 23 (for males). These authors also argue against calculation of accidents per mile, since this figure will decline for higher mileage drivers, regardless of age. They have instead compared drivers in the same mileage brackets, across all age groups, and found that, regardless of mileage, the ages 18 and 19 (usually the third and fourth year of driving) had the greatest number of accidents and violations when compared to slightly older or younger drivers with the equivalent exposure. These authors attempted to control for inexperience with driving by studying separately those groups of drivers who had learned to drive at the same time. They found that regardless of age at which driving was learned, all drivers reached a peak accident and violation level at age 18 or 19, except those who learned to drive at age 15 (the "recommended" age for driver training) who reached their peak a year or two earlier.

McGuire (1969; 1972) found no significant correlation between age and accident frequency among Air Force enlisted personnel, limited to ages 17 thru 20. This would be expected, if the age-accident relationship during this period is non-linear, as Pelz and Schuman (1971a) have suggested. McGuire does not report whether his distribution was curvilinear. McGuire also found that age at time of licensing was not a significant predictor. Similarly, Schuman et al. (1967) compared self reports of accidents and convictions, among young drivers, ages 16-24. They found reported accidents highest among the age 16-18 groups, declining very slightly for ages 19-20, with a greater drop thereafter. Reported moving violations, however, peaked at age 19-20, with slight declines for both older and younger drivers. Schuster (1966), using regression methods to predict accidents, found age to be a significant predictor of accidents for a sample of high school students, but non-significant for a similar sample of college students. This finding might also corroborate the findings of Pelz and Schuman (1971a), suggesting Schuster's college sample was measured during the peak accident liability period, where the relationship between age and accident frequency is non-linear.

Other studies have not shown a peak age for accident liability. Harrington's Young Driver Follow-up Study (1971) suggests that driving experience is far more important than age as a predictor of accident liability. His results, using records of drivers licensed at age 16 or 17, reveal little change in accident frequency during the first four years of driving, while miles of driving increased each year. Thus, the accident rate per mile driven declined. Harrington also reports that the percentage of accident-involved drivers who were judged "responsible" for their accident dropped from 61% in the first year of driving to 49% in the fourth year. (Forty-nine percent was the population average.) Conviction rates did peak at ages 18-19, even after adjustment for mileage.

Alcohol-Related Errors By Age

The major Level I sources of research data relating alcohol errors to age are the alcohol-related (A/R) traffic convictions (e.g., DWI, DUI, etc.). (Some information from accident and police records is also mentioned here to provide further clarification.) Although studies vary in methodology and samples, the general conclusion derived is that the younger 20-30 and middle age ranges 30-45 are highly implicated in alcohol-related errors. Finch and Smith (1970) report that 40% of the drinking sample who had a blood alcohol concentration (BAC) above 0.15 were ages 20-29 and 48% were ages 30-49. Selzer (1969) found comparable results in comparing control and fatal samples of drivers. The highest proportion of drinking drivers were found in the 21-30 and 31-40 age groups.

Multidisciplinary accident investigation by the Institute for Research in Public Safety (1973) added further support for the over-involvement of this middle-aged driver.

Alcohol-related accident involvement produces an exaggerated inversion of the U-shaped curve found for general accidents. (See Figure 1-6).[14] The middle age range, i.e., 33-44 year olds, surpass all other groups in accident over-involvement, in contrast to their non-alcohol accident under-involvement. The ends of the dimension, the young and the elderly, are both under-represented in alcohol-implicated accidents. Clark (1972) reported similar curvilinear age patterns for drivers involved in fatalities who had BAC's greater than 0.15 for drivers convicted of DWI. The distribution peaked at ages 35 and 44 for fatalities and DWI drivers, respectively.

The general conclusion to be drawn from these studies is the very young (less than 20) and older populations (greater than 45) are less implicated in alcohol-related crashes than the 25-45 age group. DWI arrests are also more prevalent in these age ranges, although the mean age is slightly higher than for fatalities. Shupe and Pfau (1966) showed DWI arrests to peak at age 30-34 for males and 40-44 for females. Perrine (1974) also found DWI to be over-represented in the middle age categories. He compared the age distribution for general and commercial drivers with DWI's, and reported that 45% of the DWI sample were in the age ranges of 25-39, compared to 39.6% in the general and commercial driver sample. Forty percent of the DWI sample were over forty years of age, compared to 19.8% for the general and commercial driver sample.

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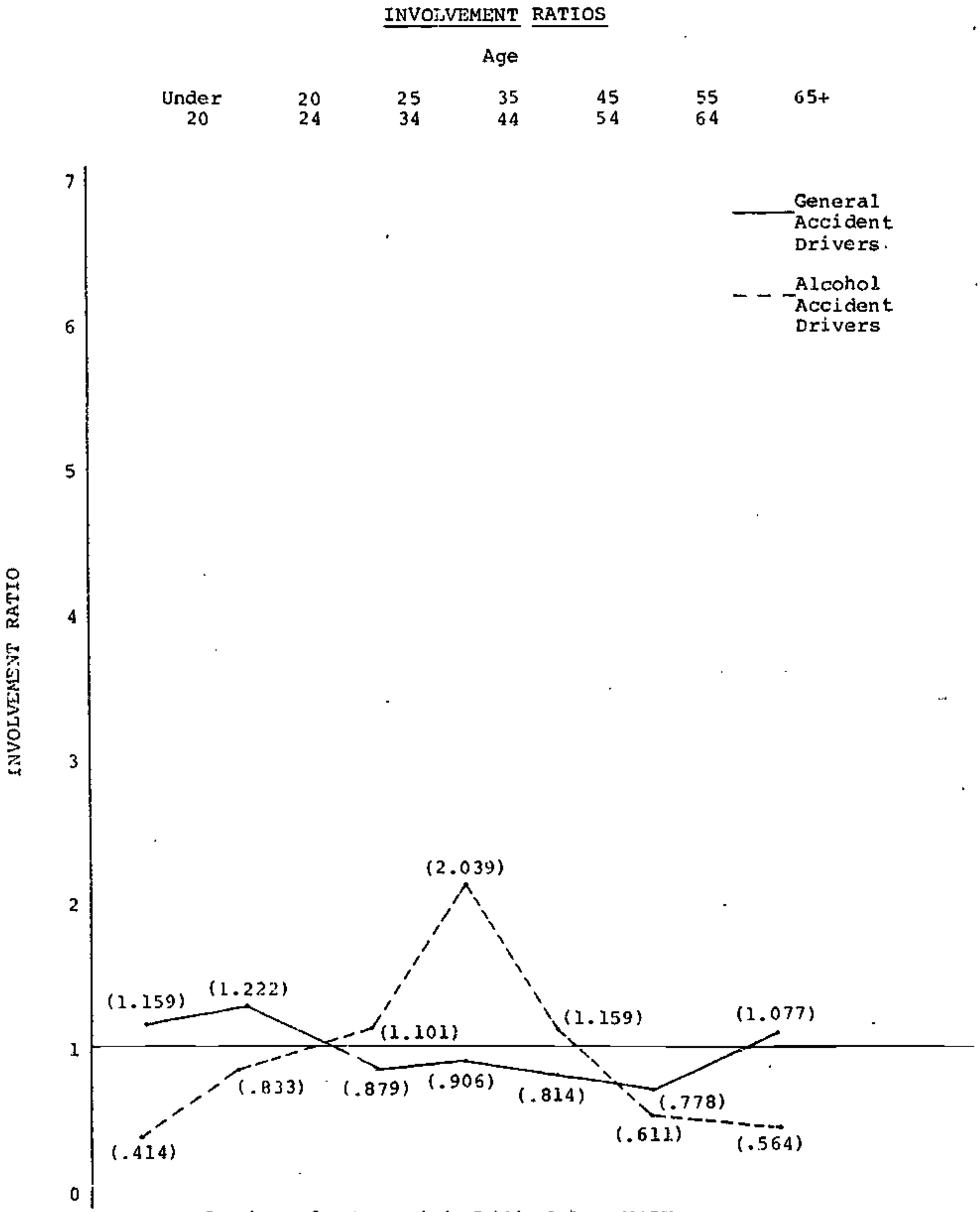
[14] The accident involvement ratio has been developed by the Institute for Research in Public Safety at Indiana University as a means of quantifying the over-involvement of problem driver subgroups. The ratio is derived from the recorded accident over-involvement of driver subgroups relative to the presence of these same subgroups in the general driving population. (Institute for Research in Public Safety, 1973).



Source: Institute for Research in Public Safety (1973)

FIGURE 1-6. ACCIDENT INVOLVEMENT RATIO BY AGE

Risk-taking Errors By Age

Risk-taking errors are reflected in traffic conviction statistics by speed, some reckless driving, and other types of violations. When types of violations are examined by age, as in Table 1-11 from Harrington and McBride (1970), young drivers (under 25) have vastly disproportionate numbers of speed violations. At this level of observation, it is apparent that high-risk behaviors rapidly decline with age. A plausible explanation for this phenomenon has been provided by David Klein:

> "Risk-taking as a Cultural Value. Closely related to frustration as a possible cause of teen-age accidents is the fact that Western culture has always prized and rewarded socially useful risk-taking. The soldier, the explorer, the aviator, and today the astronaut are popular heroes because of the degree of risk involved in their occupations, and the fact that boys recognize this at an early age is clearly reflected in their games and their occupational aspirations. With increasing maturity most young men discover sources of gratification that substitute adequately for the admiration to be derived from risk-taking -- especially since the opportunities for socially useful risk-taking seem to be declining as our culture becomes increasingly industrialized. But it is quite possible that those teen-agers who have few sources of social gratification may persist in a high level of socially dysfunctional risk-taking in order to gain the peer-group admiration which it can elicit.
>
> One might hypothesize, for example, that the teen-ager who gains admiration from adults or peers for his academic or athletic achievements or for unusual skill in some social or recreational activity is less likely to have need for risk-taking and hence less likely to have accidents. Such a hypothesis is very much in line with Tillmann's (1949) classic finding that accident-repeating adults are consistently unsuccessful in other areas of their lives." (Klein, 1966)

Recognition Errors By Age

The traffic conviction types which represent recognition errors include sign, turning, passing, and right-of-way violations. As can be seen in Table 1-11, each of these violation types appears to be a U-shaped function of age. That is, each is most frequent for the younger and older drivers, while relatively infrequent for the middle-aged driver. A plausible explanation, at this point, would be that these figures indicate inexperience and/or impatience on the part of younger drivers, and perceptual or physiological deficiencies on the part of older drivers.[15]

[15] McFarland (1966) discusses evidence that culpability among older drivers declines for accidents involving speed, equipment, driving on wrong side of road, and fatigue, but increases for accidents involving turning, right-of-way, sign, and improper starting violations. This evidence would also suggest some sort of physical or perceptual deficiency.

TABLE 1-11. VIOLATIONS PER 100,000,000 MILES BY AGE AND VIOLATION TYPE

TYPE	AGE		
	UNDER 26	26 -65	OVER 65
SPEED	1704.5	526.8	219.8
SIGN	858.7	476.2	711.2
TURNING	263.3	186.7	330.5
PASSING	314.5	168.4	213.4
RIGHT-OF-WAY	189.1	108.5	260.5
MAJOR	78.4	48.3	32.3
ALL TYPES*	4372.1	1740.6	1869.7
MILEAGE	12,422	14,213	8012

Source: Adapted from Harrington and McBride (1970)

*Excludes Miscellaneous Technical Violations (not shown).

Recognition errors for the older age group might also represent inexperience with newer vehicle and highway design features.[16] Further explanation of recognition errors is provided later by the Level III performance measures.

Predictive Utility

A number of investigators have employed the age of the driver, with numerous other variables, to predict future accidents or convictions. Levonian (1963) used stepwise multiple regression to predict "negligent operator" status, a measure of past accidents and convictions derived from California's point system. He found age to be the second best predictor, following estimated mileage. Levonian (1967), and Finkelstein and McGuire (1971) found age to be a significant predictor of subsequent accident liability second only to prior convictions. Carlson (1968), using the automatic interaction detection algorithm, also found age to be the second best accident predictor, after total convictions. Interestingly, the split occurred so that ages 16-20 and 26-75 fell into the low accident group, while ages 20-25 and 75+ composed the high accident group.

However, Harano et al. (1973) included in their regression several hundred variables including biographical, personality, socio-economic, attitudinal, and performance measures. They found that when these were included, age was replaced by other variables. This suggests the possibility that attitudes and social pressures, rather than age per se, result in poor driving records. The variable age could thus represent a host of life style and socio-economic variables which in turn relate to both driving exposure (qualitative and quantitative) and accident liability.

Operational Constraints

Age is readily available in state driver license files. However, accuracy of reported ages could potentially be a problem. There are several reasons why a driver might inaccurately report his age to a driver licensing agency. Younger drivers might falsely represent their age to qualify for driving at an earlier age, to qualify for employment, to be able to purchase liquor, etc. Initially falsified information might remain within the licensing records throughout the life of the driver. A systematic validity (accuracy) study, cross-checking driver license file age data against another agency's records, or against actual birth records, has not, to our knowledge, been conducted. Such a study might suggest categories of drivers for whom cross-checking of reported ages might be fruitful.

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[16] Wiener (1972) presents an excellent review of research in the areas of elderly drivers and pedestrians.

There is also considerable evidence that the reporting of both violations and accidents is biased by age. Klein (1966) discusses the two major problems in interpreting age-related accident and violation data: exposure and reporting bias. His conclusion can be summarized as:

Exposure: Present methods of estimating exposure are grossly inadequate, especially when applied to individual age groups. Also, the teen-ager may be more likely to be exposed to the most hazardous driving conditions. (Nighttime, poor weather, etc.)

Differential Reporting: Statistical reports of violations and accidents deal with only a small proportion of the deviant population. Adults are more often not cited by traffic control officers, more likely to be exonerated by judges, and often able to settle accident claims without reporting to law enforcement agencies.

Klein and Waller (1970) present further evidence of differential reporting of accidents by age, as shown in Table 1-12. Although the sample size here is relatively small, these data clearly show that drivers above age 30 have a substantially higher proportion of unreported accidents (at least in this one jurisdiction). Again, we know of no research study which has effectively controlled for reporting bias while analyzing the frequencies of violations and accidents by age groups. Thus, reporting bias may be, at this time, the most serious limitation for the use of age as an accident liability predictor in a driver licensing setting.[17] The use of age to differentially apply assessment, treatment, or control programs could also be interpreted as age discrimination.

Discussion

Table 1-13 presents the findings of several research studies which have used the driver's age as a predictor variable. The correlations found have been relatively high, particularly for the more frequently occurring types of convictions. In most cases, the correlations are also considerably higher for males than females (probably resulting from higher exposure, and thus higher criterion frequency).

In summary we can say that younger drivers tend to have poorer driving records, even after correction for number of miles driven.

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[17]It should be noted that controlling for reporting bias, as in the case of exposure control, is unnecessary for most actuarial purposes. Insurance agencies are concerned primarily with reported accidents, not with "true" driving risk, which is an important concern of researchers and licensing agencies.

TABLE 1-12. REPORTABLE CRASHES OBTAINED BY INTERVIEW VERSUS THOSE FOUND IN RECORDS OF MISSISSIPPI HIGHWAY PATROL -- BY AGE, SEX, AND OCCUPATIONAL CATEGORY FOR 500 SUBJECTS

Age	N	Total crashes by interview	No. in Highway Patrol records	No. *not* in Highway Patrol records	Percent interview crashes in Highway Patrol records
15-20	228	63	38	25	60
21-30	90	16	10	6	62
31 and over	182	31	9	22	29
Totals	500	110	57	53	52

Source: Adapted from McGuire and Kersh (1969)

Table 1-13. Selected Studies Using Age as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Peck, McBride, and Coppin (1971)	Driver Records	Reviewed records of a 2% random sample of California Drivers	Age of Driver	One Count Convictions (3 yr):				Accidents (3 yr.):			
				Males	-.237	.05	42,228	Males	-.081	.05	42,228
				Females	-.061	.05	30,277	Females	-.021	.05	30,277
				Two Count Convictions (3 yr.)							
				Males	.047	.05	42,228				
				Females	.002	NS	30,277				
				Passing Convictions (3 yr.):							
				Males	-.071	.05	42,228				
				Females	-.004	NS	30,277				
				Right-of-Way Convictions (3 yr.):							
				Males	-.018	.05	42,228				
				Females	-.002	NS	30,277				
				Equipment Convictions (3 yr.):							
				Males	-.168	.05	42,228				
				Females	-.058	.05	30,277				
				Miscellaneous Technical Convictions (3 yr.):							
				Males	-.140	.05	42,228				
				Females	-.075	.05	30,277				
				Non Countable Convictions (3 yr.):							
				Males	-.157	.05	42,228				
				Females	-.068	.05	30,277				
				Signal/Sign Convictions (3 yr.):							
				Males	-.106	.05	42,228				
				Females	.000	NS	30,277				
				Turning/Stopping/Signalling Convictions (3 yr.):							
				Males	-.034	.05	42,228				
				Females	.043	.05	30,277				
				Speed Convictions (3 yr.):							
				Males	-.255	.05	42,228				
				Females	-.128	.05	30,277				
				Major Convictions (3 yr.):							
				Males	-.042	.05	42,228				
				Females	-.007	NS	30,277				

Continued

NR Not Reported
NS Not Significant

r [illegible] product moment unless otherwise specified. Occasionally mean values reported in r column.
P Probability of significance ("P" has been dropped)

Table 13. Selected Studies Using Age as an Assessment Variable *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
F.L. McGuire	Questionnaire	Correlated test and questionnaire items with self-reported accident frequency for young male drivers (Age 17-20) with a two year driving history. (Random Sample)	Age of Driver (Range 17-20)					Self-Reported Accidents (2 yrs.)	-.01	NS	1481
			Age at Time of Driver Licensing					Self-Reported Accidents (2 yrs.)	-.01	NS	1481
Goodson (1972)	Licensing and Accident Records	Assessed 4 year follow-up accident records for drivers with 3 or more accidents in same year. Random Controls. (Contrasted Sample)	Mean Age (yrs.)					≥8 Accident Group (5 yr.)	32.3	NR	127
								6-7 Accident Group	29.9	NR	228
								5 Accident Group	29.6	NR	361
								Control Group	38.7	NR	326
M.W. Perrine (1974)	Questionnaire	Questionnaire Administered to learner applicants, applicants for junior operator's license, applicants for operator's license, fleet safety group, DWIs (Contrasted Sample)	Age Per cent 40+	Operator Pass	20%	NR	185				
				Fail	19%	NR	64				
				Fleet	22%	NR	79				
				DWI	40%	NR	78				
Harano (1974)	Driver Records	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (cluster analysis, and data collection reported in earlier study Finkelstein and McGuire 1971)	Age	Total Convictions (Subsequent (1 yr.)	-.131	.01	850	Total Collisions (Subsequent (1 yr.)	-.074	.05	850

NR Not Reported
NS Not Significant

r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P - Probability of significance (< has been dropped)

However, this finding can be criticized, since both reported violations and accidents may be biased in favor of the older driver. All of our remaining conclusions must be viewed in light of this constraint. Controlled research is needed to determine the extent to which such biases may distort conclusions about age.

Younger drivers do drive more frequently with excessive speed. As a result, the accidents they have tend to be more severe. When considering the more severe accident classes only, decreasing age appears to reduce involvement. This relationship, however, is not necessarily linear, since increased exposure and various social pressures tend to increase the problems of the young driver, while increasing driving proficiency decreases these problems. The most hazardous period appears to be 3-4 years after learning to drive.

Klein (1966) suggests several reasons for the peak and subsequent decline of driver errors at ages 18-20:

- Learning Effect: Violations and accidents are errors which decrease with greater experience.

- The Role of the Teen-ager in our Society: The automobile may be used to express unfulfilled needs and rebellion.

- Risk-taking as a Cultural Value: Influence of popular heroes may increase high-risk behaviors among the young.

The problems of the older driver tend to be the result of deteriorating physical and perceptual skills, decreased ability to withstand crashes, and inexperience with newer highway and vehicle design features. Fortunately, these effects are largely mitigated by the decreased highway exposure of this group. Quenault et al. (1968), who compared a sample of young drivers (ages 17-20) with older drivers (ages 60-70) on driving simulator performance, offer the following general conclusions about their results:

> "The picture which emerges from these results is that of a young, fast, competitive driver, more easily frustrated than the older driver and with quicker visual reaction times. On the other hand, the older driver is seen as slower, steadier, and more tolerant of other drivers' behavior, but given to lapses in judgement of traffic situations while driving..."

These general trends reflect both physical and psycho-social group differences for which, using driver record data, the simple variable "age" is a gross measure.

Sex

Aside from age, sex is most frequently mentioned as a biographical predictor of citation and accident frequency. Numerous sex-related differences in driving performances have been found, in both general driving performance and in specific types of driving errors.

General Driving Errors By Sex

Virtually all studies examining general driving errors by sex have implicated the male driver in the vast majority of both accidents and convictions. The California Highway Patrol Data (1967), population adjusted by Homburger (1968), reports traffic injury and death rates by sex, as shown in Table 1-14. Peck, McBride, and Coppin (1971), reporting their statistical breakdown of accident rates, report, "All sex differences were highly significant, with males having over twice the accident and citation rate of females." Similar results abound. O'Neall (1967), reports that "while men make up 57 percent of the licensed driver universe, they account for 73 percent of the accident-involved drivers..." Kraus et al. (1970), found that only 9% of their accident-involved sample were female (but conclude that this can be explained by the lower percentage of females who obtain driver's licenses, and by lower mileage driven by females who do drive). Goodson (1972) studied recidivism among high accident drivers and observed "nearly all high accident drivers are male." None of the above findings have attempted to control the biggest problem in reporting sex differences--driving exposure. When exposure is properly controlled, sex differences are not nearly as pronounced.

Some research studies have attempted to control for exposure by using group statistical exposure estimates. Harrington and McBride (1970) report that while male total violations per driver are almost exactly three times as high as for females, when these figures are adjusted for gross mileage, estimated male violations are only slightly higher than female. For young drivers, Harrington (1971) reports that mean accident and conviction rates were much higher for males than females in his sample, ages 16-20. After adjusting for mileage, however, accident rates for both sexes became quite similar, although the conviction rate for males remained twice as high. (He also reports differences by sex on type of violation with males having more speed citations, females more right-of-way violations.)

Another means to minimize the confounding effects of experience and exposure is the separate calculation of percent error within subgroups. Harrington's (1971) results using this technique are presented in Table 1-15.

TABLE 1-14. INJURY RATES (ALL VICTIMS) PER 100,000 POPULATION

	All Injuries	Fatal Injuries
Male	1422	37
Female	987	14

Source: Homberger (1968).

TABLE 1-15. PERCENT ACCIDENT TYPES BY SEX

	Male	Female
Percent of drivers at fault	58	47
Percent single vehicle	24	15
Percent alcohol involved	6	2
Percent with speeding violations	47	38
Percent with right-of-way violations	18	28

Source: Harrington (1971).

Multivariate studies have also shown sex to be an important predictor of accident liability.[18] Levonian (1967) found a simple correlation of .115 between sex and poor driving record, making it the third of four significant predictors in a regression equation predicting negligent operator status. The other significant variables were driving exposure, age, and marital status. Other variables, including vision scales, were not significant. Similarly, Finkelstein and McGuire (1971) found sex to be a significant predictor of accident liability, when used in conjunction with numerous driving record variables. However, when analyzing a six-year sample of drivers by the automatic interaction detection statistical procedure, Carlson (1968) found that sex was not a significant predictor of accidents, when included with such variables as conviction record and age.

In every category except accidents with right-of-way violations, males still demonstrated poorer driving performance. Similarly, Baker (1970) reports that 25% of female fatal accident victims (drivers) had been judged "not at fault" compared to only 10% of the male sample. However, Perchonok (1972), also using post-accident accounts to determine culpability, produced an opposite effect. His results for two-vehicle collisions are reported in Table 1-16. A recomputation to examine all involved drivers separately by sex (similar to Harrington's and Baker's analyses) showed males at fault in 48.0% of the two-vehicle accidents in which they were involved, while females were at fault in 55.5%. In considering all accidents, however, Perchonok found no significant differences in culpability by sex.

Maximum control over the problem of differential exposure can be achieved by using roadblocks to stop and survey non-involved drivers at the same time, day-of-week, and locations as accidents have occurred. This provides a valid control group. Borkenstein et al. (1964), conducting case-controlled roadside surveys at accident locations, found that females comprised 21% of the populations-at-risk (all drivers at the same accident time and place), yet were involved in 22% of the accidents. Perrine et al. (1971), reported that 17% of their roadblock (control group) sample were female, while only 5% of their fatally injured driver sample, and 2% of their recent DWI sample, were female.

The 1964 California Driver Record Study, Part 6, presents an additional interesting finding of driver record differences by sex. These authors correlated total number of accidents per year, separately by sex, for both consecutive and alternate years. Their findings are presented in Figure 1-7. They found accident-accident correlations

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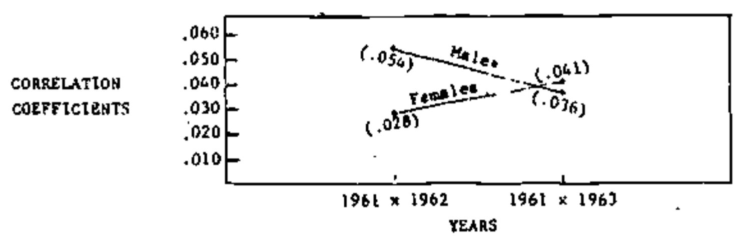
[18] In fact, due to this strong relationship, many researchers have conducted analysis separately by sex. This technique clarifies interactions and increases overall accident prediction (although the multiple R declines). Of course, this method could be applied to any variable which is related to the criterion.

TABLE 1-16. CULPABILITY VERSUS SEX FOR DRIVERS IN THE SAME ACCIDENTS

	Nonculpable Male	Nonculpable Female
Culpable male	272	68
Culpable female	97	48

Source: Perchonok (1972).



Source: California Department of Motor Vehicles (1965)
(See also, Peck et al., 1971)

FIGURE 1-7. ACCIDENT-ACCIDENT CORRELATIONS BY SEX OVER TIME
(Consecutive vs. alternate years)

higher for males in consecutive years, and higher for females in alternate years. Although the magnitude of these correlations, or the differences between them, is not high (they were significant since an extremely large sample was used), the authors consider this finding suggestive of a "suppressor effect" of the accident experience. That is, the occurrence of an accident may have sufficient psychological impact to decrease the probability of a subsequent accident. This suppressor effect, if present, apparently has a more pronounced or longer-lasting influence upon female drivers. The authors found no similar effect using conviction statistics.

Alcohol-Related Errors By Sex

Harrington (1971) demonstrated, as shown earlier in Table 1-15, that for his young driver sample, males were three times as likely as females to be involved in alcohol-related accidents. Similarly, Baker (1970) reports higher male alcohol consumption among fatally-injured accident drivers. Fifty-two percent of the male victims had blood alcohol concentrations greater than 0.10, compared to only 24% of the female victims.

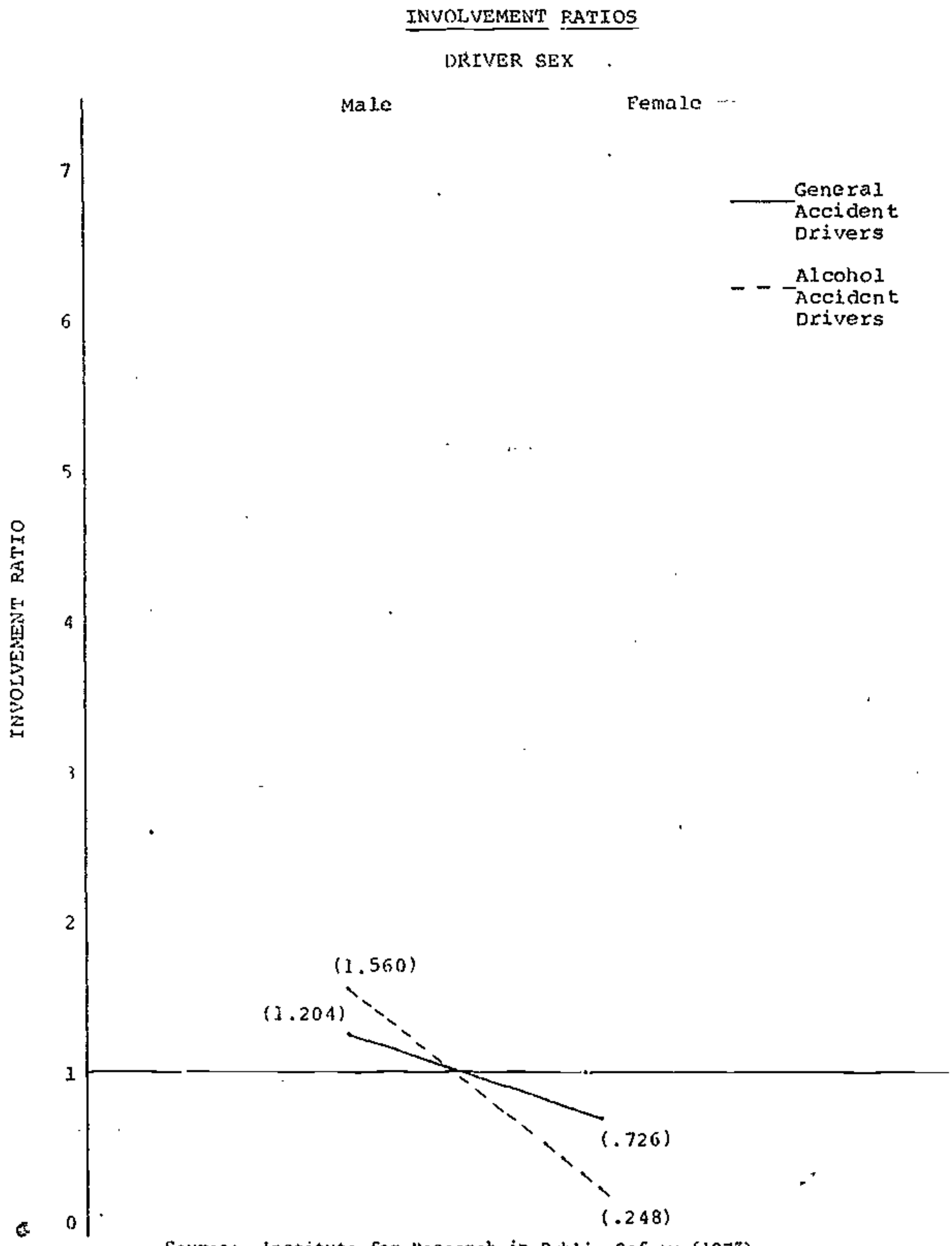
The Institute for Research in Public Safety's (1973) multidisciplinary accident investigation (Figure 1-8) has demonstrated that males are highly over-involved in accidents, which is further enhanced in alcohol-implicated accidents. Females, on the other hand, represent a mirror image of slight under-involvement in general accidents, and marked under-involvement when alcohol is implicated.

Males are also highly over-represented in DWI convictions. Comparisons of several ASAP sites throughout the United States revealed that 90% to 97% of DWI offenders were males (Human Factors Laboratory, South Dakota, 1974). Similar results have been found in research concerned with general drinking problems. Cahalan (1970) found that among a random sample of 1359 subjects, 27% of the males had some form of a drinking problem, compared to only 8% of the females.

Thus, sex of the driver shows a very strong relationship with alcohol-related driving errors, with males highly over-involved.

Risk-taking Errors By Sex

Perchonok (1972), examining culpability for all crashes, found no significant differences by sex. When examining culpable drivers only, however, Perchonok found culpable males to be more likely to have engaged in "high-risk" behaviors. Harrington's (1971) analysis of young drivers found males more likely (47% vs. 38%) to commit accident-related speed violations. Harrington and McBride's (1970) more detailed breakdown of violation types adjusted for mileage (Table 1-17) shows males higher on both speed and major violations, each of which contains an element of "high-risk" behavior.



Source: Institute for Research in Public Safety (1973)

FIGURE 1-8. ACCIDENT INVOLVEMENT RATIO BY SEX

1-60

TABLE 1-17. VIOLATIONS PER 100,000,000 MILES BY SEX AND VIOLATION TYPE

TYPE*	SEX	
	MALE	FEMALE
SPEED	701	562
SIGN	523	584
TURNING	201	210
PASSING	199	156
RIGHT-OF-WAY	119	149
MAJOR	59	26
ALL TYPES	2171	1825
MILEAGE	18,000	7200

Source: Adapted from Harrington and McBride (1970).

*Excludes Miscellaneous Technical Violations (not shown)

From these studies it can be concluded that males are more likely to commit risk-taking errors although the differences by sex are less dramatic than differences by age.

Recognition Errors By Sex

Harrington and McBride's (1970) analysis of violations by types, Table 1-17, demonstrates that for the common measures of recognition errors, including sign, turning, passing, and right-of-way violations, females have more of each of the types, with the single exception of passing violations. It is hypothesized that this one exception may result from the fact that passing violations contain an element of impatience or high-risk, as well as an element of recognition. The remainder of the recognition error types occur significantly more frequently for females, suggesting some sort of perceptual or performance deficiency. It should be noted that these figures are derived from group mileage estimates, which may or may not be accurate. In addition, reported convictions may also be subject to bias by sex.

It is, however, apparent from this level of observation that recognition-related errors occur differentially by sex. The qualitative aspects of these differences will be further examined in Chapter 3.

Discussion

As an operational variable, sex of the driver can be considered highly reliable and accurate, since there is relatively little opportunity for reporting discrepancies. However, any analysis of driving criteria by sex is subject to the errors of exposure and reporting bias. Lack of proper exposure control renders many experimental results questionable. Reporting bias could also be a problem if, for any reason, either sex tended to have fewer actual violations reported, be convicted of lesser offenses for similar violations, etc. Additionally, use of the driver's sex for differential countermeasure assignment may be subject to charges of sex discrimination.

Traffic Convictions. When differences in exposure and experience are controlled, males appear to have a significantly higher conviction rate. Qualitatively, males have more "high-risk" violations such as speeding, illegal passing, etc. Males also constitute the vast majority of DWI arrests. Females have more citations for signs and right-of-way, perhaps suggesting a difference in perceptual style.

Accidents. Both sexes appear to have very similar accident rates after proper controls for exposure, although there is some evidence that the rate is slightly higher for females. There are, again, major qualitative differences. Males are involved in more single vehicle crashes, which very frequently involve alcohol. Males are also prone to have emitted "high-risk" behaviors (speeding, etc.) at the time of their accident. These "high-risk" behaviors tend to increase the severity of accidents. Thus, males are over-represented in fatal crashes. Females may be involved in slightly more per "population-at-risk" accidents, and may be slightly more likely to have been culpable, but since they are less prone to high-risk behaviors, their accidents are significantly less severe, resulting in fewer fatalities.

From the vantage point of the program administrator, males clearly represent the greatest problem, in terms of percent involvement. Table 1-18 illustrates this for several criteria. Males are highly over-represented in all categories, although differences are significantly less on accidents than on the violation criteria. Of course, none of these data are controlled for exposure.

Utility. In regression equations predicting a gross accident measure such as total accidents in a given period, sex will not necessarily be a useful predictor, since males and females have very similar total accident rates when exposure is properly controlled. When employed in this manner, its success seems to be a function of the other variables in the equation. If an accurate measure of exposure is included, sex should not be a significant predictor, since per-mile accident rates by sex are similar. Thus, in the absence of good individual exposure data (which appears likely to continue), the variable "sex" will be of significant utility in increasing gross accident prediction (reflecting primarily exposure differential). However, strong differences by sex have been shown when examining particular types of driving errors. As will be seen later, numerous other differences occur by sex, including physical, perceptual, social, attitudinal, and driving performance variables. Thus, the sex of the driver would seem especially useful in predicting more specific accident criteria, such as particular accident types, or accident severity, where per-mile rates reveal strong differences. Table 1-19 presents the findings of several research studies using sex as an assessment variable.

Marital Status

Married drivers have often been cited as safer drivers than single drivers. Harrington and McBride (1970) report that for all types of violations, unmarried drivers generally have poorer records, with the exception of married males in the under-21 age group, who average more violations than their unmarried counterparts for most violation types.

TABLE 1-18. DISTRIBUTION OF ACCIDENT/VIOLATION CRITERIA BY SEX

	1967 Multiple Accident Driver %	1967 Violator %	1967 Multiple Violator %	1967 Drink Violator %
Male	84.4	90.3	94.5	93.9
Female	15.6	8.1	4.2	4.9
Unknown Sex	.0	1.6	1.3	1.2
TOTAL	100.0	100.0	100.0	100.0
N =	(2121)	(6547)	(547)	(2098)

Source: Ingersoll, Throw & Clarke (1970).

Table 1-19. Selected Studies Using Sex as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Goodson (1972)	Licensing and Accident Records	Assessed 4 year follow-up accident records for drivers with 3 or more accidents in same year. Random Controls. (Contrasted Sample)	Per cent of Males					≥8 Accident Group (5 yr.)	97.6%	NR	127
								6-7 Accident Group	94.8%	NR	288
								5 Accident Group	95.6%	NR	361
								Control Group	59.2%	NR	326
Harano (1974	Driver Records	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting. Predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Sex (0=male, 1=female)	Total Convictions (Subsequent 1 yr.)	-.092	.01	850	Total Collisions (Subsequent 1 yr.)	.005	NS	850
Peck, McBride and Coppin (1971)	Driver Record	Reviewed records of a random sample (2%) of the California driving population. Females=30,277 Males=43,509	Sex of Driver	Mean Convictions (3 yrs.) Males Females	.92 .35	.001	see method	Mean Accidents (3 yrs.) Males Females	.26 .13	.001	see method
Harrington (1971)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16-17. (Random Sample)	Sex of Driver	Mean Number of Convictions (4 yrs.): Males Females	3.17 0.83	NR	4717 4199	Mean Number of Accidents (4 yrs.): Males Females	0.64 0.35	NR	4717 4199

NR - Not Reported
NS - Not Significant

r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P - Probability of significance (≤ has been dropped)

Using accident criteria, Peck, McBride, and Coppin (1971) demonstrated that married drivers have significantly less accidents, as well as citations, than their unmarried counterparts. The difference was not quite as pronounced for accidents (See Figures 1-9 and 1=10). They also found that marital status differences tend to decline in the older age groups. A significant interaction was found between marital status and age, further demonstrating that marital status does not exert a constant effect for all age groups.

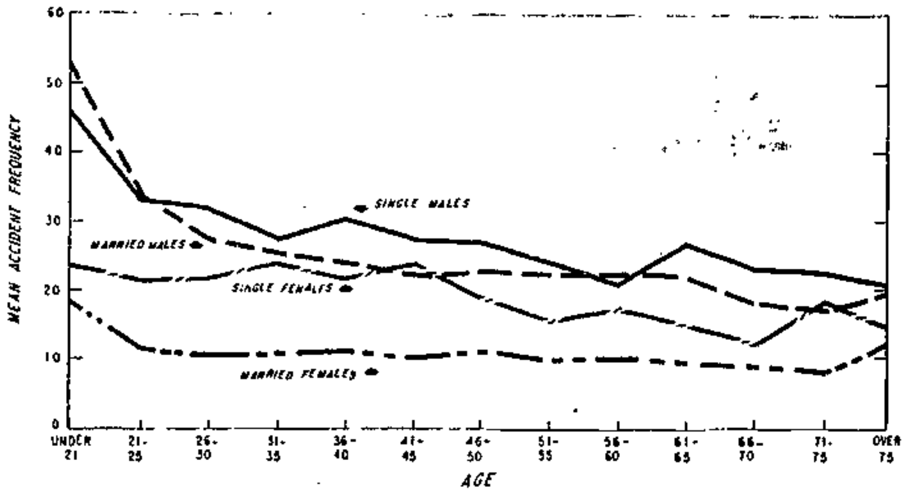
Other studies demonstrate similar differences by marital status. Harano, et al. (1973) also found a significant correlation between accident liability and marital status (r=-.25), with single drivers over-represented in the accident-repeater group. Unmarried drivers composed only 27% of the population-at-risk roadblock sample of drivers in a case-controlled study by Perrine et al. (1971), yet they comprised 41% of the fatally injured driver sample. They were 34.9% of Baker's (1970) fatally injured sample, but there was no control group. Baker also found no significant relationship between marital status and crash responsibility, but did note that unmarried drivers under age 25 were over-represented in single vehicle accidents. Wallace (1969) found that remedial driver improvement programs were less successful for single drivers.

The Institute for Research in Public Safety's (1973) multidisciplinary accident investigations have demonstrated that general accident involvement is slightly higher than expected for both single and divorced-and-remarried drivers, while general accident involvement was slightly lower than expected for both married and widowed drivers. However, for divorced or separated drivers, general accident involvement was found to be at least four times as high as expected.

Levonian (1967) used multiple regression to predict negligent operator points (primarily convictions), and found marital status to be the fourth and final significant predictor, after exposure, age, and sex. (r=-.075). Harano et al. (1973) and Finkelstein and McGuire (1971) both found marital status to be a significant predictor of accident liability, in conjunction with other variables. The Harano study, which employed many variables, assessing driving record, personality, attitude, socioeconomic, perceptual, and performance measures, found marital status to be a useful predictor, but of less significance than a variety of other variables. Additionally, Harano reports greater predictive validity using the simple married-single dichotomy, rather than more specific categories, such as married, widowed, divorced, etc.

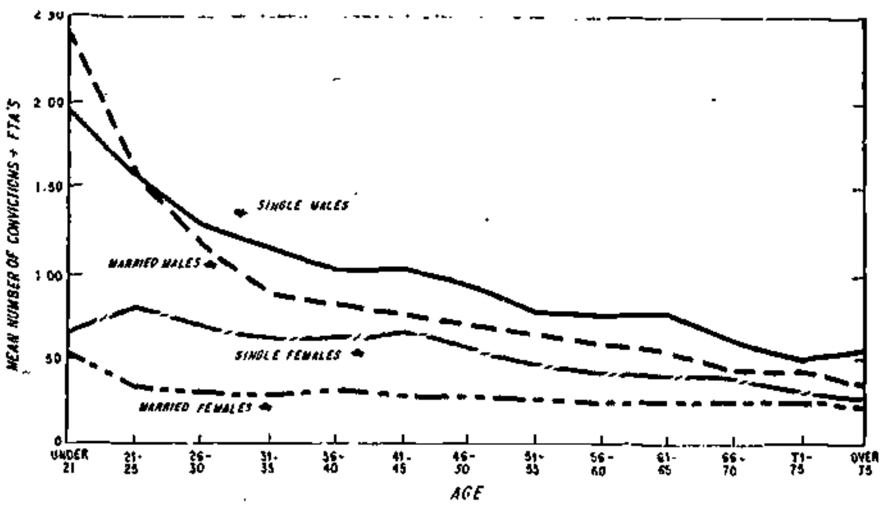
Alcohol Related Errors By Marital Status

Marital status, especially if recent changes can be measured, is an important predictor of general accidents, but is even more important as a predictor in alcohol-related accidents. Single drivers, whether they are divorced, separated, widowed, or never married, have a



Source: Peck, McBride and Coppin (1971)

FIGURE 1-9. MEAN ACCIDENT FREQUENCY BY AGE, SEX AND MARITAL STATUS
(Three Year Driving Record 1961-1963)



Source: Peck, McBride and Coppin (1971)

FIGURE 1-10. MEAN CITATION FREQUENCY (COUNTABLE CONVICTIONS + MOVING FTA'S) BY AGE, SEX AND MARITAL STATUS

(Three Year Driving Record 1961-1963)

disproportionate involvement in accidents, specifically fatal accidents involving alcohol. (It should be noted that marital status as obtained from licensing bureau files often does not contain up-to-date information on changes in marital status.)

The Indiana multidisciplinary accident investigation (Institute for Research in Public Safety, 1973) produced a breakdown of alcohol-related accident involvement by marital status (Figure 1-11). The divorced subgroup, which is the most over-involved in general accidents, nearly doubles its involvement ratio in alcohol-related accidents. The separated subgroup, however, climbs from a high over-involvement ratio in general accidents (4.0) to an extremely high ratio for alcohol-involved accidents (30.3). Further evidence for the role of marital status in alcohol-related fatalities was found by Finch and Smith (1970). Forty percent of the fatally injured drivers were separated/divorced, compared to only 4% in the control. Forty-four percent of the fatals had been married twice, compared to only 16% in the control sample. In a roadside survey Filkins et al. (1974) reported that divorced or separated males were over-represented in drinking and driving. While 4.5% of the U.S. male population are divorced or separated, Filkins found that 13.9% of the drivers who had BAC levels greater than 0.10 were divorced or separated. In an analysis of an accident file, drinking divorced/separated drivers were also over-represented.

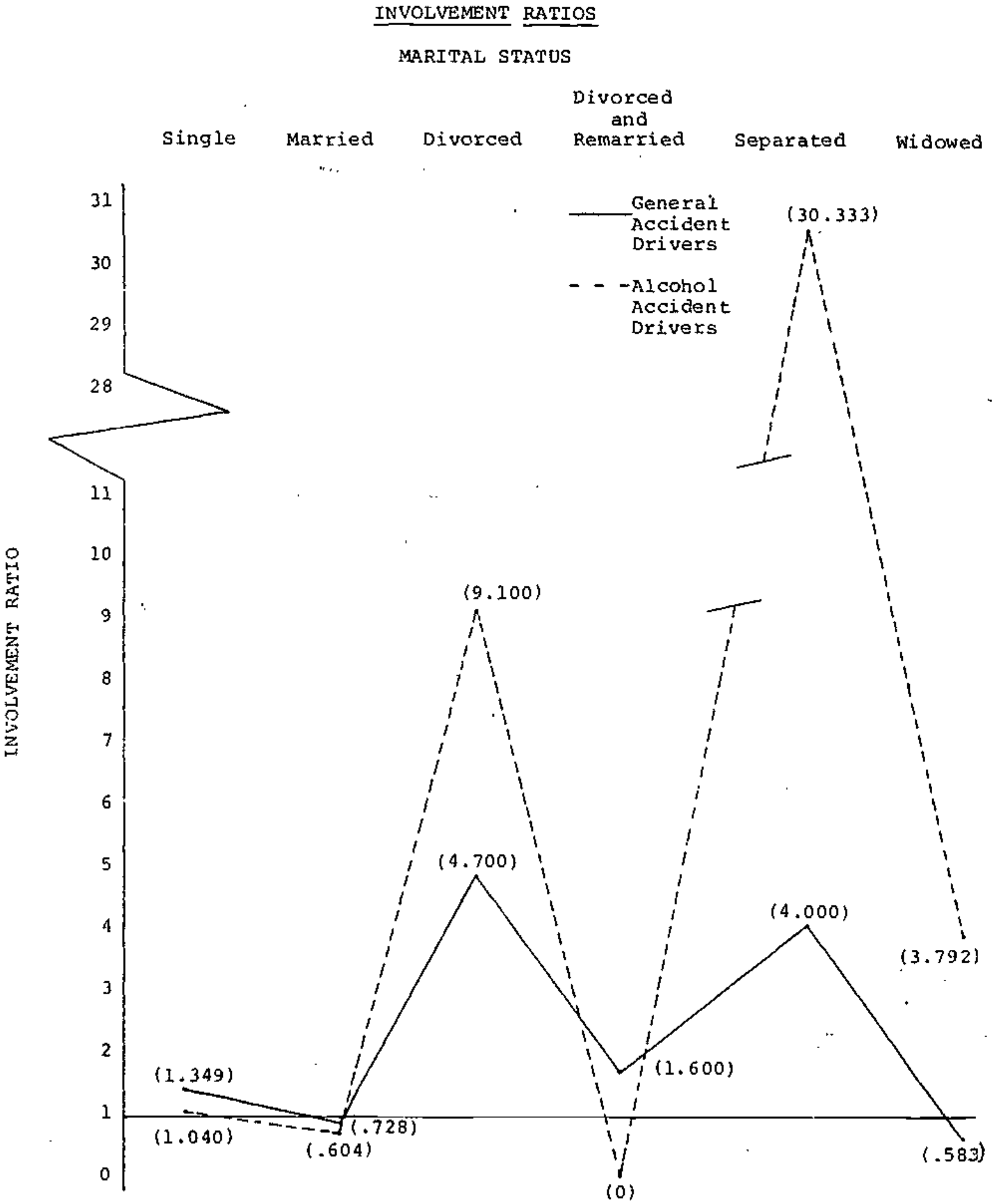
In summary, these studies demonstrate a high relationship between marital status and alcohol-related accidents. General trends have been presented here. Marital discord and its attendant social and phychological factors will be discussed in Chapter 3.

Risk-taking Errors By Marital Status

The detailed breakdowns of violation types by age, sex, and marital status presented by Harrington and McBride (1970) demonstrate that the previously noted interaction between age, sex, and marital status (married drivers having more violations only among the youngest males) also occurs when examining only speed violations. Peck, McBride, and Coppin (1971) report a correlation of speed violations with marital status for males of .133 (.072 for females), compared to -.255 (-.128 for females) for the same violations correlated with age. This would indicate that marital status is still a useful predictor of risk-taking related violations.

Recognition Errors By Marital Status

Correlations between marital status and recognition errors (as reflected by recognition-related convictions) have been very low, although still significant. For example, Peck, McBride, and Coppin (1971) report a correlation of only .040 for males between turning, stopping, signalling convictions and marital status (.064 for females). These low correlations



Source: Institute for Research in Public Safety (1973)

FIGURE 1-11: ACCIDENT INVOLVEMENT RATIO BY MARITAL STATUS may, in part, be a result of the low frequency of such recognition-related convictions. For practical purposes, marital status does not at present appear to be a useful predictor of recognition errors.

Discussion

Marital Status is not always collected or filed by driver licensing agencies. Even in those agencies where it is routinely collected, there is a major problem of recency of information. Since licensing agencies seldom re-examine drivers at less than two-year intervals, information contained in license files is often out-of-date. This is of critical importance since there is some evidence (in subsequent chapters) that recently separated or divorced people tend to have especially high alcohol-crash involvement, presumably due to emotional stress. As a result, more useful marital status information can be obtained from other agencies (Chapter 2) or whenever a driver is present in the licensing agency for re-assessment (Chapter 3).

Some of the research findings concerning the relationship between marital status and driving errors are summarized in Table 1-20. The correlations, particularly those with total convictions, are relatively high. Almost all are significant.

There is little doubt that significant differences exist in general driving behaviors by marital status, even from Level I sources. In every case except the young (under 21) male, married drivers on the average perform better than single drivers. (This one exception may reflect social factors affecting the young, married male.) These differences are larger for convictions than for accident criteria, and seem to persist with or without controlling for differential exposure. They do seem to be related to such other measures as age, sex, attitudinal, and personality factors. As a result, marital status will be a useful predictor of general accident liability, until more specific attitudinal, and personality measures can be found which more directly assess the differences between the married and non-married driving population.

For predicting specific types of driving problems, marital status is especially important in alcohol-related errors. Both divorced and separated drivers have extremely high alcohol over-involvement. However, data of sufficient recency and accuracy to make this type of assessment is seldom available in driver records. It is apparent that every effort should be made to obtain such recent, accurate marital status data at any agency conducting driver diagnostic assessment.

Race

In the past, the driver's race has been ascertained by licensing agencies primarily for identification purposes. With the recent trend toward placing the driver's picture on the license, there has been a

Table 1-20. Selected Studies Using Marital Status as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Finch and Smith (1970)	Interview/ Questionnaire	In-depth investigation of background characteristics of 25 drivers involved in fatal accidents and a control sample of 25 drivers.	Marital Status					Control			
								Married	84%	.01	25
								Separated	0%		
								Divorced	4%		
								Single	12%		
								Widowed	0%		
								Fatal			
								Married	40%	.01	25
								Separated	24%		
								Divorced	16%		
								Single	16%		
								Widowed	4%		
Finkelstein & McGuire (1971)		A large test battery was administered to a group of 950 negligent drivers. Cluster analysis done to identify types. Concurrent correlations of selected variables reported here. (1 yr. driving record)	Single	Concurrent Convictions (1-3 yr. driving record)	–.10	.01	950	Concurrent Accidents (1-3 yr. driving record)	.03	NS	950
Peck, McBride, and Coppin (1971)	Driver Records	Reviewed records of a 2% random sample of California Drivers	Marital Status of Driver	One Count Convictions (3 yr.)				Accidents (3 yr.)			
				Males	.147	.05	42,228	Males	.051	.05	42,228
				Females	.137	.05	30,277	Females	.087	.05	30,277
				Two Count Convictions (3 yr.)							
				Males	.052	.05	42,228				
				Females	.027	.05	30,277				
				Passing Convictions (3 yr.)							
				Males	.038	.05	42,228				
				Females	.039	.05	30,277				
				Right-of-Way Convictions (3 yr.)							
				Males	.030	.05	42,228				
				Females	.043	.05	30,277				
				Equipment Convictions (3 yr.)							
				Males	.089	.05	42,228				
				Females	.028	.05	30,277				
				Miscellaneous Technical Convictions (3 yr.)							
				Males	.067	.05	42,228				
				Females	.042	.05	30,277				
				Non-Countable Convictions (3 yr.)							
				Males	.066	.05	42,228				
				Females	.026	.05	30,277				

Continued

NR Not Reported
NS Not Significant

r [illegible] unless otherwise specified. Occasionally mean values [illegible]
P Probability of Significance [illegible]

Table 1-20. Selected Studies Using Marital Status as an Assessment Variable *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	p	Sample Size	Validity: Accidents Type	r	p	Sample Size
				Signal/Sign Convictions (3 yr.)							
				Males	.082	.05	42,228				
				Females	.101	.05	30,277				
				Turning/Stopping/Signaling Convictions (3 yr.)							
				Males	.040	.05	42,228				
				Females	.064	.05	30,277				
				Speed Convictions (3 yr.)							
				Males	.133	.05	42,228				
				Females	.072	.05	30,277				
				Major Convictions (3 yr.)							
				Males	.044	.05	42,228				
				Females	.012	.05	30,277				
Harrington (1971)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16-17. (Random Sample)	Married	Total Convictions (4 yr.)				Total Accidents (4 yr.)			
				Male	.150	.05	5,108	Males	.006	.05	5,018
				Females	.037	05	4,378	Females	−.048	.05	4,378
			Divorced/Separated	Total Convictions (4 yr.)				Total Accidents (4 yr.)			
				Males	079	.05	5,018	Males	.026	.05	5,018
				Females	.049	.05	4,378	Females	.024	.05	4,378
Harano (1974)	*Driver Records*	*A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (Cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)*	*Marital Status (0=married, 1=single)*	*Total Convictions (Subsequent 1 yr.)*	*.077*	*.05*	*850*	*Total Collisions (Subsequent 1 yr.)*	*.010*	*NS*	*850*

NR Not Reported
NS Not Significant

r [illegible]
P Probability [illegible]

corresponding decline in licensing agency requests for applicants to list their race. As a result, the variable is less frequently available for statistical research purposes.

The few studies examining drivers by race have uncovered few strong differences. Harano et al. (1973) contrasted accident and control male driver samples (N = 427) on several hundred variables, including the dichotomous variables Caucasian, Negro, Oriental, and Mexican. The two contrasted groups differed significantly only on the variable "Caucasian," apparently because Caucasians were more numerous in the sample, and the dichotomization of the variable contrasted them against the other three groups. Thus, an increase in the sample size might have made differences in the other three categories significant, although still very small in magnitude. Similarly, Finch and Smith (1970) found Negro subjects slightly over-represented in a fatal accident sample, contrasted with controls, but the sample size was small (n = 50) and differences were not significant.

However, Marsh and Hubert (1974) found that the categorical variable "black" correlated significantly with both convictions and accidents after a driver improvement contact, and remained in the stepwise regression equation for both criteria. This finding would suggest the need for further research to examine potential utility of the variable. However, race may only reflect differing socio-economic status, which will be examined in later chapters.

Driver Education/Training

The value of formal driver education, as a means of accident reduction, and consequently as a simple predictor of subsequent accident liability, is still quite controversial despite a large body of research in this area.

F. L. McGuire (1969, 1972) compared the driving histories of a large sample of enlisted airmen, and found no significant correlation between driver education and accident frequency. Other studies, e.g., Kraus et al. (1970) studying young driver accidents, and Asher and Dodson (1970) studying young highway fatalities, have also shown no significant differences. Carlson (1968) reported very minor significance for young drivers. Schuster (1966) reports significance for college, but not high school samples.

Other researchers have shown more positive differences. Harrington (1971) found that those drivers who had taken "behind-the-wheel" driver training had better driving records, and also more socially-desirable personal characteristics, than those not taking the course, especially the females. A similar analysis indicated that classroom driver education appeared to reduce fatal injury accidents for females, but had little, if any, effect for males. Perchonok (1972), investigating accidents in-depth, found that driver education made no significant difference in accident culpability, or in frequency of "high-risk" behaviors. He did, however, find those with driver training were significantly lower in alcohol consumption.

Inconsistent findings such as these have made firm conclusions difficult. Klein (1966) has put some of these issues into perspective. The following is a summary of his conclusions:

> Statistical data showing better driving performance for those who have received driver education or training has led to insurance premium reductions contingent upon completion of the training, which has led to massive driver training programs, and belief in a national "teen-age driver problem." Such reactions are based solely on "faith in the efficiency of education." There is no evidence whatever that driver education is directly responsible to any extent for reducing the accident or violation rates. Studies purporting to show differences between groups with and without driver training have failed "to isolate the driver education course as the relevant variable," since no study has effectively matched control and training groups across a wide variety of attitude and personality measures, and then demonstrated subsequent differences in driving performance.
>
> Finally, psychologists and sociologists have found that attitudes and values are instilled in children at a very early age, and become virtually "instinctive." If, as several researchers (e.g., Mann, 1958) have suggested, these attitudes and values play an important role in driving safety, then it is doubtful that a single high school course will alter them greatly.

In summary, little evidence exists that voluntary driver education courses improve driving performance, and any differences noted by this variable probably reflect psychological or social factors. (Table 1-21 reviews some of this evidence, revealing low and generally insignificant correlations with driving record.) As driver education becomes increasingly mandatory, even these slight differences diminish. Thus, although certificates noting completion of driver education are often required by licensing agencies to assure compliance with mandatory requirements for licensing young drivers, the expense associated with retaining this information for predictive purposes alone does not appear to be warranted.

Other Biographical Information

Driver license files usually contain certain other variables for identification purposes, most commonly height and weight. Because these variables are easily obtained in studies of licensing data, several researchers have assessed their relationship to driver problems.

Table 1-21. Selected Studies Using Driver Education/Training as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Asher and Dodson (1970)	Test Battery	Contrasted fatally injured high school students vs. peers on Project Talent data items. (Contrasted Sample)	Driver Training					Compared differences between fatal accident victims & normative group.	NR	NS	44
Kraus, Steele, Ghent, and Thompson (1970)	Interview Questionnaire	From drivers under age 21, selected 100 with at least one accident, 100 accident - free controls, matched on age, sex, population of area of residence. (Contrasted Sample)	Driver Education					Compared differences between accident sample and controls	NR	NS	100/100
F. L. McGuire	Questionnaire	Correlated test and questionnaire items with self-reported accident frequency for young male drivers (age 17-20) having a two year driving history. (Random Sample)	Driver Education					Self-Reported Accidents (2 Yr.)	−.01	NS	1,481
Harrington (1971)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16-17. (Random Sample)	Driver Education taken					Total Accidents (1 Yr. subsequent record): Males Females	.02 −.01	NS NS	4,783 4,208
			Driver Training taken when offered					Males Females	−.05 −.04	.01 .01	6,423 4,765
			Driver Education Taken					(4 Yr. Subsequent record): Males Females	.03 .00	.05 NS	4,788 4,208
			Driver Training taken when offered					Males Females	−.01 −.04	NS .01	6,423 4,765

NR = Not Reported
NS = Not Significant

r = Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P = Probability of significance (% has been dropped)

Peck, McBride, and Coppin (1971) correlated height and weight from license files with various types of driver problems. They found small but usually significant correlations between height and most common conviction and accident types. It was also found to be a minor but significant (concurrent) predictor of driver problems in certain regression equations. These findings can be partially explained by the moderate correlation between height and age (males: $r = -.192$, $p < .01$; females: $r = -.082$; $p < .01$). These authors found that weight produced even less consistent correlations with driver problems, presumably because weight correlated substantially with age only for females (males: $r = .018$, $p < .05$; females: $r = .238$, $p < .01$). Weight also producted a slight increase in concurrent prediction by multiple regression.

Peck et al. (1971) also used height-to-weight ratio as a variable, to test the assumption that this combined measure might reflect an individual's socialization difficulties and/or anthropometic characteristics. The measure produced low but often significant correlations with specific driver problems, similar to the correlation for height and weight separately. The combined measure was also related to age (males: $r = .080$, $p < .05$; females: $r = .252$, $p < .05$).

PSYCHOLOGICAL/SOCIAL/ATTITUDE VARIABLES

At present, there is no attempt made at Level I sources to collect any psychological or attitude assessment variables. There is, however, one Level I source of information which appears indicative of social attitudes and values--motor vehicle registration files. Owning a motor vehicle is probably simply an indicator of greater amount of driving. For that reason, vehicle ownership will be discussed in the Exposure Variables section.

Other factors, such as age, weight and model of vehicle, however, might relate to both social attitudes and values, as well as socio-economic status. Comparing type of car, body style, price range, weight/type, cubic inches and transmission, Harano et al. (1973) found none of these variables significantly discriminated between accident repeater and accident-free drivers. Since the comparison included all age ranges, the interaction (e.g., younger drivers) of these variables was not reported. Ingersoll et al. (1970) found that younger accident-involved drivers had a disproportinate number of older vehicles. This probably reflects lower socio-economic status for younger drivers.

In using an elaborate coding system for vehicle type (e.g., weighted indices for price, style, performance) Marsh and Hubert (1974) did not find any of these measure to predict accident liability for a sample of negligent drivers. Significant correlations were found for age of vehicle with accidents: older vehicles ($r = .03$), vehicle age over 5 years ($r = .03$). For convictions the correlations ranged from .04 to .06.

Correlations of this order of magnitude offer little promise for individual diagnostic assessment. However, further research may indicate applicability to particular sub-populations.

MEDICAL/PHYSIOLOGICAL VARIABLES

Licensing agencies usually collect certain medical information on the driver. This might include visual and hearing abilities, as well as reports of mental and physical deficiencies.

There are many alternative sources from which licensing agencies receive information on the medical conditions of drivers. Since these vary widely across jurisdictions, some of the present mechanisms for the identification of drivers with medical impairments will be discussed here briefly. The remainder of this section will then review the research findings relating medical impairments to driving behavior.

Alternatives For Diagnosis

Requiring Physicians to Report

At present, relatively few states have laws which require doctors to report patients who are diagnosed as having disorders affecting driving ability. The American Association of Motor Vehicle Administration (AAMVA) has conducted a survey of the licensing agencies in states with laws requiring physicians to report. They received responses from five states. In three states (California, Connecticut and New Jersey), the responding department official felt that the reporting law was somewhat successful. In another state, the responding official described the percentage of reporting as very poor. In the fifth state, the licensing agency spokesman indicated the law was successful only in cases of epilepsy. However, in California, only 45 percent of the reported epilepsy cases were found to have been reported by physicians (Erickson and Waller, 1964). Thus, more extensive evaluations are needed to determine the administrative effectiveness of the laws. It would appear that reporting laws, while obviously not completely successful, do identify more drivers than are identified simply by voluntary reporting.

<u>Traffic Laws Commentary</u> (1972a) contains an analysis of some of the problems accompanying the compulsory reporting law. One problem is the potential for damaging the physician-patient relationship. The increased highway accident risk of the driver with a disabling condition who is discouraged from seeking medical help because of the reporting law, may outweigh any decrease in accident risk produced by the successful operation of that law. The second major problem is physician non-compliance. The physician may not feel ethically justified in breaking the patient's confidence. He may not want to be responsible for a patient's loss of license, and he may fear liability. There is also potential for the discriminatory exercise of the reporting law. The more affluent patients

who have a close relationship with a private physician may be less affected by the reporting law than lower socio-economic status persons who must rely on clinics for medical attention. For reasons such as these, most states rely on other means to identify persons with health problems that may affect driving.

Mandatory Disclosure by Applicant

One such alternative is to require that any person with a reportable condition divulge that information on his license application. For example, the state of New Jersey has a disclosure requirement, and its evasion constitutes a misdemeanor. Similarly, in California, failure to report is grounds for suspension or revocation. The individual who is afraid of losing his license (or ignorant of his condition) will not be identified under such laws.

Diagnosis by Driver Licensing Examiners

Another way to identify medically impaired persons is to train driver licensing examiners to recognize the symptoms of various medical problems. Guidelines have, in fact, been written for this purpose. It is unlikely that many health problems would be detected by these means, since only the most gross symptoms can be easily recognized in this situation. Additionally, many states do not require drivers to appear in person for license renewal.

Reports From the Community

Additional identifying sources are reports from police officers, courts, family members, friends, governmental agencies, and employers who might be aware that an individual suffers from a disease that could affect driving performance. In fact, in some studies more medically restricted drivers are referred by their family than by their physicians. Obviously, it is difficult to standardize this kind of diagnostic assessment.

Licensing Agency Medical Examinations

Yet another means for identifying medically handicapped drivers is to subject all licensed drivers to a medical examination. The State of Pennsylvania tried such a program for several years in the early 1960's. Two million drivers were examined, and 30,000 of those found medically unacceptable. An inspection of the past driving record of these drivers, though, revealed that their accident rate had been about half that of all licensed drivers (Traffic Law Commentary, 1972b). It may be that these particular drivers had less exposure than the general population.

However, based on these results, the medical exam for diagnostic purposes would appear to be neither valid nor cost-effective.

Medical Advisory Boards

State medical advisory boards (MAB) associated with licensing agencies can be an auxiliary means for the identification of the medically-impaired driver. Most states have medical advisory boards which exercise one or both of two main functions: (1) advising the licensing agency on standards for licensing all drivers; and (2) advising the license examiner on the qualifications of particular drivers. Less than half of the state medical advisory boards are governed by laws specifying their function, and among these laws there is little uniformity (Traffic Laws Commentary, 1972b).

In the absence of adequate data on the ability of medical factors to predict accident involvement, it is questionable that medical advisory boards can make reliable recommendations. Reese makes some cogent arguments against institutionalizing the MAB:

> "There is the danger that the licensing recommendations of medical boards may be accepted at face value and presumed to be based on reliable scientific knowledge. Will not administrators and judges hesitate to overrule the licensing recommendations of a board of medical "experts?". . . Who in government will protect the interests of the license applicant who is in the awkward position of having to attack "expert" recommendation?. . . Unless medical boards justify their opinions by articulating the criteria and standards on which these conclusions are based, no effective attack can be made. . ." (Reese, 1971).

Discussion

There are obvious advantages and limitations to each of these data collection methods. Most are non-standardized and subject to many biases. Only compulsory medical examinations will identify all cases of impairment. However, present evidence relating medical deficiencies to driving does not appear to justify the cost of this approach. Until this evidence is provided, the present methods of voluntary reporting from the community and mandatory disclosure by the applicant appear to be sufficient. The medical advisory board may be useful to advise the licensing agency on standards for all drivers, but may unduly penalize the individual driver by forcing him to refute "expert" opinion.

Medical Impairments

Licensing agencies have often assumed that individuals with certain health problems are not able to drive with as much skill and safety as the "average" driver. Long before there were data to suggest that medically impaired drivers had worse records than other drivers, license applicants with diseases such as epilepsy, diabetes, heart disease, and sometimes mental illness were given special scrutiny by licensing officials, and often barred from holding a license. It was not until the mid-1960's that there was any research done to investigate the comparative accident and violation rates of medically handicapped and unimpaired drivers.

Little (1966), in The State of the Art of Traffic Safety, concluded that the knowledge relating medical impairments to accident losses was "poor". At the same time medical factors were rated as being of "minor" importance to traffic accident loss reduction. Concerning the justification for regulating the medically-impaired driver, Little states "the popular concern about the danger of such diseases (heart disease, epilepsy, diabetes, etc.) to driving appears to be exaggerated." Little emphasized:

> "It is important to recognize that as with other characteristics which might be identified as a basis for restricting driving privileges any medical variable so chosen must be demonstrated to be highly correlated with accident risk . . . As the evidence demonstrates, no medical group having such greatly increased risk has been identified, with the possible exception of those suffering from alcoholism." (Little, 1966).

Chronic Illness

Malfetti (1963) reported that there was little evidence on the incidence of accidents specifically caused by diabetics, epileptics and those with cardiovascular lesions. Two years later, a major study relating chronic medical conditions to traffic safety was conducted by Waller (1965). Waller compared the accident and violation rates of a sample of 2,700 persons with known chronic medical conditions to a randomly selected control group. He found that, as a group, drivers with diabetes, epilepsy, cardiovascular disease, alcoholism, and mental illness averaged twice as many accidents per mile as the comparison group on an age-adjusted basis. This same group of drivers also averaged a significantly higher rate of violations, but the difference was much less than that for the accident rate. Waller also found that the primary medical condition was not the only human factor (or even the major human factor) associated with increased accident potential. Accident rates for those individuals with chronic medical conditions increased for those over 60 years old, those with a poor attitude towards maintaining their medical regimens, those with the more severe illnesses, and those with prior accidents related to their medical conditions.

Waller's results must be viewed cautiously for several reasons. His medical sample and comparison sample were not adequately matched, since they varied on age, sex, marital status, and socio-economic status. Waller himself emphasized that his study described the accident experience of only those people with medical conditions known to the California Department of Motor Vehicles. This kind of sample selection bias has been a problem in almost all studies concerning medically impaired drivers.

In a later study, the Washington State Department of Motor Vehicles (Crancer and McMurray, 1967) examined the violation and accident experiences of Washington motorists whose driving privileges were restricted because of certain physical, medical or mental conditions. Their results only partially support Waller's findings. They found no statistical difference between the accident and violation rates of drivers with cardiovascular disease and the corresponding general population of drivers. Curiously, they found that the accident rates for all these medically impaired males were significantly lower than the corresponding rates for the average of Washington male drivers, while those of the medically impaired females were significantly higher than those for the total female population. They also found that females in the 36-50 age group had an accident rate of over three times that of the males in the same age group with similar medical driving restrictions. Like Waller, Crancer and McMurray (1967) reported that drivers whose licenses were restricted because of diabetes, epilepsy, fainting, and other conditions did have higher accident rates (the magnitude of the difference in the accident rates was not as great as that reported by Waller). However, the violation rates for these groups were not significantly different from those of the comparison group.

In a subsequent study, Crancer and Quiring (1968b) again obtained results at variance with the Waller findings. They looked at the driving records of a group of hospitalized diabetics and cardiovascular patients, and compared them with the driving records of non-afflicted persons living in the same geographical area. While the diabetics had a statistically higher accident rate than the comparable population, the cardiovascular group did not, but did have statistically higher violation rates.

Puzzled by the consistent failure of Washington drivers with cardiovascular disease to exhibit higher-than-normal accident rates, Crancer and O'Neall (1969) again examined this group. By dividing the sample by the type of heart disease, it was indeed found that drivers with arteriosclerotic and hypertensive heart disease had a significantly higher accident rate than the comparison population, although drivers with other kinds of heart disease, such as rheumatic, did not have higher accident rates. These results are closer to Waller's findings for his heart disease group.

Flaws in methodology also hamper interpretation of the Washington studies. Control groups were not properly matched with experimental groups on such important variables as exposure, nor can the Waller data be compared to that of Crancer and associates with any confidence since their populations and methodologies were obviously different.

To further examine the relationship between chronic medical conditions and driving performance, Waller and Goo (1968) compared accident and violation rates as well as driving performance test scores for 1,234 drivers with chronic medical conditions and 401 control drivers. Only minor differences in types of accidents and violations were observed for each group. Interestingly, drivers with psychosocial disorders showed almost no consistency between two successive performance test scores (test-retest), whereas a moderate correlation (r = .21) between successive scores was noted for drivers with organic medical conditions or no known medical condition.

Waller and Goo (1969) again studied the kinds of crashes and violations attributed to medically impaired drivers known to the California Department of Motor Vehicles. All medical groups (epilepsy, cardiovascular disease, diabetes, alcoholism, mental illness, etc.) had greater proportions of crashes in which the subjects were believed to be completely at fault. There was an excess of single vehicle crashes, collisions with parked cars, and crashes in which the drivers were weaving, ran off the road, or were on the wrong side of the road. These findings suggest that at the time of these crashes the drivers had little or no steering control. The investigators then examined the kinds of crashes experienced by drivers with less severe illnesses. These crashes were frequently described as caused by "inattention or other poorly definable causes." Although these results suggest a connection between certain medical impairments and safe driving, they cannot be regarded as evidence of a causal relationship between medical impairment and driving problems. Waller and Goo cite electrocardiographic telemetry studies of cardiovascular disease and driving by Hoffman (1966), which suggest that "drivers with medical conditions may be relatively handicapped in coping with more complex driving tasks" (Waller and Goo, 1969), as evidence of a causal relationship.

In a more recent study of medically restricted drivers in Oklahoma (Davis et al.,1973), drivers with diabetes, epilepsy and other neurological disorders again had significantly higher accident rates than controls, matched on age and sex. Drivers with cardiovascular impairments did not differ significantly from the rest of the driving population. Again there was no control for exposure.

West et al. (1968) studied the extent of natural deaths at the wheel. Examinations were made of over a thousand California drivers who died shortly after their involvement in single vehicle crashes. These authors found that 15 percent of the accident victims died of natural causes; almost all of these died of heart disease. This study is unusual since there is generally no record made of recognized natural deaths in traffic accidents.

Baker and Spitz (1970) examined evidence of disease in fatally injured drivers from past studies and reported that natural causes have accounted for the deaths of some 15 to 25 percent of the drivers who were at fault. The researchers point out that these collisions were usually minor. This is quite different than Waller's assertion that up to 25 percent of major highway crashes are linked to medically impaired drivers. To clarify the issue, Baker and Spitz looked at the autopsy reports on all drivers in the Baltimore area who died of injuries sustained in a motor vehicle accident during a four-year period. They found no correlation between driver responsibility for the crash, and autopsy evidence of disease or physical disability. Arteriosclerotic heart disease was discovered with similar frequency in drivers at fault and drivers not at fault. Even when the autopsy revealed severe heart disease, there was no conclusive evidence of a causal relationship between the illness and the crash. The authors conclude that the restriction of driving privileges for elderly drivers, who frequently exhibit symptoms of arteriosclerosis, is not justified.

Examining the relationship of general health to fatal accident involvement, Asher and Dodson (1970) obtained data from the Project TALENT data bank (collected on a 5% sample of all U.S. high school students[19]) and isolated those students in one state who were subsequently fatally injured in traffic accidents. They found that those who were later to be killed had reported fewer allergies than their peers, but reported generally poorer health. It is possible that these findings might only be a indicator of lower socio-economic status.

Statistics on the prevalence of the various medical conditions assumed to be related to safe driving have not been particularly helpful for the prediction of high accident liability groups. Waller (1973), using estimates based on National Health Survey data, concludes that about 15 percent of the driving population may possess a medical handicap which could affect driving ability (excluding drinking problems). But, as Baker and Spitz demonstrated, there is not necessarily a causal link between the presence of a disease, even in a severe form, and fatal accident involvement.[20] However, Waller argues that even if relatively few medically impaired drivers have such severe conditions that they actually create a hazard (i.e., drivers who have seizures or other episodes of altered consciousness while behind the wheel), many drivers with health problems are still handicapped because they lack the extra capacity to respond effectively to demanding driving situations. This hypothesis has not been empirically tested.

[19] See Flanagan et al. (1964)

[20] Multidisciplinary accident investigations performed by Indiana University present preliminary evidence that medical and mental conditions (excluding alcohol) account for less than 6% of probable/definite accident causes. (Institute for Research in Public Safety, 1973.)

Mental Illness

Several studies have examined the accident and violation rates of those drivers known to have suffered from some form of mental illness. Waller's mental illness category of drivers had an accident rate of approximately twice that of the comparison group. Selzer and Payne (1962) reported that their sample (n = 60) of psychiatric inpatients with suicidal tendencies also had an accident rate two times greater than their control group. Crancer and Quiring (1968a) examined the driving records of persons hospitalized for suicide gestures, and found the suicide group had a higher accident and violation rate than a comparison group from the same geographic area. The kinds of violations from this group were predominantly of a socially deviant nature such as drunken driving, reckless driving, hit and run, negligent driving, etc. MacDonald (1964) found that the incidence of fatal accidents for drivers who had been patients at a psychiatric hospital was greater than 30 times the expected rate. He hypothesized that these were largely suicides. He supported his point by citing a study in which the risk of suicide in former mental patients in the first six months after leaving the hospital was over 30 times greater than in the general population.

Each of these studies suggest that information on mental illness should be an important consideration in driver licensing and control.

Other Handicaps

Traffic safety research has occassionally examined the driving records of drivers with orthopedic disabilities. These drivers are often noted in license files by special equipment license restrictions such as hand controls or steering knob attachments.

McFarland et al. (1968) reported that prior to their study of the driving ability of the physically handicapped there was no methodologically acceptable data concerning the accident and violation experiences of disabled drivers. Their investigation controlled for age, sex, and years of licensure in a group of disabled drivers and a non-disabled control group, although there was no control for exposure. They found that the disabled drivers had significantly lower accident and violation rates.

Similarly, Dreyer (1973) also compared driving records of physically handicapped drivers and a randomly selected non-disabled driver population. On accident criteria, he found no significant differences. However, he found that the handicapped drivers had significantly fewer convictions. Again, there were no controls for exposure.

These studies each suggest that handicapped drivers are safer than the population norm, at least on an actuarial basis. It is possible that handicapped drivers compensate for their handicaps by safer driving, although it is equally possible that they merely drive less often than the non-disabled population. In either case, the variable "physically handicapped" should be a useful predictor of lower accident liability, at least in the absence of accurate exposure data.

Hearing Deficiencies

The studies on the relationship between hearing deficiency and accident involvement have produced very inconclusive results. In one of the more extensive studies, Coppin and Peck (1964) found that deaf males had 1.8 times as many accidents as all male drivers. Deaf and non-deaf females did not differ. Other researchers have obtained contradictory results. For example, Henderson and Burg (1973) reported an inverse relationship between magnitude of hearing loss and extent of accident involvement.

As a predictor variable, for the general driving population, hearing deficiencies show limited potential. Harano et al. (1973), using subjects' self-report on hearing deficiencies, found no differences between accident repeaters and accident-free drivers (approximately 10% of the sample reported some hearing problem).

As pointed out by Henderson and Burg (1974), the use of hearing ability screening also cannot currently be justified, since driving situations in which hearing ability is critical are extremely rare, and since ambient noise (e.g., radio, tape players, road noise) can easily render normal drivers equally impaired. These authors conclude:

> Although there are undoubtedly instances in which good auditory capability provides a margin of safety perhaps denied an individual with impaired hearing, there is no analytical model available for systematically identifying these instances or evaluating their significance to driving safety. On the basis of these considerations, it is concluded that there is no justification for the screening of auditory capability in driver license applicants." (Henderson and Burg, 1974)

Although not justified for screening purposes, hearing ability may potentially be a valid indicator of increased accident liability for certain sub-populations (e.g., totally deaf), as suggested by Coppin and Peck (1964). Further research may also have additional uses, including suggestions for improvement and standardization of vehicle and highway design features, and possibly providing specialized driver training for those with auditory impairment.

Vision Testing

All state driver licensing and control agencies currently require some form of vision testing for new driver license applicants. Although it is apparent that some minimal level of visual ability is required for safe driving, there is very little conclusive evidence to support any particular "minimal level", or even to make definitive statements of the relationship of visual ability and driving performance.

Goldstein (1964) reviewed the research on vision and driving. He concluded that although numerous research studies have been conducted to identify the specific visual functions which relate to driving ability, very few have produced more than slight correlations. Burg (1964) extended Goldstein's review and concluded that ". . . at the present time there is no widely-recognized indication that vision is related to driving." The A. D. Little (1966) literature review concluded ". . . at the present time, valid information is not available on relationships between various visual impairments and accidents."

The apparent causes for the failure of most past efforts to uncover basic relationships between vision and driving performance have been summarized by Henderson and Burg (1972):

(1) Vision is only one of many factors that influence driving performance.

(2) It is possible that drivers vary in the extent to which they utilize their visual capabilities in driving.

(3) It is possible that some individuals may compensate for their visual deficiencies, for example, by avoiding night driving.

(4) Research subjects may represent a restriction in range in visual efficiency due to prior screening by licensing agencies.

(5) The visual functions which have been investigated in driving studies may not be the ones most critical for driving.

(6) The reliability and validity of the vision tests and of the criterion may be low.

(7) Many studies suffer from methodological shortcomings, for example, unrepresentative sampling of drivers.

In recent years, research on vision and driving produced more significant findings. A study by Burg (1964) found evidence suggesting that dynamic visual acuity (the ability to clearly see objects that are in motion with respect to the subject) may be positively related to driving record. He acknowledged that his sample was too small (N = 200), and the statistical significance of his results too low, to permit firm conclusions. He recommended that his study be replicated with a larger sample and closer control over age and exposure variables.

Crancer and O'Neall (1969) administered a number of visual tests to accident and accident-free drivers (N = 285) between the ages of 50 and 70, for whom visual impairment might be especially important. Their data suggest that drivers with worse driving records were more visually competent than the good drivers, on measures of static visual acuity, dynamic visual acuity, and glare vision. Henderson and Burg (1972) point out that these findings are highly questionable, because of the small sample size and the lack of adequate control for age and miles driven.

More directly related to driver licensing, Schuster (1968) found visual restrictions, in combination with other predictors (number of employers, number of non-driving accidents, prior violations and accidents, and amount of driving) to significantly predict accidents in a three-year follow-up (cross-validated $r^2 = .16$). Drivers with more visual restrictions tended to have more accidents.

The most rigorous investigation of the relationship between vision and driving performance to date is the recent study by Henderson and Burg (1974). Drawing upon the task analysis of driver behavior by McKnight (1970), and upon the relevant scientific literature on vision, these researchers analyzed the visual (and auditory) requirements of the driving task. They then selected or created tests to measure a subject's capability to meet these requirements, and developed a prototype vision testing device for this purpose. Their evaluation study consisted of administering the visual tests, as well as a questionnaire to collect biographical and driving exposure information, to a sample of voluntary license renewal applicants (N = 581) in the State of California. Small samples of "problem drivers," senior citizens, and high school staff members also were included. Accident information (prior 3 years) was extracted from official records. Mileage-adjusted accident rates were then computed using mileage estimates obtained from the questionnaires.

Consistent with the earlier findings of Crancer and O'Neall, a majority of the significant correlations between vision test scores and driving record variables indicated that poor visual performance is associated with good driving. However, these findings varied considerably by age groups. Most of the unexpected (wrong direction) correlations occurred only for the youngest drivers (ages 16-24). For the older drivers (ages 50 +), most correlations were in the expected direction.

Since the objective of this study was to obtain information for operational use in screening license applicants, and since it would not be possible to exclude an applicant because of superior vision, Henderson and Burg devoted the bulk of their analyses to those variables which predicted in the "expected" direction within age groups.

The significant correlations (with previous 3-year driving record) which were in the expected direction (i.e., with good vision scores being associated with good driving records) are presented in Table 1-22.

The vision test measures with "expected" correlations, as described by Henderson and Burg, included:

- Central Angular Movement (CAM)--the speed with which an object must be moving in a lateral direction relative to the observer, to be detected.
- Central Movement in Depth (CMD)--the ability to perceive rate-of-closure on an object under restricted visibility conditions.
- Detection, Acquisition and Interpretation (DAI)--the individual's overall ocular-motor control capability and, in part, peripheral vision.
- Static Acuity - Normal Illumination (SA-Norm)--the ability of the eye to resolve detail in a stationary object is measured by presenting to the subject a series of Landolt rings, calibrated in size to correspond, in terms of the angular subtense of the break in the circle, to the Snellen system of notation, e.g., 20/20, 20/40, etc.
- Peripheral Angular Movement (PAM)--the ability to use information derived from the peripheral field of view without directing foveal vision on the object or event, using the movement tests (both angular and in-depth).
- Field of View--a measure of field of view obtained by requiring the observer to fixate a point straight ahead, and respond to a series of short-duration lights introduced at random locations in his peripheral field.

Multiple regression analyses were also conducted to assess the contribution of the visual test scores alone, and in combination with biographical variables, to predict driving record for the different age groups. Separate regression equations for different age groups (16-24, 25-49, 50+) and total sample were computed. Among the visual measures, Central Angular Movement (CAM) appeared to be the best overall accident predictor. In most of these analyses, visual measures were found to be the strongest predictors of accidents, stronger than age, sex, or exposure. However, inferences as to the strength of visual measures relative to biographical factors should be somewhat tempered since (1) vision variables were pre-selected (those in a desired direction), and (2) homogeneous grouping (by age) restricted the range of age as well as other variables (e.g., annual mileage). Using the total sample for prediction resulted in biographical variables contributing the major share of variance for total accidents. However, using accident rate, a visual measure emerged as the most important predictor. This result, again, should be interpreted with caution since complex

TABLE 1-22. SUMMARY OF CORRELATIONAL ANALYSIS RESULTS - SIGNIFICANT CORRELATIONS IN DESIRED DIRECTION ONLY

Vision Test	Number of Accidents				Accident Rate			
	All Ages	16-24	25-49	50+	All Ages	16-24	25-49	50+
Field Extent						-.20		
DAI 40% Extent								-.14
SA - Normal Illum.							.22	
CAM - Total Correct		-.16			-.06			-.14
Threshold	.07	.34			.15	.23		.19
CMD - Total Correct								-.13
Threshold Large								.17
PAM - Total Correct				-.12				

Source: Henderson and Burg, 1974.

interactions are probably occurring. For example, mileage is correlated with age and age in turn is correlated with vision. Accident rate also contains an element of "built-in" correlation, since mileage was used to calculate accident rate.

Aside from the issue of relative strength of variables, the results were very useful for exploring potentially useful vision measures for different age groupings. A major finding was that the addition of vision variables significantly increases accident prediction for drivers over age 50. As noted by the authors, the primary limitations of the study were the relatively small samples, and the lack of cross-validation for "true prediction". As a result of the encouraging findings of this exploratory study, further refinement of the visual measures is currently underway.

Indiana University's recent multi-disciplinary accident investigation findings also suggest that the importance of vision for safe driving varies with age (Institute for Research in Public Safety, 1973). Their results indicate that "Inattention" and "Improper Lookout," both of which involve vision, became increasingly more common causes of accidents among older drivers. Researchers at Indiana University, in an attempt to integrate visual testing and accident investigation data, are currently analyzing vision data for three sub-samples based on their accident investigations: (1) accident involved, not-at-fault; (2) accident involved, at fault; and (3) drivers not involved in a previous 12-month period. Preliminary results indicate that dynamic vision, simple and complex reaction time, central angular movement, and 90° left and right field of vision discriminate among the groups.

Summarizing, it appears that the importance of visual ability for safe driving varies depending upon the age, sex, and driving experience of the driver. The study by Henderson and Burg provides the strongest evidence to date of a significant relationship between visual capability and accident rates. These authors are well aware of the limitations of their study and recommend that additional effort be expended in improving the reliability and efficiency of their vision tests and in replicating the entire study with a larger random sample.

A plan for the kind of replication suggested by Henderson and Burg has been developed by the Safety Management Institute (SMI) and the Department of Motor Vehicles, State of New York. The broad objectives of the study are: to collect highly reliable estimates of the relationship between vision tests and accident rates, and to further investigate the practical alternatives for driver licensing. Visual performance data will be obtained on large random samples of drivers to validate the measures on driving performance criteria.

The device[21] proposed for the study, will provide measures of the following visual functions:

(1) Perception of movement in depth;

(2) Perception of angular movement;

(3) Useful peripheral vision;

(4) Saccadic pursuit and steady fixation;

(5) Static acuity; and

(6) Dynamic visual acuity.

The proposed study appears to be well-conceived and hopefully will provide some definitive data on the relationship between visual performance capabilities and driving behavior. If successful, this information should have direct practical value in the screening of driver license applicants.

Discussion of Medical/Physiological Variables

Most research studies on medical and physiological factors, particularly those we discussed under chronic and mental illness, are characterized by abnormally high accident rates for the impaired driving population. However, methodological deficiencies have often biased the results. Samples have usually been drawn from groups with known medical impairments. These drivers had already been classified by the licensing authorities as candidates for medically restricted licenses. In a few studies, their illnesses were so severe that the subjects were hospitalized at the time. In order for a driver to be known to a state licensing agency as medically impaired, he must: (a) report the condition himself; (b) have been reported to the authorities by his physician, family, friends, or employer; (c) have come to the attention of the authorities through a previous accident or violation, revealing the illness; or (d) have been detected by the license examiner. It seems safe to assume that the group of drivers known to the licensing agency would be weighted in the direction of increased severity of illness.

There is only meager evidence directly linking medical factors to accident involvement. Waller (1965) reported that episodes of the

[21] The prototype vision device used by Henderson and Burg is currently being refined by Honeywell Corporation under contract to the Department of Transportation, NHTSA (Mark II Integrated Vision Testing Service).

medical conditions contributed to less than 20 percent of the accidents in which drivers with each diagnosis were involved. More recently, Waller (1973) estimates between 15 and 25 percent of major highway crashes can be attributed to drivers with health problems other than drinking.

Mental illnesses have generally been strongly associated with accident involvement. Other physical handicaps (amputees, etc.) are associated with safer driving. The findings concerning hearing deficiencies have been inconclusive, but suggest little relationship with driving, except for the most extreme cases.

Vision testing also demonstrates only slight diagnostic potential. Poor vision seems to increase per-mile accident rates only for the older drivers. Since these individuals drive very few miles, and thus constitute a relatively small proportion of the number of total accidents, any diagnosis of their problems can have only a very slight impact.

In conclusion, the lack of predictive validity of medical assessment techniques at the present time should preclude expensive driver screening programs in the licensing setting, since there is only fragmentary knowledge of the potential benefit of these techniques. Until there is more objective statistical confirmation of the relationship of illness to accident causation, additions to current driver licensing procedures seem unwarranted. A possible exception might be a psychiatric examination of drivers with reported mental illness. Even this possibility will require further research to determine predictive validity.

More than ten years ago Malfetti (1963) posed these questions: What is the risk of licensing a medically impaired driver? Should a person be prevented from driving because he _might_ fail, when in his driving career, he might _never_ fail? Today his words are still apt.

> "We should not abandon present standards until we find better ones, but we should devote a greater portion of our energies to seeking more valid standards than to supporting the application of standards of questionable validity more often and more vigorously."
> (Malfetti, 1963)

EXPOSURE VARIABLES

Studies of accident prediction invariably point out the need to control for the degree to which an individual driver is exposed to the hazards of driving. Since this problem of controlling for "exposure to risk" can affect conclusions about all other aspects of diagnostic assessment, it is an issue which must be addressed by any attempt to evaluate accident liability.

Statistical reports of driving behavior which are uncontrolled for exposure can be very misleading. Such reports would, for instance, show that elderly drivers are extremely safe drivers. After controlling for exposure (elderly drivers average very few vehicle miles), on a per-mile basis, they are relatively high accident risks.[22] Such data misinterpretation must be avoided when data are used to identify problems or evaluate changes (Carroll, 1971).[23]

We shall use Carroll's (1971) proposed definition of exposure as "the frequency of traffic events which create a risk of an accident." This definition would encompass current measures of exposure, such as number of vehicle miles, but allows for the increasingly apparent probability that some vehicle miles are more dangerous than others.

There are several variables available from Level I sources which are at least indirectly related to driving exposure. For example, in states which employ classified licenses for different groups of drivers, the professional driver classes usually have much greater driving exposure than the general population, which at least partially accounts for these groups' higher accident and conviction rates. Accidents and conviction expectancies also vary by location of residence, and by local traffic density (i.e., number of motor vehicle registrations per mile of road). A number of other environmental factors such as enforcement and court procedures interact to produce differential conviction and accident rates.

Wide variation on any of these factors would have important

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22 See Harrington and McBride (1970) or Cerrelli (1972) for mileage adjustments of elderly drivers.

23 There are, however, several uses for non-exposure-controlled data. Uncontrolled summary statistics reflect the total magnitude of the problem, which is useful for administrators, particularly for allocation of resources. Secondly, controlling only for number of drivers gives the degree of risk per driver, which is useful for actuarial purposes. (An elderly driver may be a very high per mile risk, yet a very low insurance risk if he drives few miles).

implications for individual driver assessment systems. For instance, diagnostic systems based on average group performance for a total state may not be appropriate for specific regions or locations within a state. Individuals with similar driving records but from two different regions may represent two entirely different profiles, if convictions are rare in one jurisdiction, and extremely frequent in another. Any biases peculiar to the variables used to assess the individual must be considered. In fact, there is some evidence to suggest that location of accident or conviction (as indirect measures of traffic density) and enforcement factors far outweigh individual characteristics as predictors of future performance. (See Williams, 1974). This section will discuss the relative importance of these exposure variables in the driver assessment system.

All of the exposure variables obtainable from Level I are indirect measures. That is, none directly assess the quantity or quality (degree of hazard) of miles driven by the individual. Most are group estimates or indicators. Others are merely statistical or research techniques which can minimize group exposure differences.

VEHICLE MILEAGE AS EXPOSURE

Mileage data provide only a gross estimate of the quantitative degree to which a driver is "at-risk". They do not reflect qualitative differences of risk, such as traffic density, frequency of road-design safety defects, or transitory hazardous conditions such as darkness or bad weather. Despite this lack of qualitative measurement, mileage data are useful measures of exposure-to-risk, as well as predictors of accident risk. The most accurate individual mileage estimates must be obtained by direct measurement of the driver. These will be discussed in Chapter 3.

For driver record level purposes, exposure could be approximated by gross statistical mileage estimates for classes of drivers. For example, a driver improvement assessor might consult a table of mileage estimates such as the one presented in Table 1-23, from Burg (1967). These data show fairly dramatic mileage differences for age and sex groups of drivers. The predictive validity of such figures could be readily validated in an operational setting.

CLASS OF LICENSE

Many states have adopted various forms of classified drivers license, which might specify the type of vehicle a driver may operate. Specialized testing procedures might be required for operation of a motorcycle, commercial vehicle (levels often depending on size and weight), or emergency vehicle. While such license classes primarily reflect occupational groups (e.g., truck drivers) and are therefore indicators of socio-economic status, they are also useful Level I exposure measures,

TABLE 1-23. SAMPLE MILEAGE BY AGE AND SEX

AGE	SEX	AVERAGE ANNUAL MILEAGE
16-19	M F	8681.0 5151.5
20-24	M F	17305.5 7272.5
25-29	M F	19632.7 7301.5
30-34	M F	20809.9 7571.7
35-39	M F	21087.3 7217.5
40-44	M F	19965.2 7695.2
45-49	M F	19728.9 7490.2
50-54	M F	17715.9 7593.7
55-59	M F	16563.7 6623.9
60-64	M F	14057.7 6623.8
65-69	M F	10831.3 5728.1
70-74	M F	8523.9 5809.9
75-79	M F	6120.1 4146.7
80+over	M F	6485.2 3850.0
ALL	M F	17107.5 7011.2
ALL	Both	13370.8

Source: Burg (1967).

since they identify certain high mileage groups of drivers.

Numerous studies show that professional drivers are usually over-represented in groups of habitual accident offenders. Goodson (1972) compared high-accident drivers with randomly selected controls, and found that drivers with licenses designated "Public Passenger Chauffeur", a professional driver category, comprised only 1.8% of the control group, but 18.1% of the highest accident group ($\geq$ 8 accidents in 5 years). These differences, of course, reflect socio-economic characteristics of the samples, as well as exposure differences.

Many states now have a special license class for motorcycle operators. Motorcycle drivers have consistently proven to have higher accident and violation rates. The California Motorcycle Study (Harano and Peck, 1968) isolated motorcycle operators from vehicle registration files and found these drivers had almost twice as many accidents and convictions per year as did a general driver sample. After controlling for mileage as estimated by the driver, accident and conviction rates for the motorcycle drivers fell to about 5% higher than the general population. In addition, motorcycle accidents tended to be more severe, and more frequently fatal. These findings are partially a function of age, since motorcycle owners tended to be younger. The results may also reflect psychological factors, such as attitudes toward "risk-taking" among younger drivers. Nevertheless, these results indicate that motorcycle ownership is a useful measure of accident liability, possibly a measure of exposure to risk.

MOTOR VEHICLE OWNERSHIP

Motor vehicle registration files are usually available in a driver licensing agency. Since drivers who own motor vehicles might be expected to drive more often than those who do not, motor vehicle ownership might be a useful predictor.

Schuman et al. (1967) interviewed young drivers (ages 16-24) and found that those who reported owning their own car also reported a much higher accident rate. In a later study, Pelz and Schuman (1971b) did not find car ownership to correlate for any sub-populations except older females. Interestingly, older females (35-44) who owned a car had fewer crashes. For young drivers, Harrington (1971) found that those with poorer records tended to have their own car at an earlier age, and more often had new cars. For males the correlations for violations and collisions with car ownership were .18 and .08, and for females, .09 for both violations and collisions. In a sub-analysis comparing accident-free and accident-repeating males, he found that accident repeaters had more "speed accessories" (r = .16) and "custom accessories" (r = .21) on the car. Ingersoll (1970) also found that younger drivers involved in accidents tended to own older cars.

However, several factors may have been masked by these studies. Different sub-populations of young drivers may have increased accident liability for different reasons. Young school drop-outs may have increased exposure, if they are working, than do enrolled students. A sub-population of higher socio-economic status young drivers may have resources to purchase newer cars and accessories. Or the converse, lower socio-economic groups may place a high value on the ownership of a new car, and purchase one regardless of financial resources. Thus, further analysis is needed to more fully interpret these results.

AREA OF RESIDENCE

Other variables contained in a driver license file may be useful for predicting accidents and convictions. Area of residence (i.e., county code or address) may reflect differential exposure resulting from environmental conditions, enforcement policies, or traffic density.

Several research studies have examined driving records by population of the driver's area of residence. McGuire (1969,1972) examined the driving histories of young enlisted airmen and found slightly significant correlations between the driver's estimate of the population of the area in which he had lived most of his life, and the number of accidents he reported. However, upon cross-validation, the correlation became non-significant. This finding may be explained by the fact that his subjects were currently living away from home, some for longer periods than others.

Goodson (1972), studying recidivism among one year, high-accident drivers, noted that "high-accident drivers are likely to be residents of large urban areas." One finding was that while 13.2% of the random control group resided in Indianapolis, 29.1% of the highest ($\geq$ 8 accidents in 5 years) accident group resided there. This study did not, however, apply any correlational or predictive statistical technique to determine the operational utility of residence as a predictor. In addition, this finding, when viewed in light of Goodson's other finding that high accident drivers tend to have less severe accidents, may simply indicate that minor accidents are more frequently reported in large urban areas. Nonetheless, population of area of residence must be considered a potentially useful variable in the interpretation of accident data.

Estimates of local traffic density might be more related to driving performance. Peck, McBride & Coppin (1971) found that traffic density, as defined by the number of vehicle registrations divided by the number of linear miles in a county, was a useful predictor of accidents and convictions for a random sample of state drivers. For males, three-year concurrent correlations for accidents and convictions were .09 and .10 respectively. For females, the correlations with accidents and convictions were .08 and .09. All correlations were significant at the $P < .05$. Non-concurrent one-year predictions were slightly lower. Harrington (1971) found similar results when correlating the same measures with four-year accidents for young drivers. Traffic density correlated .10 and .07 for males and females.

Similar to traffic density, local conviction and accident rates might reflect degree of hazard in the driving environment. In part, they are related to traffic density but also reflect enforcement policies (primarily convictions), environmental conditions, and level of reporting (both accidents and convictions). Harano (1974) reported that area conviction and collision rates for individuals in the study significantly predicted future collisions, but not convictions. However, the correlations were in an unexpected direction. Area conviction rates correlated negatively with total collisions (-.076), and with injury related collisions (-.10). Area collision rate did not significantly correlate with total collisions, but did correlate with collisions reported to State Police (injury and fatal accidents) (-.057). In contrast, another follow-up study of drivers who attended driver improvement meetings (Marsh & Hubert, 1974) found county of residence to predict accident and convictions, but the relationships were small (less than .07). Harrington (1971) also found county of residence to be a significant predictor of accidents in a follow-up study of young drivers, but the relationships were also small.

Finally, it should be noted that measurements of local conditions may reflect only socio-economic factors. However, the studies to date of driving record and local socio-economic level have produced very inconclusive results.

Levonian and Case (1961) found that students (mostly aged 15) from higher socio-economic geographical areas were significantly more cautious (questionnaire variable). These drivers also had about one-third as many penal code violations. Students from both areas had similar traffic violation records, probably because most of these students had little driving experience.

Census data reflecting socio-economic levels were employed by Baker (1970) in a study of one city's fatal accident victims. Although the subjects from the highest socio-economic area had the lowest percent at-fault for their accident, most other results were less conclusive. The author notes that "each census tract contains individuals of almost all economic levels; therefore, one cannot assume that drivers in the study who lived in the lowest-fifth tracts were necessarily among the lowest fifth of the city's population." Such socio-economic census data might prove more useful, however, when not limited to a single urban area.

In summary, variables which describe local conditions in the driver's area of residence appear to have some utility in driver assessment. Strongest relationships have been found with those variables which directly relate to driving, such as local traffic density, and local accident and conviction rates. The non-traffic factors, local population, and local socio-economic level, appear less useful.

CONTROLLING EXPOSURE BY DATA REPORTING WITHIN GROUPS ONLY

One statistical approach to exposure control which is frequently employed in traffic safety research is the technique of performing comparisons within groups. For example, it is usually difficult to make meaningful comparisons between male and female driving records, since these groups are known to differ markedly on driving exposure. However, a within group comparison, such as Harrington's (1971) finding that 58% of male drivers were "at fault" in the accidents in which they were involved, compared to only 47% at fault for females, are less biased by exposure.

It is important to note the assumptions on which this method is based. One is that the drivers within each group are relatively homogeneous with respect to both amount of driving and frequency of hazards. This is not necessarily the case with either "young drivers" or "male drivers", since both age and sex strongly interact with exposure. Greater homogeneity of exposure might be found in "young male drivers," since reduction in exposure variance is generally proportional to specificity of groups. A second and independent assumption is that the variable on which groups are compared is unrelated to exposure. Regardless of within-group variation on exposure, if the driver-problem variable (e.g., culpability per accident) is correlated with exposure, then comparisons by this variable will not be adequately exposure-controlled. For example, since "number of speeding citations" is positively correlated with "amount of driving", group comparisons on percent of drivers with speeding citations are not valid reflections of each group's speeding rates. In many cases, however, this approach is useful for research purposes in reporting numerous types of qualitative accident and conviction differences where exposure data are not available. Baker (1970), Harrington (1971), and Perchonok (1972) have used it to assess such diverse qualities as percent culpability, percent single vehicle, percent alcohol involvement, and percent of various violation types.

ROADBLOCK CONTROL STUDIES

Roadblock controls provide an accurate (although expensive) technique of exposure control for research purposes. By using police roadblocks, a variety of data can be collected on drivers who pass by the location where accidents have occurred, at the same times and days of the week at which the accidents happened. This method effectively creates an exposure-matched control group with which to compare the accident involved sample on driving records, biographical variables, BAC's, etc. The method has been employed by many other investigators with generally favorable results.

At the present time, roadblock control groups are the best available means of exposure control for research purposes and traffic flow analysis. The method does not, of course, provide any individual exposure data for all drivers. However, group exposure estimates obtained in this manner could be employed in a licensing agency.

DISCUSSION

Both accidents and convictions are, to a certain extent, functions of the amount and difficulty of the highway exposure which a driver encounters. As amount of driving increases, so does the likelihood of driver errors. Consequently, to evaluate driver performance at the individual level, amount of exposure must be taken into account.

None of the presently available Level I exposure techniques provide this accurate degree of information on an individual basis. Class of license and area of residence are potentially useful individual predictors. Some representative research findings are presented in Table 1-24. The group exposure control methods are useful for research and administrative purposes, but have limited use for individual measurement. The qualitative aspects of exposure are particularly poorly measured at Level I. The best Level I exposure variable is apparently class of license, which at least partially reflects both the quantitative and qualitative aspects of exposure (as well as reflecting social and occupational factors).

Some alternatives for improvement of exposure measurement are discussed in Chapter 3. Hopefully, if the quality of exposure assessment can be improved, better measures of degree of risk-per-mile can be included in the records of driver licensing agencies.

Table 1-24. Selected Studies Using Exposure as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions: Type	r	p	Sample Size	Validity: Accidents: Type	r	p	Sample Size
Goodson (1972)	Licensing and Accident Records	Assessed 4 year follow-up accident records for drivers with 3 or more accidents in same year. Random Controls. (Contrasted Sample)	Percent of drivers within group holding Operator Class License					≥8 Accident Group (5 Yr)	58.3%	NR	127
								6-7 Accident Group	67.0%	NR	288
								5 Accident Group	70.9%	NR	361
								Control Group	90.5%	NR	326
			Percent of drivers within group holding Chauffeur Class License					≥8 Accident Group (5 Yr)	23.6%	NR	127
								6-7 Accident Group	26.0%	NR	288
								5 Accident Group	24.7%	NR	361
								Control Group	7.7%	NR	326
			Percent of drivers within group holding Public Passenger Chauffer Class License					≥8 Accident Group (5 Yr)	18.1%	NR	127
								6-7 Accident Group	7.0%	NR	288
								5 Accident Group	4.4%	NR	361
								Control Group	1.8%	NR	327
Harano (1974)	Driver Records	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (Cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Class 1 and 2 license (1=yes, 0=no) Chauffer/ Commercial Vehicles	Total Convictions (Subsequent 1 Yr)	.024	NS	850	Total Collisions (Subsequent 1 Yr)	.012	NS	850
Harrington (1971)	Mailed Survey Questionnaire Driver Record	Surveyed young drivers four years after licensing at ages 16-17. (Random sample)	Annual Mileage					Total accident 1-4 yrs Male Female	 .087 .105	 .05 .05	 4,928 4,329
			Traffic Density					Male Female	.030 .072	.05 .05	4,928 4,329
Harano, McBride, & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ acc: n=196 0 acc: n=231	Traffic density (within county)					Group Membership. (0/3+ acc. in three yr. period)	.02	NS	427

Continued

NR Not Reported
NS Not Significant
r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
p Probability of significance (* has been dropped)

Table 1-24. Selected Studies Using Exposure as an Assessment Variable *(Cont.)*

				Validity							
				Convictions				Accidents			
Study	Type of Instrument	Sample Description and Method	Variables	Type	r	P	Sample Size	Type	r	P	Sample Size
Peck, McBride, and Coppin (1971)	Driver Records	Reviewed Records of a 2% random sample of California Drivers	Traffic density (3 yr concurrent)	Total Convictions Males Females	 .099 .086	 .01 .01	 26,726 61,280	Total accidents Males Females	 .089 .079	 .01 .01	 42,228 30,673
			Traffic density (1 yr non-concurrent)	Traffic Convictions in 1963 Males Females	 .082 .072	 .01 .01	 86,726 61,280	Accidents in 1963 Males Females	 .030 .044	 .01 .01	 42,228 30,673

NR Not Reported
NS - Not Significant

r Correlation coefficient (Product moment unless otherwise specified. Occasionally mean values reported in r column)
P - Probability of significance (% has been dropped)

SUMMARY OF CHAPTER 1

DRIVER PERFORMANCE AND ABILITY

Driver record performance measures include traffic convictions, accidents, knowledge and performance testing, and driver improvement actions. Numerous studies have consistently demonstrated that prior accidents and particularly convictions are useful predictors of accident liability. Although specific types of convictions (a measure of particular driver errors) do not substantially increase prediction of accident liability, these measures are useful for diagnosing particular problems, such as recognition, risk-taking or alcohol.

Knowledge and performance testing may be useful for screening drivers with extremely poor performance, but have yet to demonstrate substantial predictive utility. Several methodological and practical issues (such as drivers eventually become licensed after several attempts) have rendered research results inconclusive.

Driver improvement actions and sanctions were found to be of some utility for predicting future accident liability. These variables are primarily a measure of an individual's prior accidents and convictions, but also may reflect the effectiveness of treatment (e.g., attendance at a traffic school may reduce future liability). As more vigorous evaluations of treatment programs are conducted, past attendance at such a program should become an increasingly useful assessment variable.

HUMAN CONDITIONS AND STATES

Age, sex and marital status have consistently been shown to be strong predictors of accident liability. Although these biographical variables offer little to directly identify a driver's problem, they are useful for administrative purposes to isolate high accident liability classes of drivers. For each of these groups, more refined assessment approaches (many found at Level III) can then provide insight into the specific problems which produce accident involvement. Other biographical variables, sometimes available from Level I sources, include the driver's race, height, and weight. Completion of a driver education course can also sometimes be determined. None of these variables currently appear to have diagnostic utility. Race and driver education, in particular, are frequently related to socio-economic status, which can be more specifically assessed using variables found in Level III.

Specific psychological, social or attitude measures seldom appear in Level I sources. Vehicle descriptions (e.g., weight, model, year) from registration files may reflect psychological factors, since certain individual characteristics may be associated with the ownership of particular types of automobiles (e.g., high-risk drivers may tend to purchase high performance vehicles). The research evidence, however, demonstrates only a slight relationship between vehicle type and accident liability. In addition, it is possible that these slight relationships only reflect socio-economic status.

Medical and physiological information often has high face validity for diagnostic purposes, but research studies have seldom produced results to substantiate this assumption. The research area is complicated by ethical limitations on reporting (e.g., confidentiality), inability to obtain adequate exposure information, and possibly, the confounding influence of individual compensating factors. Research results do suggest, however, that extremely deficient drivers (mentally ill, chronically ill, and hearing or vision-impaired) have increased accident liability, although these sub-populations are very small in relation to the general population.

Vision testing, especially with recent developments (increasing the measurement dimensions), appears to have potential for general diagnostic assessment, primarily for screening older drivers. However, since older drivers are involved in relatively few accidents, the potential for reduction of the total accident problem by vision testing is slight.

Diagnosis of extreme cases of mental illness may also have some potential for accident reduction. However, as with other medical conditions, the population identified would be rather small. In addition, except for information received from other sources, the cost for extensive individual diagnosis in a licensing setting does not appear to be warranted.

EXPOSURE VARIABLES

Level I exposure information is also of little utility, since most is based on group rather than individual data. The most useful variable appears to be class of license, which can indicate excessive mileage among the professional driver groups. It may also merely reflect occupational and socio-economic factors. Ownership of a motor vehicle might also indicate higher mileage. Most of the remaining variables are group estimates.

CONCLUSIONS

Thus, all the Level I exposure variables appear more useful for research and administrative purposes than for individual diagnostic assessment.

The overall accident liability prediction which can be obtained solely with Level I variables has been shown by Finkelstein & McGuire (1971). Using the method of grouping data into cells prior to regression analysis (see Freund, 1971), which increases reliability of regression results for rare event criteria, these authors employed driving record variables of 111,235 drivers, during a one-year period (1967) to predict subsequent one-year accident liability (1968). Table 1-25 presents the variables which they found to be significant.

The multiple R of their regression model was found to be 0.31, predicting future accident liability. The authors conclude that this prediction is twice as accurate as California's present point system, and uses only variables which are currently available in the driver records.

In relation to other sources of driver assessment variables, the driver record varibles are especially useful. Multiple regression studies using data from all levels of observation (I, II, III) consistently demonstrate that Level I sources have the highest practical utility for predicting gross accident liability. However, these variables have limited potential for diagnosing the specific individual problems which lead to accident liability. The sources described in subsequent chapters will provide much of the detail necessary to make such assessments.

TABLE 1-25. SIGNIFICANT DRIVER RECORD PREDICTORS

DRIVER PERFORMANCE	BIOGRAPHICAL	MEDICAL/ PHYSIOLOGICAL	EXPOSURE
Convictions Class License Drunk Driving Prior Accidents Negligent Operator (4+ points) Sanctions/Treatments: Fines Jail Traffic School Suspension and Revocation Hearing	Age Sex Marital Status	License Restrictions	Law Enforcement Code County Accident Rate Group

Source: Finkelstein and McGuire (1971)

Chapter 2

INFORMATION FROM SECONDARY SOURCES (OTHER AGENCIES)

Level II data sources are defined as the records and files of any non-driver licensing agencies which collect information on individuals, either for administrative purposes or for diagnosis and treatment of a problem. The Level II sources which are potentially useful for driver problem diagnosis may include agencies dealing with mental health, rehabilitation, alcoholism, or public health, educational institutions, and enforcement agencies. Many of these agencies have extremely detailed information on an individual or on incidents in which the individual has been involved. The utilization of information already available for problem driver assessment has strong appeal for practical and economic reasons. The use of data from existing agency records may reduce the expense of collecting additional data in another operating agency, and could eliminate overlapping or redundant treatment. In addition, problems detected and treated by one agency may reduce the potential for problems in other social areas. For example, an individual identified and treated for a drinking problem by an alcoholism treatment agency may require no further treatment in relation to motor vehicle operation. Coordination of treatment and knowledge of the problem by two independent agencies may improve the overall effect of each.

In some cases this level of coordination among agencies has been achieved. In a few instances, reports to motor vehicle agencies are even required by law. (For example, physicians and health agencies in many states are required to submit a report to motor vehicle agencies whenever a condition is diagnosed which can adversely affect motor coordination, such as epilepsy.) However, the assumption that Level II data would be more difficult to obtain than Level I data, but less difficult to obtain than Level III (direct assessment) has been found to be an oversimplification of the current state of the art. With few exceptions, this conceptual organization represents an idealized view of sources of potential information since data, especially from Level II sources, may for several reasons be difficult to obtain.

Foremost among the obstacles in utilization of information from other agencies is individual protection, including confidentiality of information, as well as the individual's right to privacy. Confidentiality is both an ethical and a practical issue. Many social agencies must be able to assure clients that data will not be distributed throughout other agencies, regardless of intent. The right to privacy is also becoming a legal issue. Several laws now specify the conditions under which certain data can be classified and stored for retrieval. In an analysis of current data systems, Turn (1974) addressed several of the issues surrounding confidentiality of data and protection of individual rights. Briefly, agency data can be classified by degree of "sensitivity," or, the extent to which the disclosure of information could adversely affect the individual. Table 2-1 provides an illustration of these sensitivity levels. Although laws differ widely among states, Turn (1974) concludes that:

> "...in general patient-physician and client-lawyer communications are held immune from subpoena. Other information that is granted statutory protection in various states includes drug abuse, alcoholism, and venereal disease records; information on victims of sex crimes; adoption proceedings, and illegitimacy records."

In the area of research, ethical issues and guidelines for research are provided by research associations (e.g., American Psychological Association), but there is no statutory protection for the individual, and "often the promises of confidentiality have no substance." (Turn, 1974)[1]

In addition to the legal and ethical issues governing dissemination of personal information, driver research using Level II data has been hampered by the nature of the available data files. There is often a lack of standardization (e.g., incompatible data systems, methods of data collection, instruments). Files are also seldom centralized, so that the records of many agencies must often be examined. Further, agencies (e.g., hospitals, other treatment agencies) are frequently unable to search their files to quickly locate the file of an individual driver.

Finally, parallel social agencies may have widely differing goals, which may preclude their requesting or obtaining information. For example, the overlap in function among public health, mental health, social control (enforcement), and driver control agencies is seldom realized. Any combination of these agencies might become involved in a particular problem, yet cooperation, or even recognition of common problems, is seldom realized except in cases of extreme emergency.

For all of these reasons, research findings using Level II data sources are very rare. Even in the few instances where information found at Level II has been utilized for research purposes, these data are generally used to isolate study populations, rather than to provide predictive variables. For example, samples of alcoholics are often identified from social agency records to allow comparison on various characteristics (e.g., driving records) between alcoholic and control

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[1] For a detailed discussion on classification of data systems and legal issues, see Turn, Privacy and Security in Personal Information Databank Systems, March, 1974.

TABLE 2-1. ILLUSTRATIVE SENSITIVITY SCALE FOR PERSONAL INFORMATION

Sensitivity Level	Potentially Adverse Effect on Subject	Revealed To	Examples Information Revealed
5	Physical safety and well-being	Community Associates	Subject is an undercover agent of an investigative agency
	(Not applicable)	Subject	Subject is under investigation for a criminal offense
4	Physical liberty, right to refrain from self-incrimination	Authorities	Self-reported information anti-social or illegal activities
	Mental and physical health and well-being	Subject	Psychiatric evaluations
3	Economic security and opportunities, employment, self-advancement	Employer Agencies involved	Lapses of self-control, medical and psychiatric records, criminal history
	Family life	Family	Illicit affairs, sexual deviations
	Devotion to family, domestic virtues	Subject	Evaluative statements by family member
2	Reputation, respectability, recognition, acceptance	Friends Associates Community	Information on political views, anti-social behavior, criminal history, evaluative statements by subject, finances
	Self-respect, strength of character, competence, loyalty	Subject	Evaluative statements by others
1	Solitude, privacy, friendship, tolerance	Community Associates Subject	Remarks made in private, publicly available information not widely disseminated, information on preferences, property, leisure activities
0	No applicable adverse effects, annoyance	Anyone	Widely published and available factual statements

Source: Turn (1974)

groups. In contrast, using information in a predictive mode might provide more useful results, but has seldom been done.[2]

Chapter 2 was originally intended to provide a description of current assessment potential, but the scarcity of research using Level II data in an assessment mode has necessitated an approach which will describe what has been done in the area and identify gaps in research. Since all Level II data were originally collected by other agencies using Level III techniques, the distinction between the two levels is primarily one of location and reliability of data. As agency goals become more integrated and overlap among agencies is reduced (i.e. one agency would deal with all alcohol problems rather than several agencies), the utility of Level II sources may increase. The dissemination of agency information will remain an issue, however, since the protection of individual rights within the Constitutional framework must be weighed against the potential gain to society.

[2] Using Level II data predictively might involve selecting a sample, searching the files of all appropriate agencies for any useful variables, and using these to predict subsequent liability.

The principal Level II sources of data on driver performance are insurance agency files and police accident and conviction reports. Insurance agencies collect accident information, but aside from reports of witnesses, their primary sources are police accident reports. Cost data from insurance reports should provide especially accurate estimates of the societal costs of accidents, but for research purposes, insurance reports are subject to several problems, such as lack of accessibility (many agencies maintain separate files), and legal issues (confidentiality). Therefore, the following discussion will be directed toward data available from police agencies.

While summary data on accidents and convictions are usually available in individual driving records, more detailed descriptions can be found in the original accident and conviction reports, as completed by the investigating officer. Since these original reports are filed by enforcement agencies, and thus are often less easily available to the licensing agency, they are included here as Level II data. Citations issued for detected driving errors may be more useful than court abstracts (convictions) because they often contain more information (e.g., speed deviation, BAC level) and are not subject to distortions in the judicial system (e.g., plea-bargaining).

As mentioned in Chapter 1, the criterion measures usually employed in accident liability prediction seldom attempt to reflect the societal costs of the accidents involved. When a driver can be predicted to have an extremely high accident probability, then the likelihood of a multi-fatality vs. minor accident should determine the appropriate countermeasure. Total accident cost, rather than accident frequency, must be predicted. In addition, driving criterion measures for diagnostic assessment should reflect, as accurately as possible, the types of driving errors that occur, so that more appropriate countermeasures can be assigned.

At present the best available source for accident severity data and driver error description is the police accident report. An example of information contained in accident reports is provided in Table 2-2. There are usually narrative descriptions and diagrams for further analysis accompanying the coded values on an accident report.

Extensive efforts have been made to implement uniform reporting procedures throughout the states. Although some variation exists, there are several elements that are common to all states. Standardized collection, reporting and storage requirements have been established by the U.S. Department of Transportation's Design Manual for State Traffic Records Systems: Standard Data Elements and Coding (1973). The full potential

TABLE 2-2. DATA ELEMENTS CONTAINED IN POLICE ACCIDENT REPORTS

- LOCATION AND ACCIDENT DESCRIPTION
  - State
  - County
  - Date
  - Hour of Day
  - Light Conditions
  - Roadside Environment
  - Accident Location and Number of Lanes
  - Vehicles and Persons Involved in Accident
  - Number Injured
  - Number Fatalities
  - Vehicle Identification
  - Highway Class
  - Road Type
  - Road Surface
  - Traffic Controls
  - Type of Vehicle
  - Vehicle Make, Model, Year
  - Vehicle Mileage
  - Vehicle Damage (parts affected)
  - Vehicle Damage (cost to repair)

- DRIVER CHARACTERISTICS
  - Age
  - Sex
  - License Classification
  - Prior Training
  - Years Experience
  - Condition of Driver (physical, mental, sobriety)

- ENVIRONMENTAL EVENTS
  - Obstructions
  - Roadway Design
  - Weather Conditions
  - Signals Obscured

- VEHICLE CONDITIONS--For Example--
  - Mechanical
  - Brakes
  - Wheel Troubles
  - Tire Blowouts
  - Exhaust Troubles

- PHASE OF OPERATION--For Example--Turning, Changing Lanes, Parked or Stopped, Backing Up

- UNSAFE ACTS BY DRIVER--For Example--Failure to Observe Traffic Controls, Unsafe Turn, Excessive Speed, Unsafe Overtaking or Passing, Insufficient Attention

- SPECIFIC REPORTED VIOLATION(S)

- DESCRIPTION OF INJURIES

Source: U.S. Department of Transportation (1973) of accident reports as a source of data for research is just beginning to be realized. Indiana University is currently analyzing a combination of general accident reports and additional data obtained from multidisciplinary accident investigation teams.[2a] Analyses of these data are extremely useful for identifying accident causal factors, and addressing the relationship of the environment, the vehicle, and the man. How does the collection of such detailed information relate to individual diagnostic assessment? The results of such research help identify types of driver errors and relate these types of errors to individual driver characteristics. Not only does this research help place accident causal factors in perspective (e.g., environment, vehicle, or man) but they provide direction for assessing priority areas for future individual assessment and treatment. The following discussion on performance measures will examine the results of research using primarily accident reports. The results will be related to the principal driving errors of alcohol, recognition and risk-taking.

ALCOHOL-RELATED ERRORS

From the secondary sources--police citations and accident reports--more specific information concerning blood alcohol concentration (BAC) is usually available. Such data is occasionally, but not routinely, contained in the individual driver's license file, especially in jurisdictions where license files are automated. Using BAC information, a much more accurate description can be made of the total alcohol problem, as well as the individual driver's alcohol problem, than would be possible if only Level I conviction data were used.

The principal means by which individuals arrive at the treatment situation is the evidence of blood alcohol concentration. In fact, 49 of the 50 states have currently adopted legislation which establishes a legal definition of intoxication (presumptive limit) based on BAC. Also, many jurisdictions in the United States include BAC's as supplemental evidence of an alcohol-related problem in an eclectic approach to *post hoc* diagnosis. Other measures include a review of driving records, and psychometric instruments.

There are, however, methodological problems which cloud the issue of BAC diagnosis. The controversy surrounding BAC and the discrepancies found between breath and blood analyses of BAC's are well described in a comprehensive summary of chemical testing by Mason and Dubowski (1974). These researchers have determined that, given current technological expertise, better and more reliable analyses are feasible. Improvements both in testing methodology and statutory definitions of levels of impairment should be forthcoming. They conclude that a BAC of 0.10%

[2a] Institute for Research in Public Safety, 1973.

W/V is an acceptable "universal limit" for impairment.[3] Hurst (1974) reported anomalies regarding BAC, which include the involvement of drivers in certain kinds of violations and crashes but not in others, and the consistent decrease in relative crash probability at higher BAC's by previous drinking experience. There is also misunderstanding concerning the "problem drinker." Many research studies have been based on such assumptions as:

> "In order to deal effectively with drinking drivers convicted of Driving While Intoxicated (DWI) or related offenses, it has been clearly recognized that it is necessary to differentiate between problem drinkers and social drinkers in a court setting." (Filkins et al., 1973)

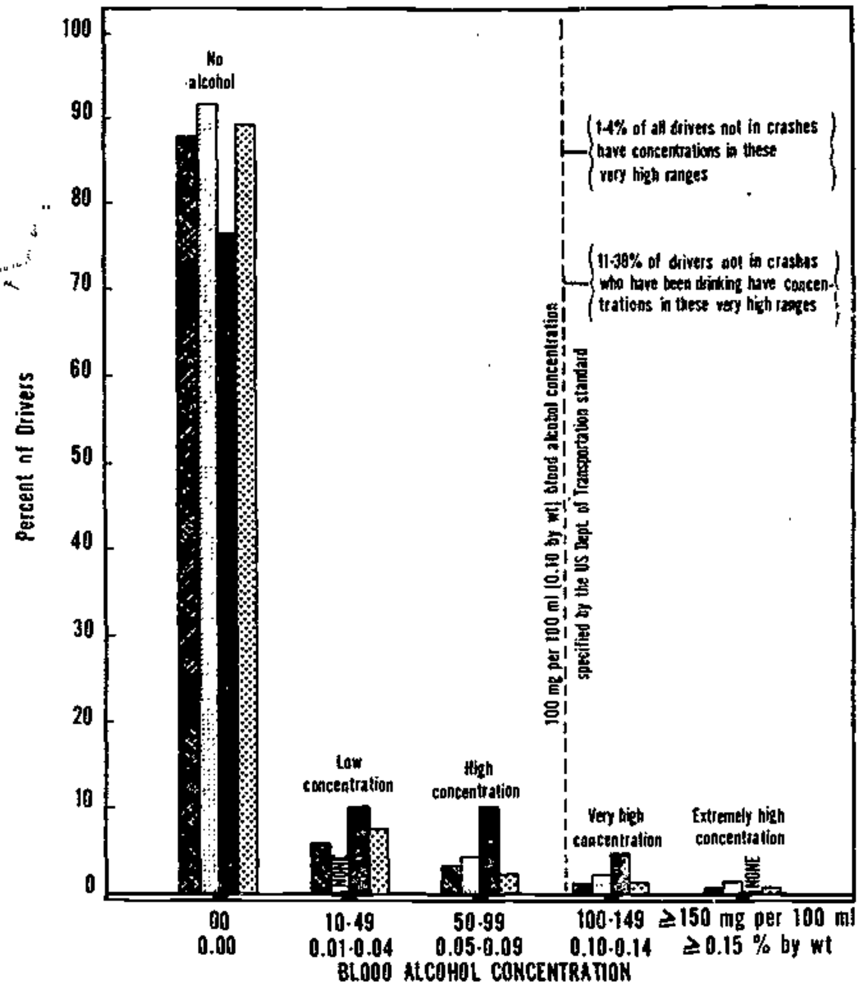
However, the current literature on BAC studies suggests that such a distinction is not necessarily appropriate. The more relevant variables appear to be amount and frequency of alcohol consumption, and amount of previous experience with alcohol. These distinctions will be discussed further in the Medical section of this chapter.

Driver problems associated with alcohol have represented a prime target for research, as well as a continuing controversy among specialists. Some researchers believe that removing a few drivers from the highways will greatly reduce the incidence of fatal and non-fatal crashes, especially alcohol-involved incidents. Other investigators recognize that one can affect only a small proportion of the driving population with currently popular post-arrest diagnosis and treatment techniques. The following pages will discuss these and other issues as they can be measured by BAC data.

Alcohol in the General Driving Population

Controlled research provides estimates of the distribution of blood alcohol concentration in the general driving population, i.e., drivers using the road but not involved in crashes. (See Figure 2-1.) In the four studies illustrated here, it is shown that 75-92% of drivers on the roads, measured at times and places of fatal and non-fatal crashes, did not have BAC's to any measurable degree. (Borkenstein et al., 1964;

[3] However, other researchers disagree. The General Motors Corporation, attempting to develop an ignition interlock system, concluded that BAC was an unreliable indicator of fitness to drive. Their research staff (Jones and Tennant, 1973) determined that though the interlock system is capable of discriminating between sober and intoxicated individuals, the debilitating effects are not large enough to eliminate more than 50% of the drivers at BAC's of 0.10% without eliminating also a large number of sober drivers. The main implication of these results is that a "Universal threshold" approach is not feasible.



Blood alcohol concentrations among drivers using the road but not involved in crashes.

- 1750 drivers tested at various times and on various days, Evanston, Illinois, 1938
- 2015 drivers tested during evening hours at crash sites, Toronto, Canada, 1951-1952
- 252 drivers tested at times and places of fatal crashes, New York City, 1960
- 7590 drivers tested at times and places similar to those at which crashes occurred, Grand Rapids, Michigan 1962-1963

Source: DOT Alcohol and Highway Safety Report to the Congress, 1968 (Chapter 2 Figure 1)

Figure 2-1

Holcomb, 1938; Lucas et al., 1955; McCarroll and Haddon, 1962) In a more recent review of studies involving roadside surveys of drinking drivers, 12-14% of the drivers in the United States had some detectable BAC level (Stroh, 1972).

Alcohol in Fatal Accidents

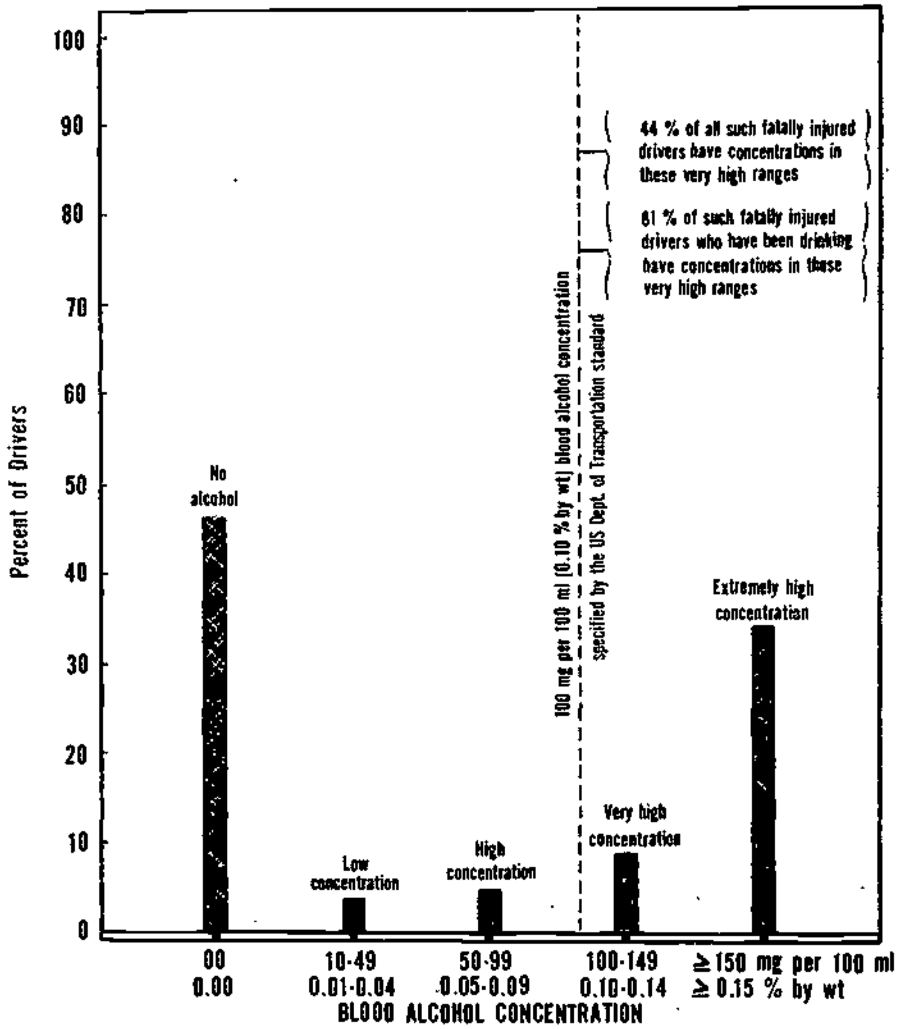
Research results also demonstrate the high association of highway fatalities with alcohol (Figure 2-2). Very high and extremely high blood alcohol concentrations (0.10% and above) were found in 45% of the drivers fatally injured in crashes involving more than one vehicle but in which no other vehicle or driver was believed to have been responsible (Nielson, 1965, 1967). Several studies have shown alcohol involvement in more than 50% of fatal crashes (Table 2-3). The percentage of alcohol involvement is even more dramatic in fatal, single vehicle accidents, where over 70% of the fatalities involve alcohol. (See Table 2-4.)

The most plausible explanation for the higher alcohol involvement in fatal, single-vehicle accidents is that more of these drivers are likely to have been at fault than those fatally injured in multivehicle crashes. Multivehicle accident driver fatalities (Table 2-3) include drivers who were not at fault in their accident (and they are much less likely to have been drinking). The facts may very well show that alcohol is a contributing factor in over 70% of all highway fatalities.

It should be emphasized that the association of alcohol with accidents does not constitute causality. Alcohol can be described as a "contributing" factor just as errors in observing, lack of basic skills, or environmental and vehicular factors might be described as contributing factors. Most accidents occur in association with a number of factors, each playing a contributing role.

At this time, most researchers conclude that alcohol impairs general driving skills and enhances the effects of other accident-associated factors. For example, young drivers are highly over-represented in alcohol-involved fatalities (almost twice as many as should be expected). At the same time, the average BAC of young driver fatalities is found to be lower than that of an older age group. This would suggest that it is in combination with excessive speed (a predilection of this age group associated with greater accident severity), that alcohol usage, even in low amounts, results in fatalities among young drivers.

Studies of pedestrian fatalities show a similar degree of alcohol involvement. Between 47 and 74% of the pedestrians killed showed at least some detectable blood alcohol concentration.



Blood alcohol concentrations among drivers fatally injured in crashes involving more than one vehicle but in which no other vehicle or driver is believed to have been responsible.

Source: DOT Alcohol and Highway Safety Report to the Congress, 1968 (Chapter 2 Figure 3)

Figure 2-2

Table 2-3. **Alcohol Detection in Fatal Accidents**

Name of Study	% of Fatally Injured Drivers With Detectable Alcohol
Neilson	55.0
Freimuth	64.4
New Jersey	57.0

Source: Arthur D. Little. Inc.. 1966.

Table 2-4. **Alcohol Detection in Single Vehicle Fatal Accidents**

Name of Study	% of Fatally Injured Drivers With Detectable Alcohol
McCarrol	70.8
Haddon	73.5
Birrell	83.0

Source: Arthur D. Little. Inc., 1966.

Alcohol in Non-Fatal Crashes

Alcohôl involvement in non-fatal crashes is especially difficult to assess, because of incomplete reporting of accidents and lack of BAC data from drivers not suspected of alcohol consumption. Those studies that have been done report high blood alcohol concentrations in 5-10% of drivers involved in minor crashes and in 10-35% of those involved in serious injury crashes.

Alcohol and Driver Performance

It is generally believed that the ingestion of varying amounts of alcohol will, given individual differences, have an adverse effect upon the psychological and physiological functioning of the driver. In 1972, NHTSA convened a symposium to review the state-of-the-art in driver-related alcohol research. Several researchers reported on the available knowledge that pertains to the influence of alcohol on driver behavior.

Perrine (1974) reported to the symposium the findings of his critical review of laboratory studies of neurophysiological, neuromuscular, and sensory activity. He maintains that a neurophysiological model is required which incorporates two interrelated issues: (a) the actual site of alcohol effects in the nervous system, and (b) the apparent biphasic effects of alcohol. Describing the subsequent areas of his report, Perrine writes:

> "Neuromuscular aspects: Standing steadiness is a sensitive behavioral indicator of alcohol intoxication, but its validity for driving impairment is not yet conclusively established at blood alcohol concentrations (BAC's) from .08% to .15%.
>
> "Sensory activity: Six reviewed aspects of vision are arranged in order of decreasing susceptibility to low and medium BAC's: (a) dynamic visual acuity; (b) adaptation and brightness sensitivity; (c) critical flicker fusion; (d) static visual accuity; (e) glare resistance and recovery; and (f) visual field. Only the first three aspects showed significant impairment at medium BAC's." (Perrine, 1974)

Perrine is not able to "unequivocally" answer his principal question: "Do alcohol influences upon performance in laboratory tasks have any valid transfer to real world driving behavior?", since validity of laboratory research has not been adequately demonstrated.

Moskowitz (1974) reported on the influence of alcohol upon sensory motor function, visual perception, and attention:

"Laboratory studies of alcohol influences on three essential driver performance areas were reviewed: vision, tracking, and division of attention. When examined by isolating a specific function, most visual and tracking studies failed to find an appreciable decrement due to alcohol. However, when these same visual or tracking functions were a component task within a more complex requirement for joint performance of several functions, large performance decrements occurred at low blood alcohol concentrations. It was concluded that alcohol affects the ability to process appreciable quantities of information when these arrive from more than one source simultaneously, as is typical of the requirements for driving. The conclusion was supported by additional evidence demonstrating alcohol-induced performance decrement of division of attention tasks and of tasks requiring rapid processing of information. Drug-dose studies demonstrated significant impairment of division of attention tasks by .02% BAC, with nearly all subjects exhibiting effects by .08%." (Moskowitz, 1974)

Barry, after an in-depth review of relevant literature reported to the symposium on the motivational cognitive effects of alcohol. He concluded that the primary psychophysical effects of alcohol--depression and disinhibition--are significant in alcohol-related accidents.

"The contrasting depressant and disinhibitory effects of alcohol both can cause highway accidents. The depressant effect involves the motivational components of sedation and self-destructiveness and the cognitive components of memory loss and learning deficit. These give rise to inattention or fatigue; typical consequences are driving off the road or into an obstacle during routine driving, and insufficient response to an emergency. The disinhibitory effect involves the motivational components of decreased fear and increased assertiveness and the cognitive components of impairment of self-criticism and dissociation from sober habits. These give rise to risk-taking or disorganization; typical consequences are speeding or risky maneuvers during routine driving, and loss of control in an emergency. Although each motivational and cognitive component can be isolated conceptually and to some degree in laboratory research, several components are involved together in most highway accidents." (Barry, 1974)

Huntley (1974) concluded the "Alcohol Influences" portion of the symposium with a discussion of closed-course driving performance. He reaffirmed the contention that studies, whether merely illustrative or empirically rigorous, have shown alcohol to have an effect upon driving performance. He is careful, however, to qualify his remarks:

"Alcohol has been shown to alter driving behavior in almost all studies. It increases steering-response rates, velocity variation, and the frequency of procedural errors; and decreases driving smoothness, stopping efficiency, cornering ability, and the extent of the visual field explored by the driver. The data indicate a high probability of impairment at BAC's between 50 and 75mg%. However, it cannot be assumed that all drivers are always impaired at these concentrations, for even BAC's as high as 130mg% are not sufficient to impair performance in all instances. The magnitude of alcohol effects is modified by driving task, and sleep deprivation. Such interactions illustrate the complicated nature of the alcohol performance relationship and indicate the importance of research on the effects of alcohol when combined with other driving-relevant variables." (Huntley, 1974)

This impairment of driver performance has also been shown in research studies using driving simulators. The relationship between average driving performance and blood alcohol concentration as demonstrated in simulated driving situations is shown in Figure 2-3 (Loomis and West, 1958).

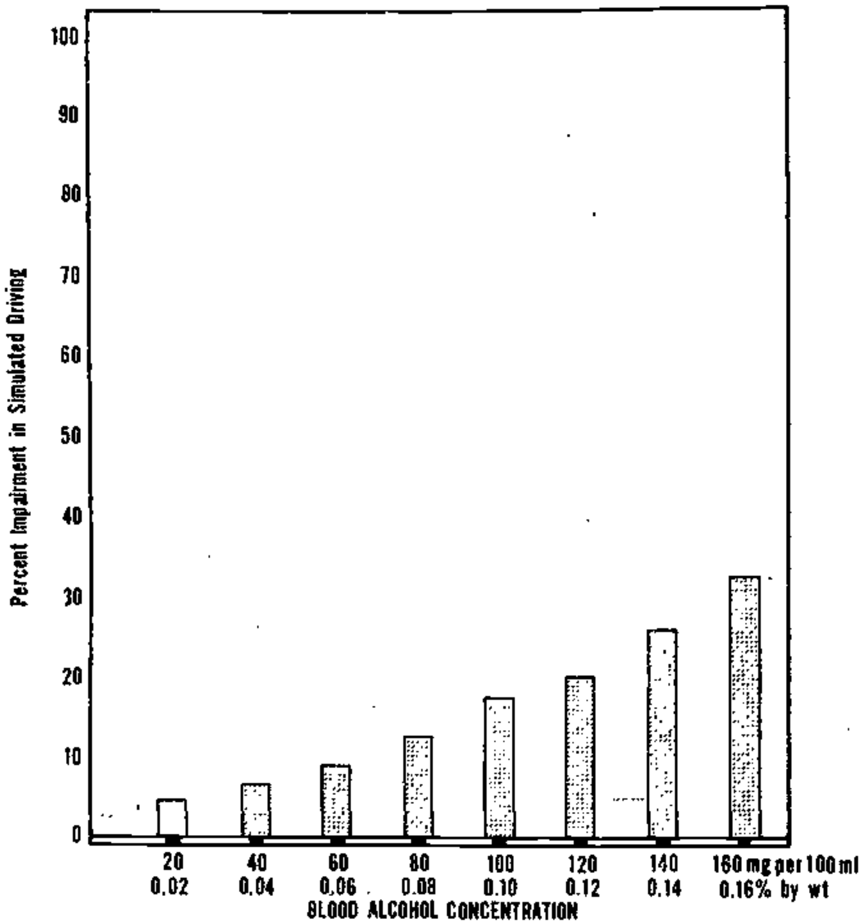
Alcohol and Relative Crash Probability

The relative probability of a crash at various blood alcohol concentrations has been determined from several controlled case studies. Figure 2-4 shows that drivers with a high or extremely high BAC (0.10-0.15% or higher) are much more likely to become involved in a serious crash than drivers who have not been drinking. Researchers estimate that drivers with a BAC of 0.10% are 6-7 times more likely to have an accident, and drivers with a BAC of 0.15% or greater are 25 times more likely to have an accident than drivers who have not been drinking. Evidence indicates that the likelihood of a crash involving alcohol begins when a driver reaches a BAC of 0.05%, and rapidly becomes progressively greater as the BAC increases.

The relative probability of a driver being responsible for a fatal crash as a function of his BAC is shown in Figure 2-5 (Perrine 1971). This crash-probability curve of drivers responsible for crashes is very similar to the curve for single-vehicle accidents presented in Figure 2-4, thus underscoring the high degree of alcohol involvement in single vehicle fatalities.

Discussion

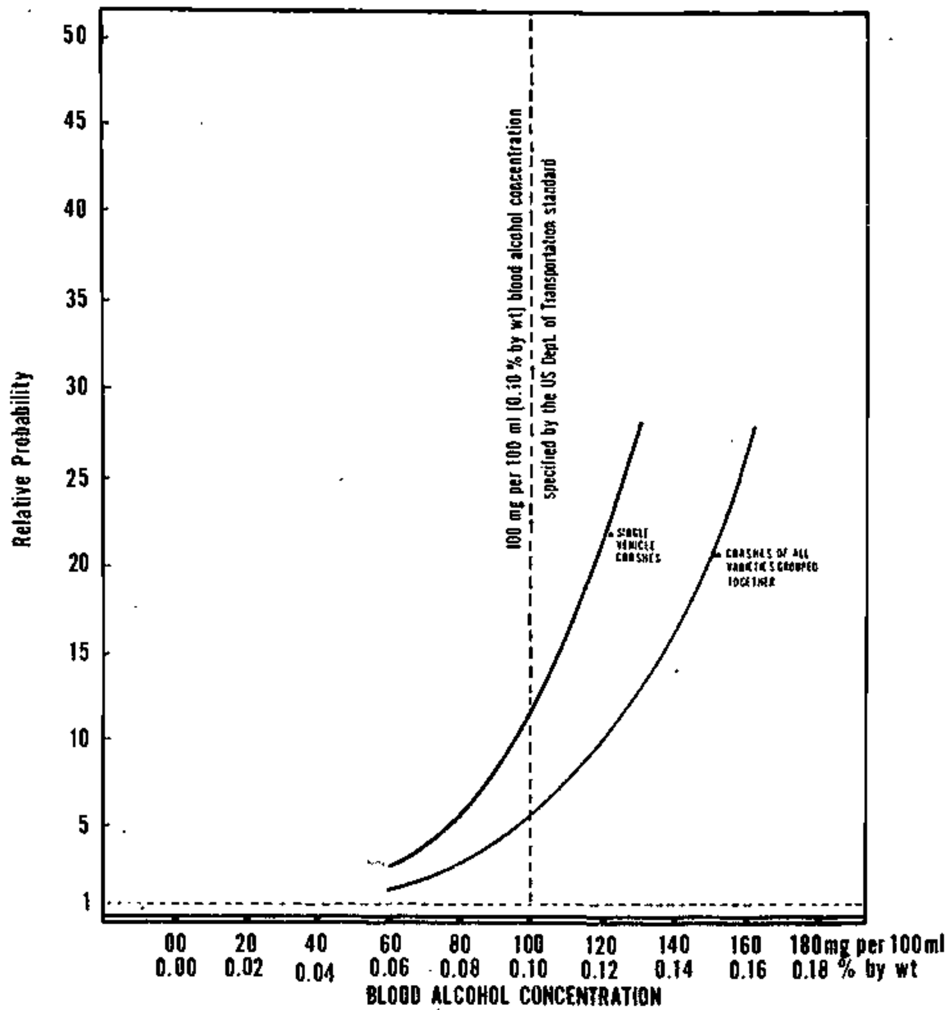
Legally, there appear to be few constraints on the use of BAC in drinking diagnosis. The U.S. Supreme Court (Schmerber vs. California, 1966) has ruled that even non-concensual blood tests do not constitute



Effect of alcohol on performance as measured by a simulated driving task.

Source: DOT Alcohol and Highway Safety Report to the Congress, 1968 (Chapter 3 Figure 1)

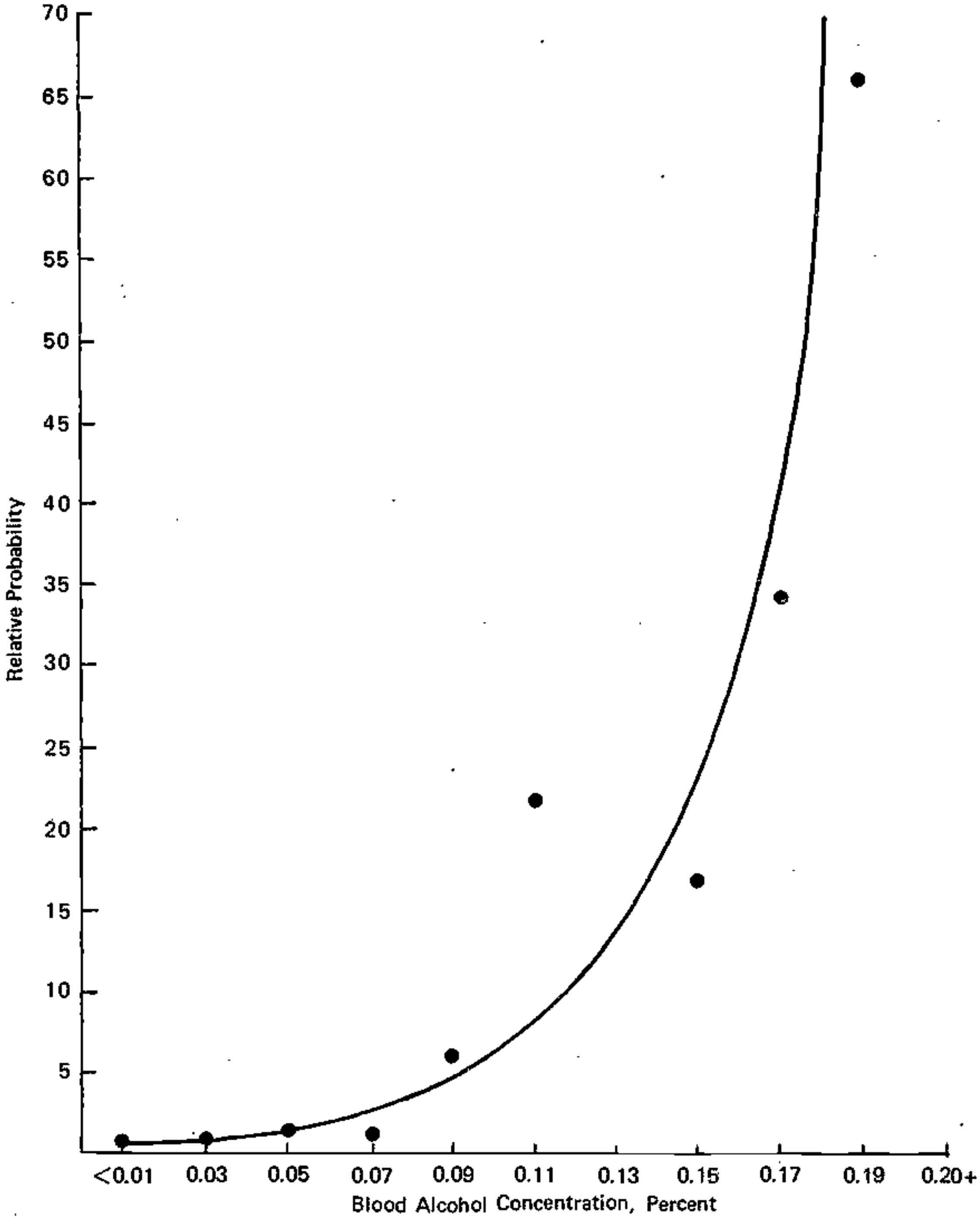
Figure 2-3



Relative probability of crash at various blood alcohol concentrations.

Source: DOT Alcohol and Highway Safety Report to the Congress, 1968
(Chapter 2 Figure 8)

Figure 2-4



Source: Perrine et al. (1971)

Relative Probability of Being Responsible for a Fatal Crash as a Function of Blood Alcohol Concentration

Figure 2-5

invasion of privacy in cases involving suspicion of drunken driving. (See Little et al., 1974.) BAC level is especially useful both to reliably quantify the degree of intoxication and to provide credible court evidence.

For diagnostic assessment, there is a major advantage to using BAC level as reported on a citation or accident report, rather than using the more widely available variables such as DWI convictions. All driving-related alcohol convictions are subject to numerous biases within the socio-legal driver control system. Because driver licensing agencies generally impose severe and mandatory sanctions, the courts are often reluctant to convict for DWI citations. These citations are also frequently reduced to lesser charges such as reckless driving or speeding. In addition, enforcement personnel are reluctant to cite drivers for DWI since convictions are difficult to obtain and often require court appearances by the officer who issued the citation. Thus, since citations do not routinely result in recorded convictions, the reported BAC of the driver is generally a much more reliable predictor.

Recent legislative developments have tended to remove the so-called alcohol abuser from the criminal category, placing him instead in the mental health treatment situation. With the increased provision for treatment alternatives, there has been an increase in reported alcohol-related citations and convictions. NHTSA-supported Alcohol Safety Action Programs (ASAP) have done much to communicate treatment alternatives to the courts and coordinate activities among the courts and the licensing and treatment agencies.

RISK-TAKING ERRORS

The relationship between speed and types of accidents has been unclear in the past. An early study by the Pennsylvania Turnpike Joint Safety Research Group (Blotzer et al., 1954) showed that different types of accidents seem to be significantly associated with different speed ranges. Accidents involving illegal and unsafe actions, or failure to cope with road conditions, occur primarily in the lower speed ranges, while accidents associated with intoxication, sleeping at the wheel, or failure to avoid objects in the road occur more often in the higher speed ranges.

Numerous studies have shown that increasing speeds of accident-involved vehicles result in increasing accident severity, in terms of both injuries and fatalities. (See, for example, Solomon, 1964; State of California, 1966; and Cornell Aeronautical Laboratory, 1968.) This effect is especially pronounced in the accidents involving very high speeds (70+ MPH), where chances for escape from injury, or even for survival, are markedly reduced.

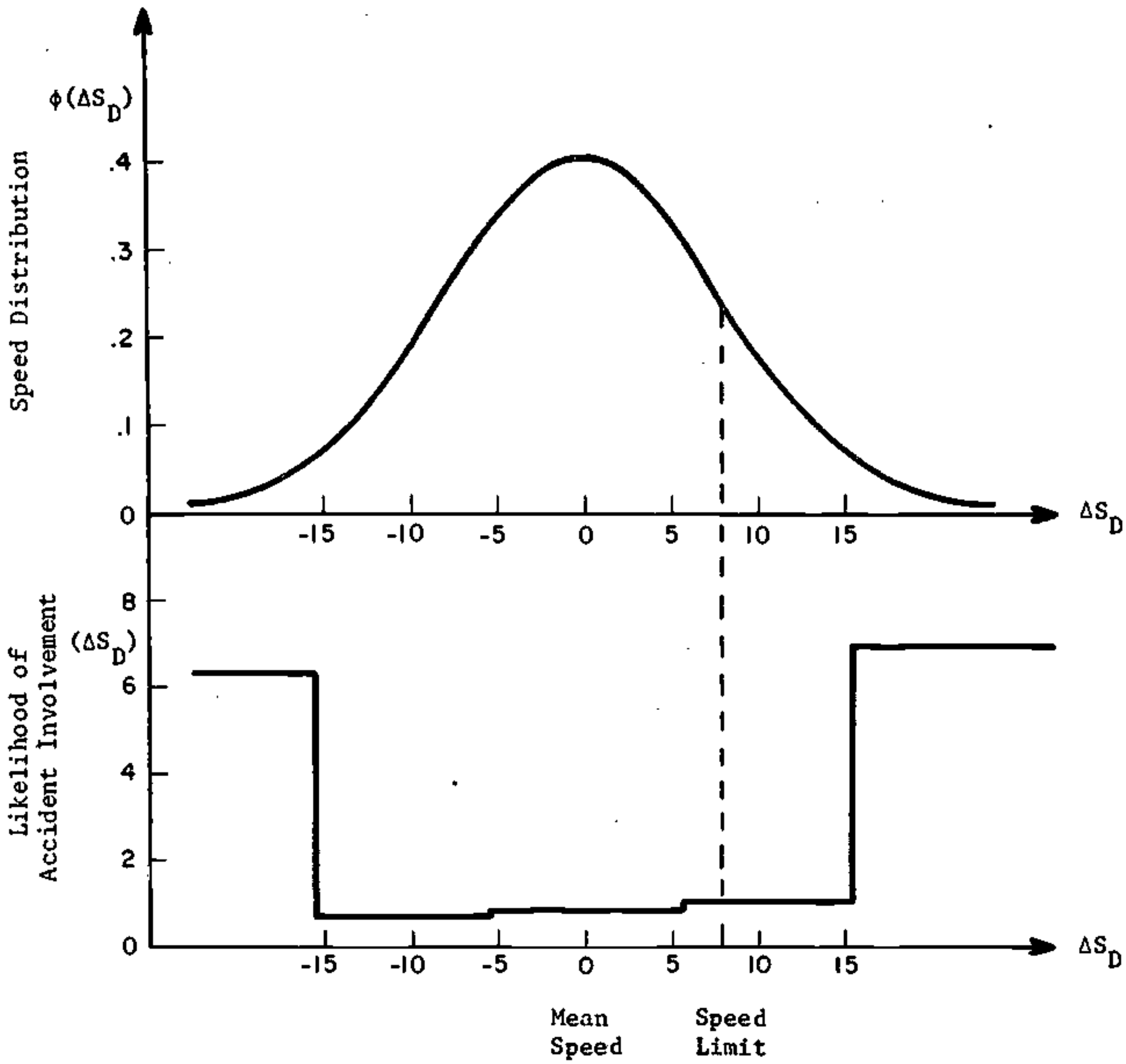
This relationship between speeding and increased accident severity has long been known, but there has historically been little evidence of a relationship between speeding and accident probability. A U.S. Department of Transportation (1969) report, "Maximum Safe Speed for Motor Vehicles," found little conclusive evidence to support a relationship between maximum state legal speed limits and state highway fatality rates. A more recent study by Research Triangle Institute (1970) conducted detailed accident investigations (questioning driver, passengers, witnesses, and examining physical evidence) to determine a best estimate of vehicle speed prior to an accident. Using a computer-sensor system to monitor speeds at eight highway locations, highly accurate exposure controls were obtained. Their major finding concerning accident probability and speed was an abrupt increase in accident rate whenever the vehicle speed deviated by 15 miles per hour (plus or minus) from the mean speed of all vehicles using the roadway. (See Figure 2-6.) Within the ± 15 MPH range accident likelihood appeared almost constant. The implication is that descriptive information about speeding, such as actual speed, deviation from mean, or deviation from speed limit would be more useful as a predictor of accident probability than simple measures such as number of speeding citations. The descriptive measures might also be more closely related to accident severity.

RECOGNITION ERRORS

Accident reports also provide data on the relationship of recognition errors to both accident causation and severity. Indiana University's Institute for Research in Public Safety (1973) has conducted a multi-level accident investigation study which addressed these issues. The multidisciplinary accident investigation teams found recognition errors to be definite causes in 36.0 - 49.2% of all accidents (depending on the phase of the study and the level of investigation). Among recognition types of errors, 18-20% were categorized as due to inattention and 19-25% due to improper lookout (e.g., intersections, rear-end collisions). False assumption (assuming that another driver was going to stop or turn, etc.) was implicated in 9-17% of the recognition-related accidents investigated. Concerning accident severity, 69.4 - 77.9% of the accidents described as caused by recognition errors were found to be property damage only, while only 66.3% of all accidents were property damage only. Thus, recognition errors appear to be inversely related to accident severity. From these results, it is clear that recognition errors account for a large percentage of the highway safety problem, although many of these accidents are minor.

SUMMARY

Using police accident and conviction reports as Level II data sources, the specific kinds of driving errors can be more precisely identified than by simply using the summary information generally found in driver license



Source: Research Triangle Institute (1970)

FIGURE 2-6. SPEED DISTRIBUTION AND LIKELIHOOD OF ACCIDENT INVOLVEMENT AS A FUNCTION OF SPEED DEVIATION (ΔS_D)

files. With the exception of BAC measurement, these data are currently most useful for research purposes. This research should eventually provide clarification of specific driver problems to be assessed.

BAC measurement, however, is currently a useful operational technique. For predictive diagnostic assessment, the use of BAC data from the original citation of the arresting officer can be regarded as much more reliable than alcohol-related conviction data, since it is not subject to biases within the judicial system.

BIOGRAPHICAL VARIABLES

Many of the biographical variables found to have significant correlation with accident frequency, particularly those which seem to be related to socio-economic level, can potentially be obtained from Level II sources. These variables include employment history, type of occupation, amount of education, etc., which should be available from employers and educational institutions. In practice, however, such data are difficult to obtain. It is seldom possible to search records of employers, or educational institutions, to locate the records of a particular individual. In addition, the educational records are subject to the recent Right to Privacy Act. Consequently, very little research has been conducted using Level II biographical data as predictors. The area represents a large gap in driver diagnostic research which may never be fully examined except in those rare cases where centralized and accessable records exist. One such possibility was explored by Crancer et al. (1968a), who demonstrated some potential utility for credit rating as a predictor of accident liability. Other possibilities might include tax records, welfare records, or social security records, but these are again subject to ethical, legal, and privacy restrictions.

In summary, the area of Level II biographical assessment appears poorly suited for use in driver diagnosis at this time. Fortunately, as will be seen later in this report, most of the useful data which could be collected here can be assessed using Level III techniques.

PSYCHOLOGICAL, SOCIAL, AND ATTITUDE VARIABLES

General Discussion

Level II psychological and attitude information, similar to biographical information, is a potentially useful area of assessment that has not been fully explored. Apparently, privacy requirements and lack of centralized records have almost completely curtailed research. As will be discussed in Chapter 3, various types of life stresses have been found to be related to accidents, particularly alcohol-involved accidents. These family, personal, marital, and occupational problems might also be reflected in data from mental health agencies, civil courts, divorce courts, or unemployment offices. As in other Level II areas of assessment, there are many obstacles to overcome before these areas become operationally useful. However, the psychological/attitude area appears to be especially promising. For instance, a driver's probability of being involved in an alcohol-related accident sharply increases immediately following a divorce. An operational system could require that mandatory reports of all divorces granted be sent from the courts to the licensing agency. An effective and timely countermeasure might then have a substantial impact on the alcohol traffic safety problem. Possibilities such as this suggest that all potential Level II data sources should be examined carefully.

Criminal History

There is one Level II psychological data source which has been commonly used in driver research--criminal conviction records. These could also be considered biographical data, but are included here since they reflect social attitudes as well. These data are relatively free of the limitations placed on other Level II data sources. Criminal data are usually collected and stored by one centralized state agency. They are generally stored so that a rapid search can be made for an individual's record, and they are also free of most privacy limitations, resulting in widespread distribution, at least among government agencies.

A history of criminal convictions has often been found to be related to traffic accident probability. Kraus et al. (1970) compared accident and control young driver samples, matched on age, sex, and population of area of residence. They reported a strong significant increase in history of non-traffic-related criminal offenses among the accident group. They found that a much larger percent of their accident group (14%) than their control group (2%) had been charged with a criminal offense (excluding those related to driving). In Harrington's (1971) study of young drivers, those drivers who reported having trouble with the police before age 20 tend to have more accidents ($r = .14$). Similarly, Carlson and Klein (1970) also report that among college students the incidence of traffic convictions is re[illegible]ted to the incidence of non-vehicular offenses. In the one year follow-up study of negligent operators, Harano (1974) found very few significant correlations between prior criminal record and negligent driver recidivism. Both drug-related arrests ($r = .07$) and, as one would expect, motor vehicle arrests ($r = .08$) correlated with subsequent traffic convictions. The only significant predictor of collisions was prior burglary and robbery convictions ($r = .09$).

Some interesting additional findings have been provided by Harano et al. (1973). These authors obtained arrest sheets from the California Bureau of Criminal Investigation and correlated the data with membership in accident-repeater and accident-free driver groups. The total number of incidents (excluding motor vehicle incidents) correlated .13 with group membership and .27 with traffic convictions. Age at time of first incident was not significant. <u>Recency</u> (months since last incident) was highly significant, but in an unexpected direction. Accident repeaters had fewer recent incidents than accident-free drivers ($r = .21$). These authors also found that accident-free subjects tended to apply for more gun permits than accident repeaters, which may be an occupational variable (protectives, policemen, etc.).

In conclusion, criminal arrest or conviction data is one of the few relatively accessible Level II psychological data sources. Generally, it is centrally located, easily searched, and relatively free of privacy constraints. Criminal data also appear to be useful predictors of driving record (perhaps related to the measures of social deviancy to be discussed in Chapter 3), although further research is needed on the various qualitative aspects of these data.

MEDICAL/PHYSIOLOGICAL VARIABLES

Level II medical variables are also quite limited, since most are protected by the confidentiality of the physician-patient relationship. Consequently, very little traffic safety-related research has been conducted using these sources, with the exceptions of alcoholism and drug usage.

Alcoholism

Since alcohol involvement was first identified as a major factor in highway safety, there has been a shift in research perspective. The "social drinker" used to be the focus of major diagnoses and treatment. Currently, the "problem drinker," or person clinically diagnosed as an "alcoholic" is often considered the most appropriate subject for assessment and treatment. The research community, however, has been sharply divided over whether such emphasis on any particular sub-population of drinkers can be justified. The A.D. Little (1966) review of traffic safety literature concluded:

> "It is the opinion of several responsible researchers that pathological drinking may be a factor in perhaps one quarter of all automobile fatalities. The distinction between infrequent heavy drinking and chronic alcoholism is not clear...present evidence is adequate to justify intensive investigation of alcoholism as a factor in fatal automobile accidents and of its treatment as a means of reducing the fatality rate. (Little, 1966)

Since 1966, the controversy over this assumption, that a small percentage of drivers (problem drinkers) is responsible for a large percentage of the accidents, has increased. The advocates of the viewpoint expressed in the Little review maintain that one-third of all traffic deaths are caused by problem drinkers. Zylman (1973) details the weaknesses of and the generalizations made in the various studies that support this statement. He concludes that the studies were conducted using small segments of the populations, and therefore, the data were incomplete. Two other common statements for which Zylman finds supporting data inadequate are:

(1) While the alcoholic may be a sick person, the alcoholic driver is a criminal, and he should not be permitted total driving freedom.

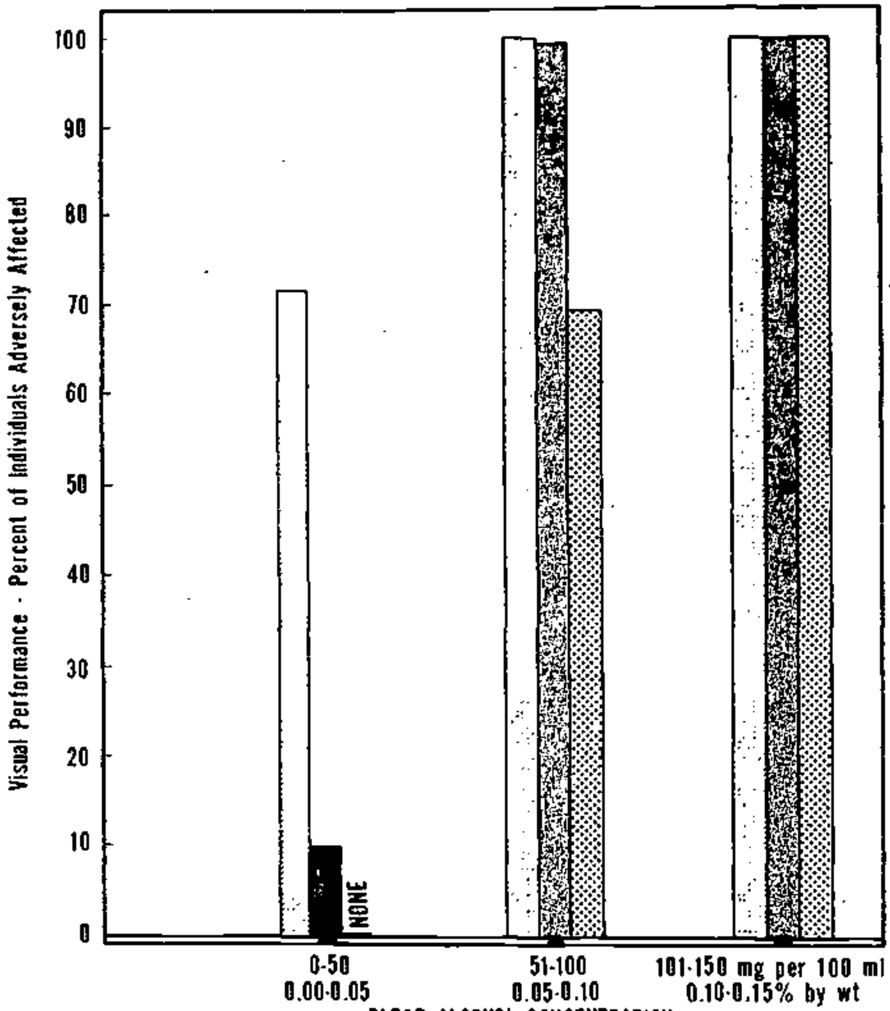
(2) One out of every 50 drivers on the road is intoxicated.

Schmidt and Smart (Little, 1966) have also challenged the "problem drinker" assumption with their findings, suggesting that the amount of alcohol consumed, rather than any other characteristic of any particular class of drinking drivers, seems to be responsible for the observed high accident rates. The evidence presented earlier in this chapter in Figures 2-3, 2-4, and 2-5 showing the relationship of BAC to simulated driving performance, to crash probability, and to responsible fatal crash probabilities, indicates that these relationships are all in the form of positively accelerated smooth curves. This implies that the alcohol/automobile problem is a function of the amount of alcohol consumed, and not exclusively the problem of any particular subgroup. It also implies that the target population for alcohol/traffic safety measures is anyone who may attempt to drive with a high BAC--social drinkers, problem drinkers, and "alcoholics."

There is even evidence that experienced drinkers may drive better than novice drinkers at their relatively lower BAC levels. Schmidt et al. (1962) studied the effects of various BAC's upon performance of occasional, moderate, and heavy drinkers. A sample of the results of their study on a visual testing task (Figure 2-7) is representative of their general findings that at lower blood alcohol concentrations, the performance of experienced drinkers is affected less than the performance of individuals with little drinking experience. With higher concentrations, all persons are adversely affected.

In summary, it is difficult to determine from the empirical evidence which population group is the appropriate target for diagnosis. It is apparent that ultimate research objectives should not be narrowly confined, but rather, that as many points as possible should be examined along the alcohol usage curve. However, the diagnostic assessment of alcohol problems is not tantamount to locating an individual on the alcohol usage continuum. Differing psychological and social factors may cause two individuals to consume equal quantities of alcohol for entirely different reasons, for whom different treatments are indicated. Thus, all identifiable drinking sub-populations merit further study, including the alcoholic population.

Since a number of social agencies are currently engaged in the treatment of alcoholism, these agencies are potentially very useful sources for alcoholism data. Unfortunately, information confidentiality requirements and inability to coordinate objectives have severely limited both research and operational programs.



Effect of alcohol on performance as measured by a visual test.

Source: DOT Alcohol and Highway Safety Report to the Congress, 1968 (Chapter 3 Figure 3)

Figure 2-7

Waller (1967) conducted a study to identify the sources of existing information in a community about previous problem drinking. Community services providing information included an alcoholism clinic, several family and welfare agencies, and the police department. "Screening criteria" were established to identify the problem drinker. These included two or more arrests involving the use of alcohol, or a "diagnosis" by personnel at an agency which indicated that the subject had an alcohol-related problem. (This latter criterion was employed only when it was based on something other than knowledge of previous drinking-related arrests.). Using these criteria, almost two-thirds of a DWI arrest sample (n = 150) were identified as problem drinkers from records of other agencies. However, while these results have important implications regarding the extent of problem drinking among DWI's, they are of little utility for diagnosis. By employing a preselected DWI sample, these analyses suggest only that a past DWI arrest can predict problem drinking, not that past problem drinking can predict a DWI arrest.

In a study more directly related to driver assessment, Crancer and Quiring (1968b) obtained from a county hospital the names of 515 persons diagnosed as chronic alcoholics. Of these, 140 were found to be local residents with valid drivers licenses and complete driving records. These drivers were then compared with population norms during a subsequent three-year period to examine accident and conviction frequencies. The chronic alcoholics were found to have 54.5% more accidents, and 88.4% more convictions (both significant $p < .05$) than the county population norm. On most violation types, the alcoholics had poorer records, including 7.6 times the population average for drunken driving arrests. However, it should be noted that there were no controls for biographical variables including age and sex, which apparently differed between the samples. These findings should therefore be viewed as evidence that prior diagnosis of chronic alcoholism should be a useful predictor of accident liability. Much further research using more comprehensive statistical techniques will be required.

A more detailed study of a larger alcoholic population (n = 2367) and their driving records is reported by Clay (1970). This analysis demonstrated that the best single predictor of an alcoholic's driving risk potential was his total number of prior non-alcohol-related moving traffic offenses (which is, of course, also the best predictor for non-alcoholics). Numerous other predictors have since been discovered (Clay, 1972), but since there was no appropriate control sample, the added predictive capability of the diagnosis of alcoholism could not be determined.

In summary, there is some evidence that problem drinkers and alcoholics (if these terms can be operationally defined) account for a significant portion of the alcohol-related traffic problem, although the exact proportion is uncertain. There is some evidence (although circumstantial) that a clinical diagnosis of alcoholism can be useful as a predictor of alcohol traffic safety errors. This evidence should be sufficient to justify continued research.

Drug Usage

A review of the literature concerning drug use and highway safety has been conducted by Nichols (1971) and Smart (1974). Each has concluded that at present there is little evidence to support the use of drug-related variables in any operational diagnostic assessment program. Nichols concludes his review by saying:

> "In reviewing the literature of the drug-driving area it is apparent that our present state of knowledge is little more than fra⌃ ⌃ntary...It cannot be concluded that drugs are not having a . ⌃nificant impact on highway crashes. Rather, it must be concluded that presently there is no valid evidence that drug use and/or abuse is contributing disproportionately to highway crashes." (Nichols, 1971)

Similarly, Smart concludes:

> "To date there has been no determined effort to associate the use of psycho-active drugs by drivers with specific driving errors or with responsibility for accidents. Of course, this would be an essential step in establishing the potential hazard of drinking and drug use. Further, it is not known whether drivers who need psycho-active drugs would actually be more dangerous on the road without them than with them." (Smart, 1974)

Waller (1965) found that drivers with past drug convictions had nearly twice the violation rate as non-users in the same age group, but their accident rates did not differ. Waller (1971) also pointed out that the excessive violation rate of these users often preceded their drug use.

Other researchers (Crancer and Quiring, 1968c; Klein et al., 1971) have also reported higher accident and/or violation rates for known users of illegal drugs ranging from marijuana to heroin. However, none of the studies incorporated controls for either personality or socio-economic variables. Since it is probable that these factors are related to both drug use and accident involvement, the contribution of drug usage alone is uncertain. Moser et al. (1972) did not find that drug users, primarily heroin addicts, had higher accident or violation rates.in a study controlled for personality and socio-economic factors. However, as Smart points out, heroin addicts may not contribute their share to accident statistics because (a) few are licensed; and (b) users are not apt to drive while under the drug's influence.

On marijuana, Waller (1973) reports that the evidence indicates even a large dose of marijuana has a less damaging effect than a moderate dose of alcohol, and that unlike alcohol, marijuana lessens the propensity to take risks. Also, a driver under the influence of marijuana may retain the ability to respond appropriately in an emergency situation. What scant evidence there is on marijuana involvement in highway crashes is often contaminated by the presence of high blood alcohol concentrations as well.

Barbiturates and tranquilizers, although intended to induce relaxation and drowsiness, produce a high degree of tolerance in the habitual user. The danger then would be to the experimenter or the person who combined the drug with alcohol.

Concerning LSD and other hallucinogens there is virtually no evidence on crash risk.

Amphetamines, Waller (1973) claims, are the one drug group other than alcohol proven to be associated with an increase in crash risk. These drugs are known to produce an increased level of activity and an exaggerated sense of self-confidence and competence.

Legal drug usage should also be considered; that is, the use of prescription and over-the-counter drugs. Waller (1973) cites a study in which the presence of drug levels in drivers killed in fatal single-vehicle crashes was examined. In about 11 percent of the cases drugs were found, usually in combination with alcohol. He calculated that this was the proportion of persons who would normally be expected to be taking medications at any moment in time, and the blood alcohol level was sufficient to account for the driver impairment. Waller sums up by saying:

> "These studies...do not support the contention that, in general, the use of drugs other than alcohol either legally or illegally seriously reduces driving skill. The studies do not reject the argument that in some instances the use of a drug may contribute to the occurrence of a crash." (Waller, 1973)

Thus, drug-related variables may still hold some promise for driver diagnostic assessment. There is some evidence that drug-related convictions (readily available from Level II sources) are useful predictors, but may only reflect biographical or attitudinal factors. One other Level II approach would be an exchange of information between driver licensing agencies and other agencies with which drug users come in contact. However, this is seldom possible, because of the many ethical issues involving those agencies, both government and private, which require confidentiality for their successful operation.

Using direct measurement of the driver (Level III), there are few operationally feasible assessment techniques. There is presently no technique which can detect all drugs in body fluid samples. Most available screening techniques are cumbersome and require expensive clinical facilities and a full-time staff with medical expertise. Direct questioning of license applicants concerning their drug usage habits would also appear futile, especially in relation to illegal drugs.

In summary, the area of drug usage may have future potential for the diagnostic assessment of driver problems, but at present, there is little justification for any large-scale research efforts.

EXPOSURE VARIABLES

Similar to the driver record exposure variables, the exposure estimates available from other agency sources are mainly qualitative group hazard indicators. At Level II, these consist of accident and conviction descriptors, such as time of day, day of week, weather conditions, roadway conditions, etc. Most of the research to date has emphasized the use of these variables for administrative purposes, such as suggesting times to allocate enforcement personnel, or suggesting places to change roadway design features. These variables, however, do have some potential for diagnostic assessment since they can provide more detailed qualitative descriptions of a driver's problem. For example, a driver problem diagnosed as "excessive alcohol consumption" would suggest a countermeasure designed to modify drinking habits. However, a driver problem diagnosed as "excessive nighttime alcohol consumption" might more easily be modified by simply restricting the driver's license to daytime hours.

To date, very few of these variables have been examined as diagnostic indicators. As a result, this section will be limited to a discussion of time of day (of accident or conviction). A statistical technique to estimate group exposure, based on accident culpability, is also included.

TIME OF DAY

From the secondary sources of police citations and accident reports, diagnostic assessors can readily obtain accurate information on the time of day (and also day of week) at which an accident or violation occurred. Several research studies have demonstrated a strong relationship between time of day, and types of traffic accidents (e.g., the majority of alcohol-related crashes occur late at night). Since time of day might also be a qualitative measure of an individual's driving exposure, it might also be useful as an assessment variable.[4]

Wallace (1969) found a significant relationship between number of nighttime citations, and future driving errors. This is apparently related to the finding of Harano et al. (1973), who reported that an accident repeater sample drove significantly more at midnight than an accident free sample (r = -.17).

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[4] Chapter 3 will examine the utility of directly questionning the driver. For example, the question might be asked "How often do you drive at night?".

Qualitative exposure variables might be most useful in interactive multivariate prediction. In an analysis of a fatal accident file, O'Day (1970) used several different types of accident descriptors. Figure 2-8 indicates how various biographical variables, driver errors, and time variables (time of day and week) interact to describe the proportions of fatal accidents involving alcohol. O'Day's analysis reveals sub-populations of drivers for which alcohol was highly implicated. Five out of six drivers who were involved in fatal accidents in dark hours of the night and who had committed violations such as driving wrong way, speeding, left of center, or improper passing, had been drinking. This analysis, although not predictive, does provide information at a macro level to further examine characteristics of accident involved drivers.

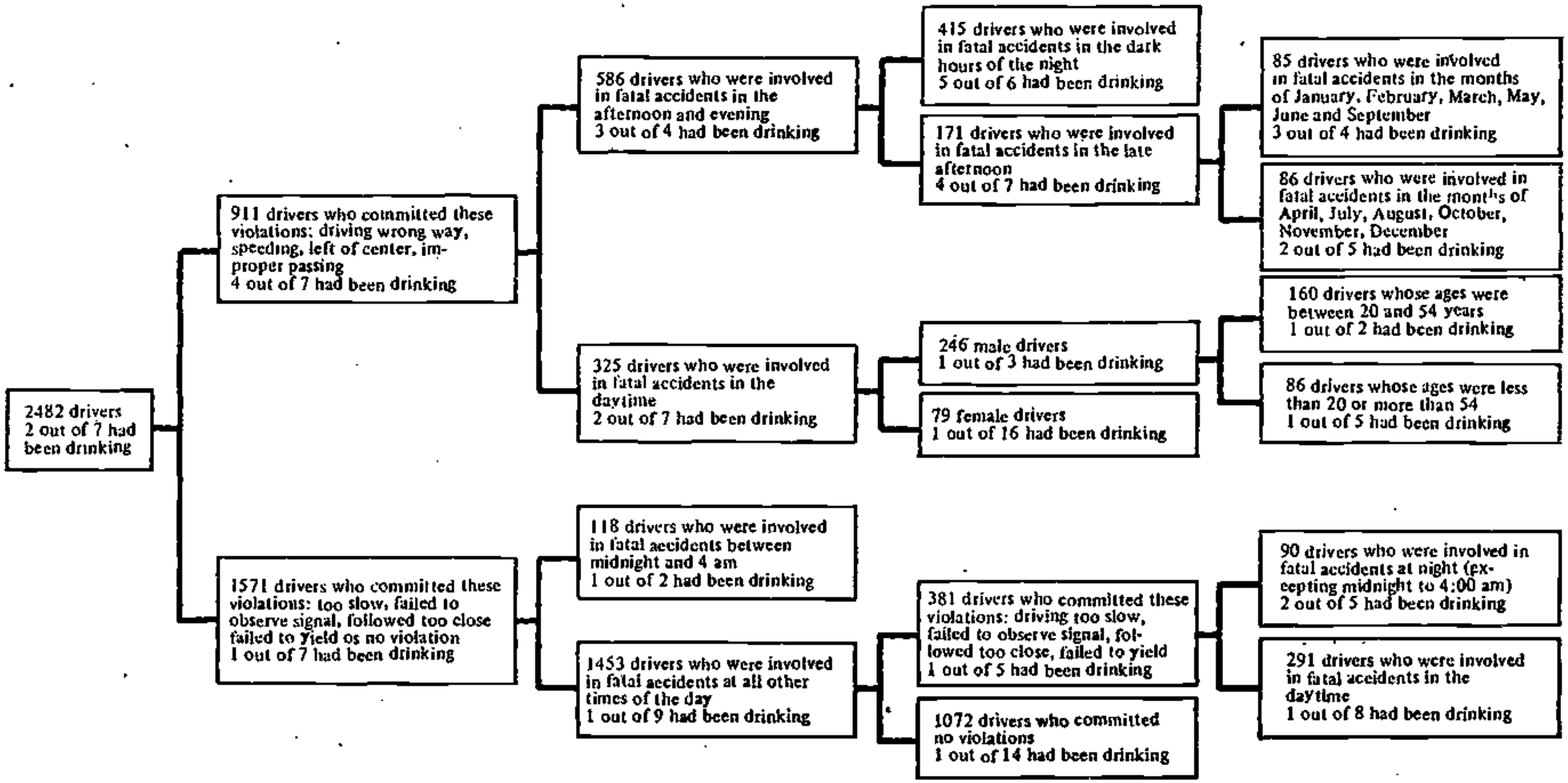
There is, however, much more research needed. If exposure is indeed "the frequency of traffic events which create the risk of accident," time of day, as a predictor, may reflect the qualitative degree of hazard to which the individual is frequently exposed. In addition, this factor may have implications for countermeasure assignment (e.g., restricted license).

INDUCED EXPOSURE

Based on Level II sources, there is a statistical exposure control technique which is useful for research purposes. Using accident culpability measures inferred from accident reports or accident-related convictions, group exposure can be controlled by a method known as "induced exposure" (Cerrelli, 1972). This technique is summarized as follows by Wiener (1972):

> "Based on the assumption, central to this technique, that the non-responsible drivers proportionally reflect the overall driving population, exposure indices for various dimensions (e.g., sex, age, etc.) can be computed by dividing percent of innocently involved drivers in a certain category by the percent of licensees in that category. This yields a Relative Exposure Index (RE). Likewise, dividing the percent of at-fault drivers by the same denominator yields a Liability Index (LI), a measure of accident liability uncorrected for exposure (which might be useful in insurance rate setting). Finally, if one divides the LI by the RE for a given class, it yields a Hazard Index (HI), a measure of the relative hazard. Values greater than unity represent higher than expected exposure, liability or hazard." (Wiener, 1972)

The principal assumption of the above procedure is difficult to validate empirically. The relative exposure index is computed from the number of innocently-involved drivers. Whether degree of "innocent" accident involvement is proportional to amount and difficulty of exposure is subject to question. A driver may have a disproportionately high number of non-culpable accidents per mile due to undetected errors,



Source: O'Day (1970)

FIGURE 2-8. 1969 ALCOHOL AUTOMATIC INTERACTION DETECTOR PLOT: MICHIGAN FATAL ACCIDENT FILE or reporting biases. However, the technique does appear to be worthy of further study, since it may provide estimates of exposure which are more accurate than those currently obtained. Without verification, however, there is presently little justification for the operational use of any group estimates obtained by this technique.

SUMMARY

Only one variable and one statistical technique were discussed, since few (if any) other such measures have been used as predictors of subsequent liability. The time of day (of an accident or citation) may have at least slight potential as a qualitative measure of an individual's driving environment. The statistical technique of induced exposure, based on reports of accident culpability, shows promise as a group exposure control, although further validation is needed.

SUMMARY OF CHAPTER 2

Level II sources currently have limited utility for individual assessment. With the exception of police accident reports and citations, research possibilities are also limited, since socio-legal and ethical issues frequently prevent access to information from other government or private agencies. Studies using accident reports, particularly in-depth multi-disciplinary accident investigations, do provide an important link in interpreting data from other levels of measurement.

Future research may eventually suggest the addition of other techniques to Level II sources. For example, enforcement officers issuing citations might routinely administer assessment variables to drivers (using Level III techniques) to identify deficiencies. Variables from multi-disciplinary accident investigations might also be included in standard accident reports, if found to have predictive validity.

The most useful variable from Level II sources appears to be BAC level obtained from arrest and accident reports. This variable is currently employed in numerous operational and research programs throughout the United States for diagnosing individual problem drinking. Divorce information might also be especially useful for driver problem assessment, since recent divorces have been shown to be closely associated with alcohol-related driving errors. Such information could be routinely reported by divorce courts to licensing agencies.

The remaining Level II variables appear less promising. At present, it is difficult to obtain biographical, psychological, medical and exposure information from other agencies. As will be seen later, it is more feasible to obtain these kinds of variables directly from the driver. In driver control operational settings such information can usually be obtained through pre-sentence investigations or driver improvement meetings and hearings. Consequently, Level II sources do not appear essential to driver diagnosis, but in cases where information flow difficulties can be minimized, the use of other agency data sources might still provide more timely and accurate information.

Chapter 3

INFORMATION FROM DIRECT MEASUREMENT OF THE DRIVER

There are numerous diagnostic techniques which have shown some utility for further delineation of potential driver problems, yet whose results are not usually available in driver licensing or other agency files. For application of these techniques, the driver must be physically located to be assessed. Although a few are applicable to telephone or questionnaire surveys, most of these techniques require the driver's actual presence at the assessing agency.

Many of the instruments and techniques which follow have been tried, on an experimental basis, in various operational settings. Others are purely research methods, with little or no current application potential. These are discussed primarily to provide perspective on current research objectives. It must again be recognized that any of these techniques could be routinely administered by a driver control agency, with the results stored in the license file. At present, however, this is not the case.

This chapter is divided into our main sub-headings:

- Driver Performance and Ability
- Human Conditions and States

  Biographical Variables
  Psychological/Social/Attitude Variables
  Medical/Physiological Variables

- Exposure Variables

DRIVER PERFORMANCE AND ABILITY

By direct measurement of the driver, a more complete analysis of the total driving task is possible. Although many such direct measurement techniques have been developed, few are currently employed except in research settings. The few exceptions are the performance testing required in license examinations (and occasionally re-examinations), which have been reviewed in Chapter 1, and the performance testing found in driver training programs, where utility is often claimed for both educational and performance-criterion purposes. The remainder of these techniques are limited primarily to experimental applications. As a result, much of this section will consist of exploratory research reviews, with greater implications for future research than for current operational diagnostic testing.

It is useful to categorize the research findings on driver performance by a conceptual model of the components of the driving task. One representative description of driving performance is the PIVAT model (Whittenburg et al, 1972, 1974), which includes the behavioral functions of:

1. Search
2. Detect
3. Identify
4. Situation Diagnosis
5. Action Selection
6. Action Execution

There are several reasons, however, that applying such distinctions to current driving performance research is not entirely practical. In one respect, these categories are too broad to provide an accurate description. The category of action execution, for example, could contain research on thousands of performance measures, representing hundreds of dissimilar driving tasks. In another sense, however, even these broad distinctions are artificial. The six components of the PIVAT model must be considered conceptual, since specific physical evidence cannot be uniquely isolated for each. For example, distinction between action selection and execution is often arbitrary. It is seldom possible to distinguish between "Was the proper action selected?" and "Was it well-executed?" Improper actions cannot often be well-executed, and inability to properly execute an action implies a poor action selection. Thus, researchers are frequently unable to isolate causal factors, even to broad degree of specificity outlined in the PIVAT model.

Consequently, to accomodate the overlap within the driving performance research studies, the PIVAT model will be somewhat condensed (as shown in Figure 3-1) for purposes of this review. This section will discuss three major categories, including:

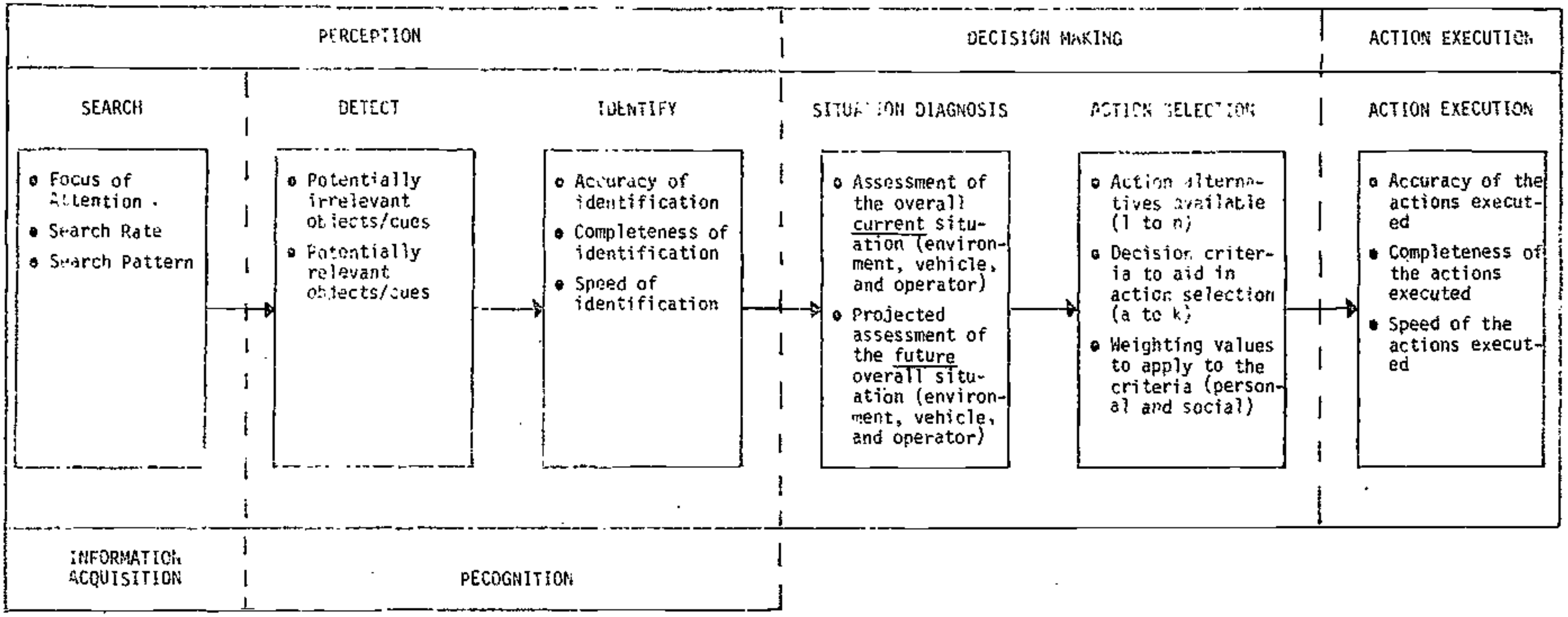
- Perception

  Information Acquisition
  Recognition

- Action Selection

- Action Execution

This general breakdown of the driving task seems to be the finest possible breakdown which still reflects the conceptual objectives of current research. The subdivision of perception is provided since many research studies address the entire perceptual process, while others address more specific components.



Source: Adapted from: Whittenburg et al. (1972)

FIGURE 3-1. BEHAVIORAL TASKS OF THE PIVAT MODEL

PERCEPTION

The past fifteen years have witnessed growing interest in the relationship of human perception to automobile driving. This increasing emphasis reflects more than a new research fad. As real world driving is studied in greater detail, particularly by recent multi-disciplinary accident investigations, the role of perceptual processing in the driving task becomes increasingly prominent. In an in-depth investigation of 215 accidents and less detailed on-site investigations of 836 accidents, Indiana University's Institute for Research in Public Safety (1973) found that 83.2% of the accidents involved some type of human factor as a direct accident cause. Examining categories within human factors, it became clear that perceptual errors (as opposed to performance errors, environmental factors, or vehicular factors) are heavily involved in accident causation. Information processing, or "recognition" errors were found to be definite causal factors in a substantial proportion (40.2%-48.1%) of the accidents examined. (Table 3-1 shows the percentage of involvement found for various causal factors.)

Indiana University's later re-examination of their MDAI data (Treat and Drakes, 1975) provides some additional insight into types of recognition errors which cause accidents. Table 3-2 presents their data for all accidents described as "driver suddenly perceives that another vehicle is approaching on a collision course," broken into 17 sub-categories. (It is assumed that these accident-involved drivers who "suddenly perceived" could also be described as "did not perceive until too late"). These 17 sub-situations were examined to determine if any patterns or clusters existed. Six of the seventeen situations (4,5,9,11,13, and 16) accounted for 60% of the "did not perceive" drivers. These six situations can be reduced to the following general categories:

- Driver does not see car coming from side or front toward vehicle (Situation 4,5,16)
- Driver does not see car next to vehicle. (Situation 11,13)
- Driver does not see car approaching from the rear. (Situation 9)

[1]One reviewer, Wright (1966), located approximately 50 articles dealing with perceptual (or information) processing, primarily visual, of car drivers. During the same period several hundred papers on psychomotor performance and accident predictive tests had been published (see for example the bibliographies of Goldstein 1961 or 1964). More recent bibliographies include Forbes (1972) and the International Driver Behavior Research Association (1973).

TABLE 3-1 SUMMARY OF PERCENTAGE OF ACCIDENTS IN WHICH DIFFERENT FACTORS WERE DEFINITE CAUSES

	Phases I & III COMBINED B*	Phases I & III COMBINED C*
Human Factors - Direct Causes	76.2%	83.2%
1. Critical Non-Performance	1.0	.9
a. Blackout	.8	.5
b. Dozing	.1	.5
2. Non-Accident (e.g., Suicide)	0	0
3. Recognition Errors	40.2	48.1
a. Driver Failed to Observe Stop Sign	3.8	7.9
b. Delays in Recognition - Reasons Identified	35.3	40.7
(1) Inattention	13.2	12.6
(2) Internal Distraction	3.3	6.1
(3) External Distraction	3.9	1.9
(4) Improper Lookout	16.4	22.0
c. Delays in Perception for Other or Unknown Reasons	3.3	4.7
d. Delays in Comprehension or Reaction - Other or Unknown	.7	.9
4. Decision Errors	41.5	36.0
a. Misjudgment	2.0	1.9
b. False Assumption	11.5	5.6
c. Improper Maneuver	7.3	7.0
d. Improper Driving Technique	4.9	5.[illegible]
e. Driving Technique was Inadequately Defensive	2.8	3.7
f. Excessive Speed	10.5	9.8
g. Tailgating	1.4	.5
h. Inadequate Signal	.8	.9
i. Failure to Turn on Headlights	.2	.0
j. Excessive Acceleration	.5	.5
k. Pedestrian Ran into Traffic	.5	1.4
l. Improper Evasive Action	6.9	8.9
5. Performance Errors	3.1	7.9
a. Overcompensation	1.8	4.7
b. Panic or Freezing	.6	0
c. Inadequate Directional Control	1.1	4.2
Human Conditions & States		
Physical/Physiological	3.9	2.3
Mental/Emotional	1.1	1.9
Experience/Exposure	3.1	.9
Environmental Factors - Including Slick Roads	23.3	16.4
Environmental Factors - Excluding Slick Roads	17.6	12.6
1. Highway Related	13.3	10.7
2. Ambiance Related	5.1	2.8
Vehicular Factors	5.7	4.2

B=On-site investigations, N=836
C=In-depth investigations, N=215

Source: Institute for Research in Public Safety (1973)

TABLE 3-2. TYPES OF ACCIDENT-RELATED PERCEPTUAL ERROR

	Situation Category	Number of Vehicles
1.	Driver, while traveling into an intersection (path or roadway), suddenly perceives another vehicle crossing in front in driver's path.	80 16.39%
2.	Driver, while traveling into an intersection (path or roadway) suddenly perceives that another vehicle is approaching towards driver's vehicle.	58 11.89%
3.	Driver, while traveling toward a roadway intersection, suddenly perceives first, a traffic control device requiring a stop, and second, another vehicle approaching on a collision course.	5 1.02%
4.	Driver, while entering an intersection (path or roadway), from a stopped or slowed condition, suddenly perceives that another vehicle is approaching towards driver's vehicle.	57 11.68%
5.	Driver, while entering an intersection (path or roadway), from a stopped or slowed condition, suddenly perceives that another vehicle crossing in front in driver's path.	32 6.56%
6.	Driver allowed vehicle to infringe upon or in the opposing lane of travel; driver suddenly perceives another vehicle approaching from the opposite lane.	27 5.53%
7.	Driver, traveling in own lane, suddenly encounters another vehicle coming from the opposite direction, infringing upon or in driver's path.	34 6.97%
8.	Driver suddenly perceives that another vehicle has slowed or stopped ahead.	62 12.70%
9.	Driver is slowing or stopped when suddenly another vehicle, approaching from the rear, creates a danger for driver.	64 13.11%
10.	Driver, traveling in own lane or passing suddenly perceives that another vehicle, traveling in the same direction, is veering into the driver's path.	19 3.89%
11.	Driver, while turning or changing lanes, suddenly perceives that another vehicle, from the same direction, is occupying the adjacent lane.	16 3.28%
12.	Driver, while traveling in own lane, suddenly encounters another vehicle pulling into driver's path from a curb or intersection (path or roadway).	9 1.84%
13.	Driver, while entering the travel lanes from the curb or an intersection (path or roadway), suddenly perceives that another vehicle is on a collision course with driver's vehicle.	7 1.43%
14.	Driver, while traveling into an intersection, suddenly encounters a stopped vehicle in driver's path.	4 0.82%
15.	Driver is stopped in own lane at a roadway intersection when suddenly another vehicle approaches towards driver's vehicle.	7 1.43%
16.	Driver, while backing (on roadway, from curb or driveway), suddenly perceives another vehicle in or crossing driver's path	5 1.02%
17.	Driver, while traveling in own lane, suddenly encounters another vehicle backing into driver's path from the curb or a driveway.	2 0.41%

Source: Treat & [illegible] 1975.

The only distinctions between these categories are directional, suggesting that the problem of failure to perceive may be more than simply a matter of inattention or vigilance decrement. The above data suggest that drivers either did not look in the right places to gather information, or were not sampling the appropriate areas frequently enough. Another interpretation is that some drivers do not adapt their visual search patterns to suit the requirements of different traffic situations. For example, drivers may exhibit all the traditionally prescribed "look far ahead and scan" habits, but not switch to a closer more careful look at intersections or road entrances. Some drivers might also not properly attend to peripheral information. Moving objects, located first on the eye's periphery, may not be recognized until the image has become foveal, when time to avert or avoid a collision situation has diminished. A likely conclusion is that each of the above interpretations, singly or in combination, may apply to different portions of the driving and accident-involved public.

Unfortunately, there is only a slight theoretical background for the assessment of a driver's perceptual performance. One area covers the psychology of perception, as well as the physiological operation of sensory-processing components of the human organism. Another viewpoint, referred to as attention theory, appears to have greater implications for traffic accidents. Because of the relatively recent reawakening of interest in attentional mechanisms (e.g., during the 1950's, following identification of the function of the reticular formation. See Magoun, 1961), there are many hypotheses, but few comprehensive theoretical positions, from which to integrate the facets of human attention and information processing. For example, a continuing dilemma is the finding that all stimulation impinging on the retina cannot be transmitted along the optic nerve to the central processor. There are too many stimuli to be transmitted, yet there is no evidence of neural structures which serve a preview and selection function, nor is there any evidence that a decision-making processor exists within the retina-optic nerve structure. There is currently no satisfactory answer to this question. The study of attention is just beginning to form a picture of information processing and attention. Applied researchers cannot expect to find an integrated body of theory to use as a starting point for developing comprehensive testing techniques. This explains, at least in part, the relative scarcity of tests in the perception-attention realm.

Although, accident analysis has demonstrated the importance of information gathering and attention failures in accident causation, these data do not precisely describe perceptual failures in behavioral or physiological terms. Without such description, development of test requirements (much less testing techniques) must be highly subjective. This lack of data further explains the limited success of diagnostic tests which have been developed to assess driver information processing abilities. To complicate the matter, attentional states fluctuate over time and are therefore difficult to test. Most tests are given under somewhat ideal conditions where subjects are "up" for the test, and rarely exhibit the sought after degraded state of behaviors.

The following pages will discuss the current research findings on (1) general perceptual characteristics, to be followed by the more specific findings concerning (2) information acquisition, and (3) recognition.

GENERAL PERCEPTUAL CHARACTERISTICS

A classic paper by Gibson & Crooks (1938) provided the first analysis of the role of perceptual processes in driving. Since then, a variety of models have been developed based on information theory (Ross, 1960; Senders et al, 1966; Allen, Lunenfield & Alexander, 1971; Barrett, Alexander & Forbes, 1973; Dumas, 1973) or closed loop control system theory (Rockwell, 1972; McRuer et al, 1974). The model posed earlier, the PIVAT Model (Whittenburg et al., 1972), includes all the basic elements found in the other models, except the mathematical transfer functions of McRuer et al.(1974).

Research investigators have studied numerous mechanisms as potential controllers of information intake and processing, such as perceptual style or field-dependence versus independence (Barrett and Thornton, 1968), and perceptual load (Bloomer, 1962). Each of these has been found related to perceptual driving performance. Generally, the methodologies originally used to study these functions as psychomotor skills have since been applied to a driving context.

Perceptual style as it relates to driving has been extensively studied. A review of this work was conducted by Barrett, Alexander, and Forbes (1973). Some of their major findings are included here:

> "Since the early 1940's, Witkin and several others have conducted a long series of studies aimed at classifying individuals with respect to their ability to extract salient information from a complex background (Witkin, 1965). They have called this ability perceptual style, with those who most demonstrate the ability being termed 'field-independent' and those who least demonstrated it 'field-dependent'.
>
> "It has been hypothesized that at least part of the driving task, that which deals with adequate responses to critical situations, requires the ability to identify pertinent information in the environment, and that this ability should be measurable (at least in part) on the field-dependence/independence dimension. The relationship between perceptual style and drivers' reactions to emergencies was first investigated by Barrett and Thornton (1968). Using a fixed-base simulator, they measured drivers' reactions to the sudden emergence of a pedestrian. Field-dependent

subjects were significantly slower in reaction time (r=.67), significantly slower in deceleration rate (r=.74), and more likely to hit the pedestrian (r=.50). In a study of matched groups of accident-involved and accident-free drivers, Harano (1970) found that a measure of field-dependence significantly combined with prior conviction frequency and annual mileage in a multiple regression (r=.64) to predict accident involvement. These results were further substantiated in the laboratory by Gallagher (1969) and in the field by Williams (1971).

"Lending support to the hypothesis that field-independent persons are perceptually more analytical, Boersma, Muir, Wilson, and Barnham (1969) recorded the eye movements of subjects who were taking the embedded figures test (a paper-and-pencil form of perceptual style test). They found that field-independent persons made more eye-shift movements between targets and alternatives. Anderson, Nilsson, and Henriksson (1970) tested a sample of drivers on the spiral-after-image test. Persons judged by this test to be "hyposensitive" (a construct quite similar to field-dependence) were found to have had more automobile accidents.

"At the abstract end, two measures of perceptual style appear to hold the greatest promise for accident research. Series 3 of the rod-and-frame test (Barrett and Thornton, 1968), and the three-dimensional embedded figures test (Williams, 1971), have the highest reliabilities and the strongest relationships with accident involvement. At a somewhat less abstract level, a series of filmed segments (either still or motion) of real traffic situations including a variety of each of the critical situations of varying complexity could be composed to run about twenty minutes and a standard scoring system developed for the driver's identification of pre-defined salient cues. At a real world level, the driver could be placed in a driving situation in actual traffic (either a closed track or on-the-road) and be observed while required to provide a running verbal commentary on those events in his own driving environment which he sees as likely to influence his own driving." (Barrett, Alexander, and Forbes, 1973)

Some of these findings deserve more detailed discussion. Harano (1970) conducted one of the few studies in which traffic accident data have been examined in relation to a measure of perceptual style. Working within the California Department of Motor Vehicles, he gathered a small group of 28 accident and 27 accident-free drivers to examine the relationship between field-dependence and motor vehicle accident involvement. A multiple regression analysis indicated that the field-dependence measures significantly increased prediction of prior accident involvement. The author concluded that measures of perceptual style such as field-dependence held promise for future research in traffic safety. Subsequently, Harano and other California DMV researchers (Harano, McBride and Peck, 1973) evaluated a larger contrasted sample (accident and accident-free drivers) using several hundred biographical and psychological variables, as well as measures of perceptual style and perceptual-motor coordination. Although the scores of the embedded figures test were significant in the final regression equation (predicting accidents), the simple correlation between field-dependence and accidents was not significant. The researchers concluded that the embedded figures test acted as a suppressor variable in the final equation, because of its near zero correlation with accidents and its relatively high correlation with other significant variables in the multiple regression: socio-economic cluster (r=.33), "elderly driver index" (r=.20), and age (r=.43). These findings suggest the need for further research on the apparently complex interactions which relate perceptual style to driving performance.

Other investigators have found slightly significant correlations between Embedded Figures Test scores and accident data. For example, Williams (1971) administered a three-dimensional version of the instrument which has consistently reported high reliabilities to a sample of accident-free and accident-involved commercial drivers. He found the three-dimensional test able to discriminate between the groups, while a simple hidden figure test did not (The two tests did not correlate significantly).

Much of the research has been concerned only with measures of perceptual style as they relate to specific components of the driving task. A study of eye movement and the Embedded Figures Test (Boersma et al. 1969) determined that subjects rated field-independent evidenced greater eye movement, with more alternative shifts between target and background, than did field-dependent subjects, suggesting a more critical and attentive approach to the driving environment.

Research has also examined the relationship between perceptual style and specific perception of danger in a simulated emergency task (Currie, 1969). Though most results have not been particularly promising, a significant relationship was found between accidents and time required to perceive the onset of dangerous situations.

Olson (1974) performed three studies exploring differences between extreme groups of field-dependent and independent drivers (N=20) on skid control and platoon car following abilities. Overall performance on skid control did not differ, although the field independent group showed improvement on the second trial. From the two car following experiments, Olson concluded that field-dependent subjects may not use information from vehicles ahead of the lead vehicle as appropriately as do field independent subjects. He hypothesized that field dependent drivers would be overinvolved in rear-end collisions, and recommended a large scale study relating perceptual style measures to accidents.

Though no significant correlations between perceptual style and speed estimation have been found (Barrett et al. 1969a), some studies do suggest tentative relationships. Case et al. (1970a) reported a negative correlation between speed estimation and driver age. Similarly, a deterioration in perceptual style has been found with increasing age (Barrett et al., 1973).

Exploratory research examining the potential for retraining field-dependent individuals has not been promising. In one small study (n=14), utilizing Rod and Frame Test scores to reflect field-dependence, Elliott and McMichael (1963) attempted to retrain space-orientation. Indicators were found that some perceptual improvement is possible. Reductions in errors subsequent to feedback (i.e., discussions of judgmental maneuvers) were significant, but proved to be transient and unstable.

To briefly summarize the tests which assess field-dependence-independence, the rod-and-frame device is portable and inexpensive, but must be given on a one-to-one basis and in a completely dark room. Any extraneous cues, eg., light reflecting off the floor or ceiling, will negate the test results, although further development may alleviate this problem. The embedded figures test is more practical, since it is a paper and pencil test that can be administered to groups. However, the rod-and-frame is highly reliable with a test-retest or r=.95, while the embedded figures test reliability averages only r=.58 (Barrett and Thornton, 1968). Much more research must be performed to determine how these tests are related, and what a diagnosis of field-dependence independence means, particularly for the large percentage of the population who will be in the middle of the scoring continuum.

Barrett et al. (1968) addressed some of these issues, examining how "perceptual style," as measured by the rod-and-frame test, is related to the field "dependence-independence" variables of the embedded figures test. Generally, he reported that the "better" one's perceptual style, the more field-independent, i.e., the more analytic and critical his observations are in respect to a more generalized stimulus background. (The correlation between the two measures was not reported.) Barrett et al. (1968) investigated perceptual style vs. driver reaction time in an emergency situation. Correlations of reaction time (braking and deceleration rate), after intrusion of a pedestrian dummy on a scaled highway system, with the perceptual style measures of the rod-and-frame test were encouraging.

Initial brake reaction time correlated r=.61 and deceleration rate correlated r=.74 with perceptual style. Subsequently, when Barrett (1969b) employed the embedded figures test, which had previously been shown to correlate with the rod-and-frame test, the results were not as promising. Using the embedded figures test, Barrett derived initial brake reaction time correlations of r=.54 and deceleration rate correlations of r=.49. These differences have led Barrett to view perceptual style as a multi-dimensional construct.

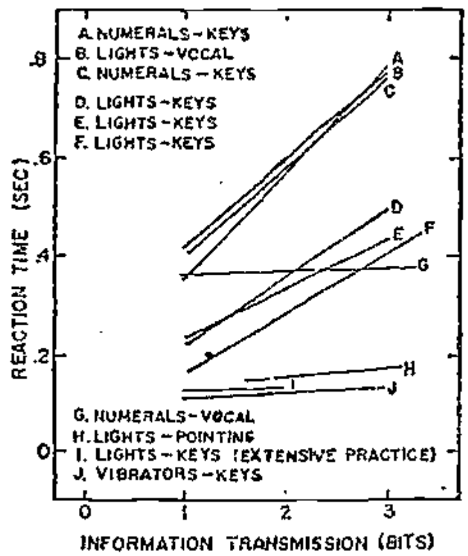
Information Acquisition

A major theoretical development which underlies much of the research to date in information processing, was the demonstration that man is basically a single channel processor (Broadbent, 1958; Mostofsky, 1970). This development has focused considerable attention on how a driver searches for, and selectively processes, sensory input.

One implication of the single channel processing theory is that as information load increases, the task of sorting, ordering, and selecting which stimuli to process (or selecting only the relevant cues among stimuli) increases, and the required time for processing and subsequent response lengthens. This has been empirically demonstrated in a number of studies. Figure 3-2 gives composite data for 10 laboratory studies, employing a variety of tasks, showing that response time increases as the amount of information increases (Posner, 1966). There appears to be some interaction with stimulus-response compatibility, but generally, processing time increases with increasing information load.

Applying these findings to the driving situation may provide useful insights for assessment. The sensory complexity (mainly visual) of driving scenes varies widely. An increase in processing and response times would be expected in increasingly complex situations, but would be of little diagnostic consequence if all drivers experienced similar changes. However, if people process information differentially, then perceptual processing, motor response time, and expectation of other drivers' actions can be differentially assessed.

Several researchers have proposed information processing models applicable to the driver population (e.g., Rockwell et al., 1967; Schlesinger and Safren, 1962; and Fergenson, 1971). Their criterion measure has often been a type of reaction time measurement. Schlesinger and Safren (1962) proposed a model in which the driver operates to maintain a optimum planning/decision-making performance situation by constantly monitoring the "field-zone ratio" with which he is confronted. The parameters of this field-zone ratio are controlled both by the speed and direction of his vehicle. Their discussion of this model states:



Source: Posner, 1966

FIGURE 3-2. REACTION TIME AS A FUNCTION OF INFORMATION TRANSMITTED FOR TASKS OF VARYING LEVELS OF STIMULUS-RESPONSE COMPATIBILITY

"In the model, the major task of the driver is the perceptual organization from moment to moment of the field of safe travel (a region in which the car can move unimpeded), a minimum stopping zone (the smallest region through which the car must pass to come to a full stop), and a comparison of these two fields. The driver's organization of these two fields, or the field-zone ratio, is a controlled stimulus guiding the control actions of the vehicle. That is, the driver varies the speed and direction of movement of the vehicle to maintain a safe field zone-ratio--one in which the field is greater than the zone."
(Schlesinger and Safren, 1962)

They felt that the result of the pilot study (employing a Drivometer[2]) supported the concepts of the model. That is, a "driver who accurately processes the incoming information has less occasion for abrupt speed and direction changes due to unexpected contingency". The skillful driver would tend to be a "smooth driver".

Numerous research studies have been unable to discover relationships between simple reaction time and accident involvement (See Goldstein, 1961). Currie (1969) could find no difference in simple reaction time between accident repeaters and accident-free drivers, although his accident group was significantly slower to perveive imminent collisions in a simulator.

Reaction pattern, or the relation between the times for onset of stimulus and onset of response, have been suggested as more relevant to the driving task. Babarik (1966) tested 127 cab drivers and found drivers with slower reaction in the complex test situation to be more involved in struck-from-behind accidents. Barrett et al. (1973) reviewed research supporting the reaction pattern concept, but were unable to verify its diagnostic utility. Harano et al. (1973) employed several complex reaction pattern measures (e.g., time-sharing capacity), and found only small correlations with accident involvement. None of the psychomotor measures were significant in the final prediction battery measure developed in the study.

Hakkinen (1958) using several simple, disjunctive, and choice reaction situations found no significant relationship to accidents for a sample of bus and train drivers. However, on eye-hand coordination tests, accident groups generally performed poorly. Additionally, using complex choice reaction tests on a part task driving simulation,

[2]They found test-retest reliability of the Drivometer to be very high ($r=.95$).

several measures were found to distinguish between accident groups and safer drivers.

Fergenson (1968) compared both simple and three choice reaction times to driving record. He concluded that information processing time discriminated accident (low speed processors) versus non-accident higher speed processors) drivers. Subsequently, Fergenson (1971) studied seventeen subjects matched for driving experience, divided into four groups according to accident and violation records. He again found that those who had a high accident record processed information at a significantly lower rate ($p<.01$) than did non-accident subjects. However, subjects who had many violations but no accidents were the best information processors. Fergenson hypothesized that anxiety might act as an intervening variable in the ultimate execution of driving tasks, suggesting the possibility of diagnostic evaluation of drivers based on information processing variables by comparison of single- and multiple-choice reaction times. Fergenson cautioned, however, that his sample population was small, all male, and of a narrow age range, and emphasized that further research is needed.

Since anxiety might relate to information acquisition, several studies have examined various measures of stress in relation to driving performance. Stress can be defined as a general condition induced by a variety of parameters, including fatigue, alcohol, drugs, complexity, and uncertainty. Smith (1972), in reviewing eye-movement and other related research, found that stress degrades the information acquisition process. Generally, loss of peripheral information and changes in eye movement patterns occur. Adaptation to the different types of stress varies. The intoxicated driver is less sensitive to directional and speed requirements, while the tired driver enlarges his eye movement patterns. These same performance degradations have been found under stress in a variety of non-highway settings (e.g., Gibbs, 1967).

Excessive information load can be viewed as a type of stress. Driving performance has been examined under various stimulus overloads, generally by secondary task incursion. Stephens and Michaels (1964) have shown that laboratory simulator performance on driving tasks deteriorated when subjects were required to perform two tasks simultaneously. (Brown, 1966, 1967a, and 1968) examined the concept of spare mental capacity by having drivers perform a secondary auditory task while driving in various traffic settings. He found some evidence that drivers better able to attend to both driving and a subsidiary task may be those who are best able to process more incoming stimulus information. Since accident experience was not a criterion in any of the applications of the technique, little can be said about its potential diagnostic utility. However, the technique of imposing a secondary task (loading) may be a useful means to include a measure of stress with other attentional and skill measures.

The use of the threat of stress (in the form of electric shock) is being explored as a test to detect individuals susceptible to performance disruption because of stress (Gibson, 1971). This application was intended for military flight school, and does not appear practical for use with drivers.

A very general theory of attention and performance was provided by Hebb (1955). His activationist hypothesis states that the relationship between performance and arousal forms an inverted "U", so that up to a point arousal increases performance, but above certain levels of arousal performance deteriorates. This concept may be useful in exploring the relationship of psychological and social stress factors with accident involvement. As will be seen later, drivers involved in fatal accidents are frequently characterized as having high stress backgrounds. From the multidisciplinary accident investigations, "attention" was found to be one of the leading causal factors. The delineation of relationships between stress and attention appears to be a fruitful area for further research.

Research to date has been hampered by the lack of operational measures of stress. Development is currently experimental in nature, and psychometric characteristics are frequently not reported. Various physiological measures have been devised, e.g., heart rate variability (O'Hanlon, 1972), alpha rhythm (Sugarman and Cozard, 1972), but these are intended as experimental measures to be taken over long time periods, and are not directly relevant to the diagnostic assessment of driver problems.

A phenomenon apparently related to excess information load, response blocking (i.e., inability to respond to a situation, "freezing up"), has been studied since the 1930's as a factor associated with human performance. Teichner (1968) reviewed the literature on this subject, and suggested that response blocking occurs under conditions typically found in driving. These are:

- The more complex a task or the higher the information flow rate, the more frequent and longer the duration of the blocks.
- Reaction time increases markedly 4-5 responses prior to a block.
- Frequency and size of response blocks increase with fatigue, lighting conditions, and conditions which reduce oxygen uptake, transport, and perfusion (CO_2, age, alcohol, altitude).
- Occurs as a reaction in emergency conditions and to conflict in decision-making situations.

Apparently no test or experimental work related to driving followed Teichner's article, although response blocking may have potential applications to driver problem assessment.

Performance is also degraded by insufficient incoming stimuli. Case et al. (1970a) found that driver judgments regarding speed vary widely when observing the same stimulus situation, and that supplemental information (e.g., posted speed signs) may exert a negative influence upon the accurate perception of one's own traveling speed. Similar results in other studies, however, may have been the result of distinct characteristics of driving simulation in the laboratory. Salvatore (1969) determined that by varying the nature of sensory input, one can directly alter the perception of traveled velocity. The removal of the "force sense feedback mechanism" (i.e., sensory acceleration cues) acts to reduce the true ratio of estimated to actual speed. In fixed-based simulation, where kinesthetic feedback is not available to a driver, much of the cueing which occurs in real world driving may be absent. Decision making and information processing are consequently delimited and inaccurate.

Since both insufficient and excessive information input can degrade driving performance, techniques to precisely measure the amount of incoming stimuli would appear especially useful. Senders et al. (1966 and 1969) developed a technique for occluding a driver's vision, a head mounted face shield blocking the driver's view. In some cases, the driver was allowed to raise the shield when he needed more information, or occlusion could be timed and controlled externally. As expected, drivers left the shield over their eyes significantly longer when there was less dense traffic, fewer roadside obstructions, straight, clear road ahead, and at slower speeds. These findings do support Senders' (1973) uncertainty hypothesis of time devoted to gathering information--the extent to which a driver attends to a particular part of the highway scene or car interior depends on his uncertainty about both the position of his own car, and that of other vehicles and obstacles on or near the road.

These authors suggest that under conditions of controlled speed, the voluntary control of occlusion interval gives a direct measure of information load. Some slight individual differences were also noted, which suggests a potential for diagnosis. It is apparent however, that for this purpose, all stimuli (not simply speed) must be controlled. These conditions would be possible only in a driving simulator. In the present study, since the technique was used for experimental purposes and was not intended for assessment, no reliability or validity data were reported. Under controlled conditions, future research examining relationships with individual driving records may suggest diagnostic potential. However, as with the eye movement techniques there are test time and equipment constraints which make the device unattractive for individual diagnosis.

Since the driver is basically a single channel processor operating in complex stimulus situations, the factors which determine what and where he attends, and which stimuli he processes, are especially important. Research directed toward these factors has been aided by the development of a reliable, useful measurement technique. The eye marker camera has evolved into a device which is now helmet mounted, relatively light weight, and no longer requires a bite bar (Rockwell, 1972), although it is still expensive and time consuming. Eye movement markers have been found to give reliable results. Rockwell (1972) reports that subjects tested several different times evidence remarkably similar scan patterns across tests, although the specific correlation was not given. Eye patterns have been found to be consistent over testing times of several hours, allowing the effects of various conditions and scan patterns to be reliably studied. However, it is doubtful that a driver with test gear on his head performs the same as without the gear, as was demonstrated by Allen, Schroeder, and Ball (1974). Using a simulator with TV display to present dangerous traffic situations, they found fewer long eye movements and more fixation errors when head movement was restricted by equipment than without it.

Despite this difficulty, studies of eye movements have produced a number of interesting findings. Rockwell (1972) has used eye movement recording to examine driver search-and-scan patterns under varying conditions of fatigue, alcohol, night and other road conditions, and traffic density. Both fatigue and alcohol resulted in a narrowing of the visual field searched, or the tunnelling effect. Another finding of eye movement analysis is the difference in search-and-scan patterns of novice versus experienced drivers (Mourant and Rockwell, 1971). Novice drivers often spend excessive time searching the environment for cues, do not fixate long enough on the relevant cues to gather adequate information, and spend too much time looking at road position cues close to the car. The experienced driver scans further in front and to the right side of the road, while positional cues are gathered peripherally (Bhise and Rockwell, 1971). To the authors' knowledge, however, there is currently no evidence of a relationship between search-and-scan patterns and traffic accidents. There may however be some diagnostic potential for eye movement measurement, for detection of individuals who use extremely inappropriate or inefficient search-and-scan techniques. Predictive validity studies, establishing strong relationships with other criteria, would of course be required. Further development will also be necessary to adapt the test for operational assessment. Despite recent advances, the usefulness of eye marker systems in operational settings is currently questionable, since test administration and scoring time are very long (30-45 minutes). A much simpler testing and scoring system are essential. Possibly monitoring gross eye and head movements, as attempted by Robinson et al, (1972), or using a motion picture display instead of on-road testing would increase testing efficiency sufficiently for operational purposes.

To summarize the research on information acquistion, there does not appear to be any compelling evidence relating information acquisition to traffic accidents. Information acquisition is only the first step in the total driving performance process. While it is possible that one parameter could disrupt the entire chain of behavior, only slight relationships of information acquisition measures with accident history have been noted. This suggests that the information acquisition measures will never be strong accident liability predictors for a large number of drivers. Individual differences on these measures have also been noted, however, suggesting that these variables may be appropriate only for a particular subgroup (perhaps those few for whom information acquisition is sufficiently poor to disrupt the entire chain of driving behavior). Further research is definitely needed to integrate this area of measurement with other areas of driver performance.

Recognition

Several tests of driver recognition have been developed, all involving recognition of hazardous traffic situations.

Using pictures from a Shell Oil Company filmstrip, McPherson and Kenel (1968) developed the Traffic Hazards Perception test, in which subjects indicate degree of hazard depicted by different traffic situations. The test was used as a criterion to determine whether the perceptual habits of individuals with learning disabilities would change after training. (The test has not been validated against accidents or "real world" driver performance, nor was test reliability (established.)

In 1972, the Traffic Hazards Perception filmstrip and test were replaced with a new filmstrip and the corresponding Perception of Driving Stimulus Test. This test is a series of scenes exposed for five seconds, and a series of questions (true-false) is then asked after each scene.

Development of the test began with an inspection of each filmstrip scene to determine relevant cues for driving, and pseudo-cues. Pseudo-cues are either irrelevant or not present, and are used in the test to determine whether a subject is falsely perceiving the driving scene. Scoring involves the simple number of items correct. Two parallel forms were constructed one intended for testing, and the other as a teaching aid.

Both forms of the test, as well as the older Traffic Hazards Perception Test, were administered to 215 high school driver education students. All students received the tests in the same order. Split-half reliabilities (KR-20) of Part I r =.74, and Part II r =.68, were reported. For the Perception of Traffic Hazards Test, split-half reliabilities of r = .13 (Spearman-Brown) and r = .35

(odd-even) were reported.

Originally, the Perception of Driving Stimulus Test was to be validated by correlation with the Traffic Hazards Perception Test scores. These correlations, item by item and total test scores, were not significant. Face validity was established by submitting the tests to four "nationally recognized driver educators." The panel agreed that:

"1. The Perception of Driving Stimulus Test did measure the ability of the student to perceive relevant cues in the driving scenes presented.

2. Both Part I and Part II were measuring this criterion to the same degree.

3. The Perception of Driving Stimulus Test was a valid tool to be used in the measurement of the stated criteria. The panel was unanimous in their concurring opinions. It was determined that face validity does exist for the Perception of Driving Stimulus Test." (Versace, 1972)

At present, no evidence of predictive validity is available. A study of predictive validity using license applicants and follow-up accident records is currently being conducted in the State of Maryland. The findings of this study should resolve the unanswered questions about the diagnostic utility of this technique.

An earlier study conducted by Spicer (1964) developed another potentially useful hazard perception test. The instrument consisted of an 11-scene 16 mm. silent picture film depicting typical city and highway traffic conditions, along with a checklist of items for each scene. The response checklist was derived from the responses of a sample of accident-free professional drivers. The list had 12 items, eight of which were positively weighted by the frequency with which the professional drivers had responded to the item. The remaining four items referred to things that did not appear in the film sequence. A group of 26 college students was administered the test and a re-test, which yielded a reliability coefficient of .81. Further item analysis of each scene to determine its ability to discriminate between accident-free and accident repeaters, however, indicated that this form was ineffective, and the checklist was revised and re-tested on a sample of 209 professional drivers.

Further refinement of the instruments resulted in a new Visual Perception Test, which also had 11, 35-second scenes depicting a variety of traffic situations. Forty-seven skilled drivers reviewed the scenes, and their responses were again used to develop the final checklist. All persons between 15 and 17 years of age, who applied for a driver's license at the Honolulu Police Department between July 1 and September 7, 1962, were then administered the test (N=875). An elaborate follow-up system was devised to ensure that all drivers who had participated in the study, and had subsequently become involved in accidents, were detected and recorded. When the test responses of matched accident-free and accident-involved subjects were compared, significant differences on Visual Perception scores were found. The test apparently reflected the inexperience of the 15 to 17 year old driver, since Visual Perception Test scores for this age group were lower than those for a sample of older drivers. The youthful drivers reflected lack of awareness of vital cues, and the consequent inability to appropriately anticipate certain events.

Adams (1968) reports that the technique of stimulus accretion was able to differentiate between two groups of accident and accident-free drivers. Reliability of the technique was acceptable (.75+ for test-retest), but validity predicting follow-up accidents was not substantiated (Weinstein, 1970).

Another technique is commentary driving. Nine older and 11 younger females described hazards while driving. No differences in various manipulative skills (as measured by the HSR car) were found, but the younger group more often reported non-moving objects as a threat. The older group saw equally as many moving and non-moving objects as a threat, confirming that differences in selective attention accompany variations in age and experience (Soliday and Allen, 1972).

In summary, there appear to be enough positive results from hazard perception related tests to warrant further research. The techniques require relatively short administration times and can be administered with a minimum of equipment. At present, however, there is little (if any) evidence of predictive validity. Unfortunately, most research efforts cited do not reflect sufficient continuity to adequately understand the principles involved. Test construction efforts do not appear to go much beyond initial test development. For example, Schuster (1971) used a simulator film of hazardous situations and asked questions about the situations by stopping the film and projecting multiple choice questions on the screen. The first version of the test was item analyzed and revised, but to the reviewers' knowledge no other research has been reported. Further research is definitely needed to establish predictive capability.

Research is also needed on the causes of recognition errors. For the younger driver, recognition errors may result from lack of experience, while the older driver may have deficient visual abilities or visual habit patterns. The evidence presented here suggests potential for a valid and reliable hazard perception test, but further development will be required for general diagnostic application.

Summary of Perception Research Findings

Through analysis of accident data, perceptual processes have been shown to be a prime accident causal factor. In one study, 42.5% of all accident-involved drivers did not perceive the collision in time to take any useful avoidance action. Accident data have not yet provided more specific behavioral details.

Research has been conducted attempting to relate perceptual characteristics and accident experience. Low correlations characterize most of these findings, and none demonstrate especially strong predictors. The apparent conclusion is that each phase of human information processing contributes to the driving operation, and can potentially contribute to an accident, although individual differences of performance on each phase make only a small contribution to the total accident problem.

Perceptual style as measured by the rod-and-frame test has a demonstrated (although low) correlation with accidents. The test has excellent reliability, but administrative characteristics are not conducive to large scale testing. To be useful, a more face-valid method would be desirable.

Although threat of physical stress is being developed as a measure for airplane pilot selection, application to driving does not appear feasible. Hazard recognition tests also show potential, but currently have no utility since little predictive validity has been demonstrated.

In summary, while perceptual errors are a major accident causal factor, the field of perceptual measurement appears to be only slightly useful for accident prediction. However, diagnostic potential may be promising for particular sub-groups with exaggerated perceptual problems.

ACTION SELECTION (DECISION-MAKING)

Poor action selection, or "decision-making," by drivers is also a major contributor to accidents. Analysis of data from multidisciplinary accident investigations by Indiana University suggest that decision errors, especially false assumptions, are frequent causal factors in crashes. On-site investigations of over 400 crashes revealed decision errors of various types were responsible for 36% to 58% of all the human-error accidents. (Human error was causal in 70% to 80% of the total accident sample.) False assumptions[4] by the driver were responsible for as many as 13% of the investigated errors. (Institute for Research in Public Safety, 1973).

Driving is a highly complex psychomotor task which requires sophistication in perception, action selection, and execution. In 1968, Ward Edwards, at the Second Annual Traffic Safety Research Symposium of the Automobile Insurance Industry, spoke directly to the issue of research on decision making as it relates to highway safety:

> "The relationship obviously exists and is critically important. People pass on blind curves at 75 m.p.h. because they choose or decide to do so. They run red lights and stop signs because they decide to do so. They fail to believe the abundant evidence to which they are exposed demonstrating that they endanger themselves and others when they drive after ten drinks; that is, they fail to process that information properly." (Edwards, 1968)

This section will review the research on the decision-making processes of the average driver (i.e., rational driver proceeding in an unaltered state, not intoxicated, fatigued, retarded, etc.) that is applicable to the diagnostic assessment of driver problems.

[4] "False assumption: This category applies whenever a driver takes action, based on a decision or opinion arrived at by assuming that to be true which in fact is not true. For example, if a driver pulls out in front of another driver who is signalling a turn, assuming that the other driver will turn before reaching his location, the original driver's mistake is properly classified as a false assumption. In this instance, the false assumption category is to be distinguished from inadequately defensive driving technique, over which it takes precedence when the fact of a false assumption has been clearly established.
Additional examples of false assumption include assumptions that other drivers must stop or yield at intersections, when in fact they do not; that a vehicle is going to make a turning maneuver which it does not, and assuming that no traffic is coming when in fact there was traffic coming..." (Institute for Research in Public Safety, 1973)

Every driver must process constantly changing "signals" with optimal efficiency. He must receive inputs from both environment and vehicle, relate these to previous experiences, process the information, and choose an appropriate output behavior. Since much is unclear about the links in this chain of behavior, decision-making presently offers little prospect as a diagnostic tool in an operational setting. Edwards concluded his statement regarding the implications of decision-making and driving with a similarly pessimistic view of prior research:

> ".....I do not plan to talk about studies of drivers processing information and making decisions about driving. My reason for not doing so is simple and compelling, at least to me: I know of only two or three such studies, and not one fits into an intellectual pattern that might point toward imporved highway safety." (Edwards, 1968)

There have been at least three major reviews of research pertaining to driver decision-making processess, but none has reached positive conclusions. In 1966, A.D. Little, Inc. investigated "driving as a skill." Little's review of this area was concerned with human factors as found in the man-machine system of highway driving, and limited utility was found in the research which was available at the time.

> "Despite the importance of this area, very little useful information has been produced so far. Most of the effort has gone into the development of instrumentation and other techniques, but many of these studies have been exploratory. To our knowledge, no one has produced sufficient data to establish his method as suitable for revealing useful, clear-cut, functional relationships, although some suggestive results have been obtained.
>
> "Some work has also gone into the study of sensorimotor and perceptual motor coordination as it applies to driving; but again, work here has not moved from the exploratory stage to the collection of useful data. Judgment (in predicting when driver and on-coming car will meet, in estimating following distances and in deciding when to pass) is perhaps the best studied subject in this area.
>
> "A most complex, but potentially very rewarding extension of these methods is the investigation of changes in judged or perceived risk compared with changes in actual risk. We have found no work in this area." (Little, 1966)

A.D. Little found the most promise in the assessment of driver judgments. However, investigations were (and are still) primarily limited to the discrepancy between the driver's estimate of some physical dimension in the driving performance environment and the actual measurement of that physical dimension. Specifically, there are three areas of psychophysical judgments which are discussed by A.D. Little--distance between on-coming cars, following distances, and passing or overtaking. Studies in each of these areas have suggested that drivers have difficulty in making accurate judgments of physical dimensions. None of the reported research was designed, however, to indicate a relationship between judgmental behavior and accidents.

Barrett et al. (1973) conducted an extensive literature review to analyze driver training requirements for decision-making in emergency situations. Their conclusions, some seven years subsequent to those of A. D. Little, also emphasize the scarcity and lack of rigor in research relating to diagnostic evaluation. They adopted a limited perspective "perceptual information processing theory" to guide their survey. They then identified specific techniques for measuring critical decision-making performance, and report four basic findings:

(1) No systematic research program had measured a range of individual intrinsic (causal) predictors.

(2) There were serious deficiencies in the criteria used in research studies. Accident data were inaccurate, and systematically biased, rendering them "virtually useless." (He also noted the fallacy of one underlying assumption of such criteria, that both individual characteristics and accident involvement data will remain constant across time and across all types of hazards and situations.)

(3) There was confusion between what he called intrinsic and coincidental predictors. He concluded that only intrinsic predictors (e.g., perceptual style) should be considered for operational settings, and that coincidental predictors, such as age, socio-economic status or marital status, are not very useful for problem identification.

(4) Most experimental studies reviewed used a postdictive validation procedure, without true predictive validity.

Barrett et al. were able to identify four "intrinsic predictors" via this literature survey. They are: (1) perceptual style; (2) reaction patterns; (3) frustration tolerance; and (4) attention. He portrayed research dealing with these dimensions as sufficient to warrant further investigations and proposed a pilot diagnostic classification system utilizing available test instruments along these dimensions.

A review of risk-taking behavior and probability theory was performed by Solvik (1964). He reports a general agreement that risk-taking is a determinable psychological variable, although the instruments and techniques available to assess this variable are (at best) rudimentary. He also pointed out the abundance of confusion and theoretical contradiction in research findings, and proposed a broader perspective for future research.

Generally, the state of the art of driver-decision problem assessment is characterized by growth in disparate directions by various researchers. These directions include the following general areas: information processing; risk-taking and probability theory; and driver judgments regarding psychomotor task requirements (e.g., direction, speed, passing, etc.). The results of the research often conflict. Much is still exploratory in nature, and diagnosis has generally been unsuccessful. There is also the confusion and difficulty associated with an extremely complex area of primary research. Basic research is needed, and applied research is currently of limited value.

Perceptual Style and Decision-Making

The report by Barrett et al. (1973) is one of the more comprehensive works on decision-making performance in emergency situations. Their literature review revealed few studies even peripherally concerned with the area, and concluded that decision-making was, in relation to driving, an ill-defined construct. They proposed a definition of decision-making based on the human information processing model, relying on psychological literature (both experimental and theoretical) to formulate his basic constructs. The components of the model are divided into pre-cue and emergency situations. Pre-cue processess include the (a) stimulus onset; (b) identification of potential influencing event; (c) evaluation of alternatives in terms of future actions; and (d) evaluation of possible actions. The emergency components include (a) evaluation of alternative outcomes of a critical event; (b) determination of actions; (c) selection of a response; and finally (d) executing a response.

Using this model, Barret et al. then delineated the critical situations in which driver decision-making is especially important to accident avoidance or occurrance, believing this taxonomy to subsume 70% of all highway accidents. These critical situations include:

1. Passing
2. Following
3. Laterally moving vehicle
4. Laterally moving object
5. Tracking
6. Gap acceptance
7. Intruding approach
8. Skidding

Barrett et al. then identified four "intrinsic predictors" of driver decision-making which suggest techniques for measuring critical performance:

1. Perceptual style (the ability of an individual to extract relevant cues from a driving scene);

2. Reaction pattern (the relationship between perceptual speed and motor speed);

3. Frustration tolerance (the ability to control hostility in frustrating driving conditions); and

4. Attention (performance under conditions of task overload and monotony)

Since tests of perceptual style had previously exhibited low common variance, Barrett et al. proposed that the four intrinsic predictors might be combined into a single battery, which could function as a diagnostic classification system.

Critical situations were defined as singular requirements of the specific performance measures. For example, a situation such as "passing" might require particular combinations for urban, rural, or thru-way conditions. These conditions might be further defined by day versus night driving variables. The specific diagnostic instruments which Barrett et al. isolated as pertinent to the measure of decision-making along the four predictor dimensions are presented in Table 3-3. They then proposed training to modify behavior in these critical situations, and development of a cost-benefit evaluation model of the training materials.

This review and proposed pilot diagnosis/training model represents the most comprehensive effort encountered in this survey. Cost factors and operational feasibility as presented by these authors are persuasive; but as they have pointed out, these concerns need verification in a diagnostic setting, ultimately by valid accident data.

A much publicized study by the Franklin Institute Research Laboratories (1970) attempted to measure the ability of drivers to judge the speed and distance variables that characterize the driving situation, as well as the relationship between these variables and the decision to pass. It was found that all the drivers were generally poor judges of decision parameters. In both sight distance and on-coming car distance judgment, subjects tended to over estimate short distances and under-estimate long distances. Distance judgment was not strongly affected by night conditions or inclement weather. Franklin Institute concluded that passing decision-making is generally unreliable and approximately 5% of the passing opportunities which driver subjects accepted would be objectively characterized as hazardous. The results further indicated that drivers vary across a wide range of reaction times and respond

TABLE 3-3. MEASUREMENT OF DRIVER DECISION PROBLEMS VIA 4 "INTRINSIC PREDICTORS"

PERCEPTUAL STYLE
At the abstract end, two measures of perceptual style appear to hold the greatest promise for accident research. Series 3 of the rod-and-frame test (Barrett & Thornton, 1968), and the three-dimensional embedded figures test (Williams, 1971) have the highest reliabilities and the strongest relationships with accident involvement. At a somewhat less abstract level, a series of filmed segments (either still or motion) of real traffic situations of varying complexity could be composed to run about twenty minutes, and a standardized scoring system developed for the driver's identification of pre-defined salient cues. At a real-world level, the driver could be placed in a driving situation in actual traffic (either a closed track or on-the-road) and be observed while required to provide a running verbal commentary on those events in his own driving environment which he sees as likely to influence his own driving.
PERCEPTUAL-MOTOR REACTION PATTERN
At the abstract level, this construct appears to be most related to driver decision-making through measures of either the spiral maze (Gibson, 1964) or Reuter's ADM (Adams & Cuneo, 1969). The ratio between simple reaction time and limb movement time on a standard reaction timing task would provide a measure somewhat closer to real-world conditions. During actual driving, an instrumented vehicle could provide measures such as braking responses and steering wheel reversals.
FRUSTRATION TOLERANCE
In order to measure this construct under laboratory conditions, a simple reaction time task could be used. A simple response to a simple stimulus would be learned until both response delay and response intensity had become stable. Following this achievement of stability, varying degrees of frustration would be induced on the subject, and increases in variability of both latency and intensity of the response would be measured. Under real-world conditions, observations of a driver's steering and braking responses under frustrating driving conditions would provide the measure.

Source: Barrett et al. (1973)

TABLE 3-3 (Continued)

ATTENTION

While the construct of attention is logically appealing and conceptually of potential value as an individual predictor of accident involvement, its usefulness can only be analyzed after a careful process of conceptual and operational definition and additional empirical research.

At an abstract level, this construct is possibly best measured by G.S.R. (palmar method) activity under both low and high information environments. At the real world end, observations of the number of responses made by a driver in low and high traffic densities could be used.

unsystematically to distinct cues in the environment. This suggests that perceptual style idiosyncrasies within the normal driving population may have potential diagnostic utility. However, the study suggested that providing a driver with factual knowledge of his critical situation (feedback) did not greatly improve his judgmental accuracy. "In general the results indicated that drivers cannot perceive and integrate the information necessary to arrive at a safe and reliable passing decisions for the range of conditions considered."

There is some indication that performance training with feedback may improve passing judgment (Lucas et al., 1973). In a study currently in progress (Quenault, 1974), drivers in five countries (Federal Republic of Germany, Italy, Sweden, United Kingdom, France) are being evaluated (via field observation) on their overtaking behavior. Generally, a substantial proportion are "non-safe overtakers." who proceed on the basis of a relatively low level of information. Non-safe overtakers appear to use their rearview mirrors less, drive at higher average speeds, drive with greater variations in speed, and commit more frequent driving errors. Further analysis is underway to determine the relationship of perception, comprehension, decision, and action execution in non-safe overtaking. One of the most popular constructs related to driver decision-making is risk-taking. Gumpper and Smith (1968) synthesized earlier risk-taking items, and consolidated them into a test for drivers, but were unable to discriminate high and low accident truck drivers. Rockwell et al. (1967) have combined some of the more common viewpoints involving decision-making and driver performance. They found that information-seeking reaction time and risk-taking ("risk acceptance") are associated. Using a "risk simulation," a large portable console with a variable speed arm equipped to administer shocks, they determined various risk-taking propensities in relation to degree of information-seeking. Their assumption was that risk could be a primary determinate in any decision during driving, i.e., "Where no chance of failure exists the only decision is whether there is anything to be gained from completing the action." They report that high risk-taking and information-seeking behavior are related, and that low risk-takers seek the most information (r=.66), suggesting that training to modify information-seeking behavior might be useful, even if training to modify risk-taking behavior is not.

The research community has generally viewed risk-taking as a unitary construct. Solvic (1964) after an extensive survey of the literature, suggested that a multi-dimensional construct was needed. In this regard, Jackson, Hourany, and Vidmar (1972) proposed four hypothetical risk-taking constructs: monetary, physical, social, and ethical risk-taking. Specific personality measures were then constructed. Correlational and factor analyses were performed, which these researchers belive provide support for their four-trait model of risk-taking.

Another model has been proposed by Haight (1972), with ten parameters representing the experience of drivers in complex traffic situations. Primarily a mathematical model, it postulates that drivers observe danger imperfectly at specific times. It suggests that drivers pass through hazardous Situation A, which may or may not hold the potential to become a dangerous situation, into hazardous Situation B, which is recognized in relation to Situation A. Thus, drivers are portrayed as proceeding in a decisional-behavioral dimension. While theoretically intriguing, the model has little empirical foundation.

Other risk-taking research has been based on experimental work (e.g., Cohen et al. 1956) which indicated that actual skill and perceived skill are important components of risk. A series of hypotheses and experiments were conducted by Cohen et al. (1968), requiring subjects to make distance judgments and drive between two posts. Before attempting the task, the driver was asked to tell the emperimenter whether he though he could make it between the posts, and how confident he was in his judgment. The test can be conducted either by the experimenter moving the posts closer (or farther away) in set increments, or allowing the subject to move the posts. The test is easy to set up and administer, although the necessary repeated trials are time-consuming. Reliability data have not been published.[5] These authors concluded:

> "It is perhaps most accurate to look at all decisions made on the road as containing some degree of accident likelihood. There are no safe drivers. But, some decisions are more likely to result in accidents than others. A continuum of decisions with degrees of accident probability ranging from low to high provides a conceptual picture of the situation. The no-accident groups in our experiment exhibited decision-making habits which tend to place them in situations in which accidents are less likely to occur. Accident groups seem to place themselves in situations of greater difficulty and hazard.
>
> "Our experiment has indicated that driving skill in itself does not seem to be a distinguishing feature between accident and no-accident groups. Findings also demonstrated the fallacy of the belief that accident drivers love to live dangerously.
>
> "While both skill and risk-taking may certainly be factors in accident likelihood, our experiment indicates that no one simple factor is involved. What is most important is the way in which the driver combines several things--his actual skill, his perceived skill, the perceived driving situation, and his willingness to act. Drivers with accident histories tend to combine all of these elements in such a way that they land themselves more often in experimentally hazardous situations." (Cohen and Preston, 1968).

[5] A similar technique was employed by Zwahlen (1973).

Other areas of driver decision-making have also been investigated. Judgment has been assessed (Fine, Malfetti, and Shoben, 1965) by a relatively simple multiple-choice pencil and paper instrument which diagnoses problems on the basis of knowledge questions dealing with performance in critical-situation environments. The test, called the Columbia Driver Judgment Test, is a collection of driving behaviors analyzed by the "critical incident technique." It was developed by systematic analysis of experts' objective descriptions of good and bad driving. In a contrasted comparison group of extremely good and extremely poor drivers, mean scores significantly differentiated between the groups at a $p<.001$ level of significance. The authors suggest the test has applicability in training or retraining drivers. They point out, however, that additional validity studies and norms are needed.

Quenault (1969) developed an in-car observational method for assessing driver performance and related this to decision-making on the part of the driver. Drivers were classified as "safe, injudicious, associated-active and associated-passive." Using various instruments to validate these classifications (e.g., a reaction time stress test, a two-hand coordination test, a picture board test, and a compensation apparatus test), Quenault arrived at the following conclusions:

(1) Information on actual driving behavior under normal traffic conditions can be provided in the form of diagnostic classifications; and

(2) Information can be and should be correlated with personality, intelligence, and attitude measures as well as scores on various test instruments.

In a subsequent investigation of this hypothesis, Quenault (1971) found no statistically significant relationships between test and performance measures.

In summary, current research suggest that valid and reliable measures of decision-making in driver performance are possible. Barrett's work, described in some detail, has provided an apt appraisal of those aspects of decision-making and information processing which seems most relevant to future research. Exploration and analysis of decision-making in the driving environment could suggest improvements in the vehicular environmental dimensions of the traffic system, as well as further research in human factors. A particular problem might be reduced more readily by improved highway design or signage, than by assessment of risk-taking or perceptual propensities.

Consequently, the diagnosis of decision-making problems encountered by the average driving population does not presently offer a viable approach to the evaluation, sanctioning, or subsequent referral of vehicle operators.

ACTION EXECUTION (DRIVING PERFORMANCE)

This section will review the techniques which have been experimentally developed to assess actual driving behavior. Those few performance measurement techniques currently in operational use for driver licensing assessment are discussed in Chapter I. Those included here are still considered developmental. This section has been grouped into the following categories:

- Driving Simulators
- Instrumented Vehicles
- Observer Ratings
- Self-Report Techniques

Driving Simulators

A National Conference on Driving Simulation (1961) reported on the potential use of driving simulators:

> "Driving simulation offers important long-range benefits to traffic safety through research, training, and driver testing. Some authorities believe that stepped-up research, aided by simulation techniques, eventually will lead to a breakthrough in the reduction of accident rate. All are agreed that research can produce substantial benefits, and that the critical importance of highway safety in our social and economic life justifies the employment of all available techniques where applicable."

Wiener (1972) summarized the problems that driver simulators were designed to solve, and the problems they have created:

> "On-the-road testing possesses a high degree of 'real world' validity, but it also carries severe methodological drawbacks: high cost, an element of risk, and the impossibility of controlling conditions of traffic from one run to the next. Driving simulation hopefully offers the answer. Simulation provides a compromise between the rich realism of the street, and the control and safety of the laboratory. Unfortunately, the high cost is also a problem here, as it is one of the paradoxes of automobile research (compared to more complex systems such as aircraft or missiles) that

so much money is required to simulate a 3000-dollar system. But if the researcher is willing to sacrifice some fidelity of simulation for lower cost, there are solutions. Research does not necessarily require the elegance of a high fidelity and high cost system ....Minicomputers which can drive large scope displays provide a possible answer, and their price is still descending. The experimenter must simply decide that he is willing to trade off some fidelity of simulation for lower cost equipment ..." (Wiener, 1972)

Barrett et al. (1973) have provided an extensive review of the literature of driving simulator development. They would add to Wiener's conclusions that the main issue includes not only whether to "trade off some fidelity of simulation," but also to decide which part of that fidelity to give up, since some cues are crucial to a valid simulation, while others may be irrelevent. Their lists of research summaries are presented here as Tables 3-4 and 3-5. Scanning these lists, the great variety of simulator types for different research purposes becomes apparent (as well as a paucity of fidelity information). These reviewers reached the following conclusions about future simulator research:

1. "Outside-in" simulators, i.e., those in which a model car, viewed from the outside, is controlled by the subject, should not be considered for future simulator research." There is no evidence that behavior in these "simulators" is related to any real world driving behaviors.

2. Present methods used to establish validity have not been very successful. Transfer of training data (e.g., ease of learning subsequent in-car tasks) is not an acceptable substitute for validity, since transfer is affected by a variety of individual differences. More validity research is needed.

3. Studies of drug effects should be curtailed until simulator validities can be established.

4. "The scientific equivalence with real world driving must be specifically discussed, presenting detailed fidelity and validity information."

5. New simulators should employ some motion cues.

6. "The research should attempt to determine person or equipment characteristics which effect the performance of the total driving system." (Driving simulation should be viewed as a man-machine interaction, rather than just a machine. Relatively few machine-made cues need parallel the actual driving experience, for the man-machine interface to operate the same as in actual driving. The degree of this behavioral similarity

TABLE 3-4. AUTOMOBILE SIMULATOR RESEARCH USING INSIDE-OUT VISUAL DISPLAYS

Author(s)	Type of Simulator	Research Focus	Variable Measured	Fidelity Information
Effects of drugs				
Crancer, Dille, Delay, Wallace, & Havkin (1969)	Programmed film; fixed-base	Effect of mari-juana & alcohol on driving	Errors in speed, steer-ing, brake, accelerator and signal	None
Drew, Colquhoun, & Long (1958)	Unprogrammed; point light source; rear projection; fixed-base	Alcohol & intro-verted & extro-verted drivers	Tracking; speed; sterring; accele-rator	None
Johansson, & Jansson (1964)	Night time simula-tor with glarelight and moving target; fixed-base	Effect of smoking upon detection times in night driving	Detection time	Illumination; speed of target
Lewis & Sarlanis (1969)	Unprogrammed; TV virtual image; fixed-base	Alcohol & traffic light controlled inter-section	Accelerator; steering; brake; speed; longitud-inal position	None
Light & Keiper (1969)	Optical display; rear projection; moving belts; moving seat	Effect of alcohol on passing behavior	EKG; accelerator; brake; speed; lateral position	None
Martin (1971)	Unprogrammed; point light source; rear projection; fixed-base	Effect of alcohol upon driving performance	Steering; acceler-ator; brake	None
Sarlanis, Lewis & Pazere (1970)	Optical display, rear projected point light source; fixed-base	Effects of alcohol on detection of low contrast moving target	Visual angle at detection	Illumination contrast, field of view
Emergency Responding				
Barrett, Kobayashi & Fox (1968b)	Unprogrammed; TV projected image; fixed-base	Driver behavior during emer-gency	Speed; brake; steering; lateral & longitudinal position; pedes-trian position	Illumination; accel-eration; steering; visual angle; field of view; visibility; speed; braking (Barrett & Nelson, 1965; 1966)
Barrett & Thorn-ton (1968); Barrett, Thorn-ton & Cabe (1969)	Unprogrammed; TV projected & virtual image; fixed-base	Emergency behavior and perceptual style	" "	" "
Case, Hulbert, & Mellinger (1970)	Programmed film; fixed-base	Fatigued good & poor habit drivers in emergency	Speed; deceleration; brake; GSA; driver error	Field of view
Dugger, Young, Budrose, & Kanter (1969)	Unprogrammed; point light source; rear projection; moving seat	Learning skid control in simu-lation and real world	Stopping distance; pylons hit; spin-outs; number of trials	None
Hoskovec, Pour & Stikar (1971)	Programmed film; fixed-base	Driver reaction to emergency & transfer of train-ing to real driving	Stopping distance, steering, pulse raye	None
Sheridan & Poland (1966)	Unprogrammed TV projected image; fixed-base	Vehicle control in response to sudden-ly emerging obsta-cles.	Starred path after obstacle emergence	Field of view, visual angle

Source: Barrett et al. (1973)

TABLE 3-4 (Continued)

Authors(s)	Type of Simulator	Research Focus	Variables Measured	Fidelity Information
Speed judgements				
Barrett, Kobayashi & Fox (1968a)	Unprogrammed; TV projected & virtual image; fixed-base	Speed judgment with two different displays	Speed	Illumination; acceleration; steering; visual angle; field of view; visibility; speed; braking (Barrett & Nelson, 1965; 1966)
Barrett & Thornton (1969)	Unprogrammed; TV projected & virtual image; fixed-base	Speed judgment and perceptual style	Speed	" "
Evans (1970 a & b)	Silent movie film; fixed-base	Speed estimation in real and simulated driving	Angular deviation	None
Kobayashi & Matsunaza	Programmed films; fixed-base	Speed judgment	Speed; braking force; steering; accelerator	None
Salvatore (1969)	Programmed film; fixed-base	Effect of removing cues upon speed judgment	Velocity estimation	None
Other				
Beers, Case, & Hulbert (1970)	Programmed film; fixed-base	Performance of younger and older drivers	Speed, acceleration; brake; breathing rate; GSR; steering	Field of view
Craneer (1968)	Programmed [illegible] [illegible]-base	Differentiating problem & non-problem drivers	Errors in speed, steering, brake, accel[illegible] accelerator and s[illegible]	Field of view
Other				
Crandall, Duggar, & Fox (1966)	Unprogrammed; point light source rear projection; fixed-base	Experienced & inexperienced d[illegible]	Steering wheel movements; speed; brake; accelerator movement	Visibility; field of view; speed; steering
Crossman, Szostak, & Case (1966)	TV monitor with computer generated lane markings; fixed-base	Comparison of real world & simulated steering	Steering, time off target	Dynamic response of steering system
Duggar, Epstein, Kantor, Weene, & Fox (1966)	Unprogrammed; point light source; rear projection; fixed-base	Performance during normal sleep hours	GSR; eye blink; heart rate; speed; steering	None
Edwards, Hahn, & Fleishman (1969)	Programmed film; fixed-base	Performance of taxi drivers on two different simulators & city driving	Errors in speed; steering, braking; & signals	None
Ellingstad (1970)	Unprogrammed; point light source; rear projection; fixed-base	Real world and simulated driving behavior	Steering reversals; speed; speed change	None
Farina & Krumm (1966)	Optical display rear projection; moving belts; moving seat	Passing as a function of illumination, velocity, vehicle lighting, & tail-light configurations	Remedial action distance; rate of translation; medial line crossing; lateral distance	Field of view; illumination

TABLE 3-4 (Continued)

Author(s)	Type of Simulator	Research Focus	Variable Measured	Fidelity Information
Other				
Henriksson, Turesson, Nilsson, & Anderson (1966)	Light source with rotary movements from steering wheel; moving base	Prediction of driver learning from simulator performance	Angular deviation	Angular acceleration (Henriksson, Prytz, Nilsson & Anderson, 1965)
Henry (1971)	Programmed film; fixed-base. Rear projection with rotary movements from steering; fixed-base	Comparison of simulation devices as training aids.	Instruction time required to pass driving test	None
Hulbert & Wojcik (1964)	Programmed film Fixed-base; also Film with moving base	Description of simulators and real-world forces	Accelerations	Field of view; velocity; control functions
Johansson, & Ottander (1964)	Night time simulator with glarelight and moving target; fixed-base	Recovery time after glare in real and simulated driving	Detection time	Illumination; speed of target
Kao & Smith (1969)	TV monitor; moving base	Displaced vision and accuracy of driving	Steering accuracy	None
Krikler	Programmed film; fixed-base	Performance of racing & ordinary motorists	Reaction time	None
Shaffer, Kirkpatrick, & Brede (1970)	Unprogrammed; TV projected image; moving base	Performance at 22 simulated intersections using an Electronic Route Guidance System information Lead Distance (ILD)	Steering; brake; accelerator; GSR peaks; heart rate; errors	Field of view; motion
Other				
Smith, Kaplan, & Kao (1969)	TV monitor, fixed-base	Steering		None
Smith, Kaplan, & Kao (1970)	TV monitor with videotape of road; fixed-base	Effects of steering feedback delays on learning of driving	Steering error and velocity of movements	None
Sussman & Morris	Programmed, point light source, rear projection, moving base.	Effects of driving time, acoustic noise and task complexity on performance.	Tracking error.	Field of view, depth of focus, movement of the simulator base.
Waldram (1960)	Rear projected film; fixed-base	Eye movements while driving at night	Eye movements	None
Wheaton, Kinslow, & Krumm (1966)	Optical display; rear projection; moving belts; moving seat	Validation of part-task driving simulator	Relative velocity; remedial action distance; medial line crossing; rate of translation; lateral separation at zero headway	Field of view; illumination; visual angle; roadway scale factors; velocity; depth of focus; steering functions, control feel; accelerator; sound; braking
Wojcik & Weir (1970)	Unprogrammed; TV projected image; fixed-base	Overtaking, passing, & car following in field & simulator	Steering; acceleration; heading rate & angle; forward & lateral velocity	Field of view; sight distance; control functions

TABLE 3-5. AUTOMOBILE SIMULATOR RESEARCH USING OUTSIDE-IN VISUAL DISPLAYS

Author(s)	Type of Simulator	Research Focus	Variables Measured	Fidelity Information
Effects of Drugs				
Heimstra, Bancroft, & DeKock (1967)	Model car on continuous rubber belt; fixed-base	Effect of smoking upon driving errors	Tracking error: speed; brake reaction time; vigilance	None
Kristofferson & Cormack (1958)	Model car on continuous rubber belt; fixed-base	Effect of quiaction and alcohol on driving errors.	Tracking accuracy, braking reaction time	None
Landauer, Milner, & Patman (1969)	Pointer moved by steering wheel in line with one of five horizontal lights; fixed-base	Effects of drugs on driving behavior	Errors in movement	None
Loomis & West (1958a)	Miniature car on continuous moving belt; fixed-base	Effect of alcohol on driving performance	Brake reaction: time to release accelerator; time on road; trip time	None
Loomis & West (1958b)	Model car on moving nylon belt; fixed-base	Effect of chlorpromazines secobarbital, neprobamate & phenaglycodol on driving errors	Tracking accuracy brake reaction time	None
Marquis et al (1956)	Model car on continuous rubber belt; fixed base.	Effect of neprobromate and alcohol on driving errors.	Tracking accuracy, brake reaction time, speed judgement.	[illegible]
Mortimer (1963)	Cursor on continuous conveyor belt; fixed-base	Alcohol & day and night driving	Tracking performance	Roadway and glare illumination
Uhr & Miller (1960)	Model car on continuous rubber belt; fixed-base	Effect of amylcamate and meprobromate on driving errors	Tracking accuracy, brake reaction time, speed judgement	None
Uhr, Pollard & Miller (1959)	Model car on continuous rubber belt; fixed-base	Effect of meprobamate and tranquil on driving errors	Tracking accuracy, & speed judgement	None
Other				
Currie (1969)	Model car on track; fixed-base	Perception of danger as related to reaction time & accident records	Initial brake reaction time	None
Heimstra (1970)	Control element on continuous rubber belt; fixed-base	Effect of stress upon driving errors	Tracking error; speed; brake reaction time; vigilance	None
Heimstra, Ellingstad, & DeKock (1967)	Model car on continuous rubber belt; fixed- base	Relationship between mood & driving performance	" "	None
Johnson & Lauer (1937)	Model car on continuous leather belt; fixed-base	Effect of one arm upon driving errors	Reaction to auditory stimulus; tracking, speed of completing; observational errors	None

Source: Barrett et al. (1973)

TABLE 3-5 (Continued)

Author(s)	Type of Simulator	Research Focus	Variables Measured	Fidelity Information
Other				
Lauer & Suhr (1957)	Miniature car on moving belt; fixed-base	Effect of refreshment and rest pauses	Brake reaction; steering; error time; total trip time	None
Lauer, Suhr, & Algaier (1958)	Miniature car on moving belt; fixed-base	Simulated and real world driving performance	" "	None
Mortimer (1967)	Point moving with reference to center cross-hairs on CRT; fixed-base	Visual cues used in driving	Speed	None
Mortimer (1964)	Cursor on continuous conveyor belt; fixed-base	Effect of glare upon tracking	Tracking performance	Roadway & glare illumination

represents validity ... "Automobile simulator research has been almost hopelessly muddled by unnecessary pseudo-complexity.") (Barrett et al. 1973)

Most research studies which have attempted to correlate driving simulator performance measures with either on-road performance or driver record criteria, have met with little success. Harano et al. (1973), whose study employed hundreds of variables assessing driving record, personality, attitude, socio-economic, perceptual, psychomotor, and simulator performance measures, reported that on cross-validation none of the psychomotor or simulator performance measures were found to be significant predictors of accident liability, when employed in a regression equation with variables in all other areas of driver assessment.

Edwards et al. (1969) report similar findings. They assessed on-road performance, performance on two different simulators, and perceptual-motor skill performance for 300 taxi drivers. They report that assessment measures from either simulator did not correlate with road performance. Finally, none of the various performance measures correlated with official records of accidents and violations. One possible explanation of these findings is that, since all subjects were taxi operators, they were all, presumably, well experienced. Performance measures may seem more applicable to novice drivers, where a much greater proportion should fall below minimum skill-level safety standards, and variation in performance should be greater.

Similarly disappointing findings are reported by researchers studying driving simulators as training devices. Nolan (1964) compared students trained in a simulator and on-street versus a multiple car range and on-street program, and found very little significant difference. Gustafson (1965) found driver range training alone superior to combined simulator and range training, when range test scores were used as a criteria.

Despite these currently negative findings, driving simulation still appears to have a useful future in both training and testing situations. Hulbert and Wojcik, (1972), discuss the lure of the simulator for the highway researcher:

"Simulation is used in highway and traffic safety research for the following reasons:

1. It is safer.
2. It is more economical.
3. It may be the only practicable way to create conditions that are controlled enough for research purposes.

"The most intriguing and important aspect of driving simulation is the capability of studying research variables in a systematic fashion and thus determining their effects on driving behavior. For example, in a simulator it is possible to change road configuration, reduce perceptual cues, alter steering-gear ratio, vary steering-force gradient, induce mechanical failures, introduce a talkative passenger and observe their effects on the driver's performance. These variables--the road, the vehicle, and the social situation--can be manipulated either as single elements or as patterns. Such research is needed to understand the total driving process and especially to understand what contributes to successful driving and accident-involved driving." (Hulbert and Wojcik, 1972)

It must be concluded that driving simulators hold some promise as a means of assessment. Additionally, the development of valid simulator techniques should provide much needed clarification about which of many external stimuli are actually relevant to the driving task. If and when a truly valid driving simulator is built, then a low-cost, reliable and accurate means of assessing driving skill across a very wide variety of traffic situations would be possible.[6] This would allow the accurate exclusion from the driving population of all drivers who do not possess sufficient driving skill to meet minimum safety requirements. (At present, we cannot even estimate the size of this sub-population, since we cannot accurately assess performance, nor accurately determine minimum safety requirements.)

Although there are many indications that driving simulators will become a valuable assessment tool in the future, they currently have little utility in an applied assessment setting.

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[6] Another development could further aid the accuracy of this assessment. Several researchers, (e.g., Fox and Lehman, 1967; Kroll, 1971) have attempted to create mathematically accurate computer models of driving behavior. At present, these computer simulations reflect relatively simplistic and non-typical driving situations and behaviors. As development of these models becomes more complex and typical of highway conditions and performance, computer simulation could become a major tool in many areas of highway safety research (e.g., analysis of traffic flow; highway design features, driver problems, etc.)

In the area of driver assessment, the model might prove useful in interpreting a driver's test performance (measuring various performance parameters) and extrapolating (applying his parameters to the computer driver model) to vast ranges of real-life driving situations, allowing more precise estimation of real-world accident liability. Numerous other applications of computer models to driving performance are also possible.

Instrumented Vehicles

Most of the literature on instrumented on-road vehicles involves use of some form of the "Drivometer" (Greenshields, 1963), or the Highway Safety Research (HSR) Car (Aaron, 1972). In Canada, work has been progressing for five years on the development and use of instrumented vehicles (Sewell and Perratt, 1975). Other measurement systems have been developed but are not substantially different, nor have they been used as extensively as the Drivometer and HSR Car (Schori, 1970).

Almost all of the measurement systems reported in the literature to date are limited to driver output parameters, such as steering wheel reversals, brake applications, etc., and these are seldom analyzed in the context of specific traffic situations. The Drivometer does include an event recorder so that traffic density indices can be correlated with driver response measures. The interaction between traffic density and response measures was found to be particularly important in discriminating experienced from non-experienced drivers (Greenshield and Platt, 1967). Recent research has emphasized the importance of considering these patterns and their relation to the driving situation (Ellingstad et al., 1970; Safren, Cohen, and Schlesinger, 1970; Forbes et al., 1973; and McRuer et al., 1974).

During the 1960's physiological measures were widely used in psychological research, and were of course applied to the highway situation. The contention then, as now, was that the physiological status of the driver reflected emotional and physical conditions which might affect performance. Many studies have been conducted using GSR, EMG, EEG, respiration rate, blood pressure, and body temperatures as physiological measures (e.g., Ellis and McGlamery, 1970; Berkhout et al., 1972; and Weir and Allen, 1972). The system most frequently used in these evaluations is the Drivometer. The HSR Car, which incorporates several physiological and driver response measures, is now available to many more researchers (Aaron, 1972).

Of the variety of driver output and physiological measures, only a few continue to show promise. Steering reversals, speed change, and heart rate or systolic blood pressure have been the most successful in discriminating various categories of drivers (Brown, 1969; Platt, 1970; Greenshields, 1974; and Sewell and Parrett, 1974). Unfortunately, the studies have used highly divergent groups, i.e., high accidents or violations vs. no accidents, or beginning drivers, in measuring the attributes of these groups. The tests (e.g., the British IAM Advanced Motorists Test, Hoinville et al., 1972) discriminate between groups more successfully than between individuals (Greenshields and Platt, 1967). Driver response measures were also found unable to discriminate more homogeneous driver groups (Safren, Cohen, and Schlesinger, 1970). Due to their reliability, standardization, and quantification, instrumented vehicles are particularly attractive to the safety research community. However, extensive work has revealed a number of limitations on their operational use for diagnostic assessment, particularly for license applicants.

The instrumentation and installation requirements present logistic, measurement, and feasibility problems. A subject must either drive the unfamiliar instrumented car or have instruments installed in his own car. Neither situation is desirable--the former provides less than optimal conditions which may result in invalid measurements, and the latter requires excessive installation time and does not appear to be feasible. Secondly, data processing requirements for instrumented vehicles do not appear to be cost-effective. In addition, for physiological measures to discriminate driver performance under stress or different traffic conditions, the applicant should be exposed to both high and low density traffic to compare baseline and elevated rates. This presents both measurement and logistics problems, to administer these tests under standardized conditions. Finally, most instrumentation does not provide measurement of the relation between vehicle and road. In other words, the model of man as controller in a closed man-vehicle-highway loop has not been utilized. Thus, the full system relationships have not been explored (McRuer et al., 1974).

The psychometric characteristics for the Drivometer appear relatively favorable compared to many other types of driver testing (Whittenburg et al., 1975). On a controlled test route driven sixteen times per trial, test-retest correlations were .95 for steering wheel reversals, [illegible] speed changes, and under .50 for accelerator reversals, brake applications, and total trip time (Safren, Cohen, and Schlesinger, 1970). Validity was established using test results to place drivers in categories based on prior driving record. Table 3-6 from the Greenshields (1974) study gives the results. Unfortunately, predictive studies have not been performed. Until they are, validity must remain questionable. Table 3-7 summarizes the characteristics of the major instrumented-vehicle measurement systems.

[illegible] findings suggest that information concerning vehicle location in the roadway and the traffic situations encountered would appear especially useful for diagnosis. The emerging instrumented vehicle and measurement systems (e.g., McRuer et al., 1974) will have this capability. By measuring multiple parameters, physical and physiological, the data will be available to determine individual driving patterns, and consistency or variability of patterns. Further research should determine the relation of patterns to accident experience, but at present these techniques must be considered purely experimental.

Observer Ratings

While instrumented vehicles are being improved, considerable effort has been devoted to observer rating systems. Early observer rating methods reported by a number of researchers (Uhlaner, Van Steenburg, and Goldstein, 1951; McFarland and Mosely, 1954; Neyhart, 1955; McGlade, 1963; Quenault, 1967 and 1973; and Edwards and Hahn, 1970) report a number of

Table 3-6 CLASSIFICATION OF INDIVIDUAL DRIVERS

Pre-Selected Category	Number	No. Placed In Category	Pct. Correctly Placed
Beginning	26	14	70
High Violation	8	8	100
Low Violation	8	6	75
High Accident	9	6	67

Source: Greenshields (1974)

TABLE 3-7 INSTRUMENTED VEHICLE MEASUREMENT TECHNIQUE SUMMARY

Test	Target Population	Test Techniques	Reliability	Validity
Canadian Research Council (Sewell & Perratt, 1975)	all drivers	Instrumented and telemetered steering wheel reversals brake & accel. movement. Heart rate. Location on road and relative to other cars.	Hardware - 90+ none other reported	Not reported
DPMAS (McRuer, 1974)	all drivers	Instrumented car-includes driver output physiological car location on road, traffic scene via TV.	Hardware still under development	Not reported
HSR case including Drivometer (Platt & Greenshields, 1967)	all drivers	Instrumented car-steering wheel, reversal acceleration & brake movement. Heart rate & GSR Traffic events count	Test-retested .73-.95 Hardware 95 + %	Able to discriminate between high and low accident groups not individuals at significant but low levels

deficiencies. These have included low or no reliability, low accident prediction, other kinds of validity of unknown importance to accident causation, long administration time, univariate data analysis, or applicability only to special populations (e.g., military drivers). A summary of observer rating measurement techniques is presented in Table 3-8.

Direct ratings can be reliable, and have the ability to discriminate between patterns of driver behavior, as shown by Forbes et al. (1973) and McGlade (1961). McGlade developed a road checklist with test-retest reliability of r = .77. Both McGlade and Forbes et al. (1973) achieved high (r = .80+) inter and intra rater reliabilities. Whittenburg et al. (1973), using a battery of ten maneuvers, found reliabilities in the .5 - .8 range, although no predictive validity. Herbert et al. (1963) developed twelve skill tests for use in a range setting. Each skill was scored separately and reliabilities ranged from .35 to .88. The battery of skill measures correlated with number of hours driven (r = .38), since performance deteriorated over time. High reliability does not, of course, imply high validity. None of the road tests developed appear to be highly related to accident involvement. Most research has found low postdictive relationships, while predictive validity studies have seldom been conducted. Tests developed by Quenault (1971, 1973), McGlade (1963), and Forbes et al. (1973) do report validity using other criteria. McGlade (1963) and Quenault (1971) were able to discriminate between problem and non-problem drivers, based on violations.

Interestingly, the latest research in observer rating (Forbes et al., 1973) resulted in the same conclusion as was reached in the instrumented vehicle studies. Patterns of driving and the consistency of these patterns appear more related to safe behavior than the separate skills, knowledges, or attitude components which have been the focus of driver performance research and prediction for many years. Unfortunately, the Forbes et al. (1973) technique suffers from burdensome operational constraints (e.g., two observers per subject, three trials per test) and has not been shown to be highly related to accident involvement. However, it represents one of the few multivariate studies in which the feasibility of highly reliable rating has been demonstrated, and a research method for measuring patterns of individual component driving tasks has been achieved through observer rating. Subsequent efforts must be directed toward relating these patterns to individual problem diagnosis and future accident liability prediction.

Self Report Techniques

Two studies have reported the use of self-evaluation techniques. While both were in a training context, it might be possible to adapt these to novice or problem driver testing. Pease and Damron (1974) found no significant pre-post difference using the McGlade Road Test as a criterion between self-evaluation and teacher critique. Adams

TABLE 3-8. OBSERVER RATING MEASUREMENT TECHNIQUE SUMMARY

Test	Target Population	Test Technique	Reliability	Validity
Driver Performance Measurement (Forbes et al., 1973)	All Drivers	Rating of behavior in response to the situation	Trial 1 vs. 2 vs. 3: .80+s. Inter rater: .70-.90+.	Content only
Filmed behavior (Edwards & Hahn, 1970)	All Drivers	Five minute film following driver	Of scoring: .47-.70	Low--in .10-.20 range.
Road Test Checklist (Neyhart, 1955)	Car Drivers	Check off errors as they occur while driving a route	Not reported	Low--specific items do not significantly relate to accidents (nor does total score)
IAM advanced driving test (Hoinville et al. 1972)	Experienced Drivers	Observe and rate driver--other details not given	Not reported	Discriminates groups, not individuals.
McGlade Road Test (1961)	All Drivers	Observer rates drivers on 55 items	Test-retest: .77	Significantly discriminates problem drivers vs. controls
Driver Behavior Test (Quenault, 1973)	All Drivers	Observe drivers and rate on 5 variables	Not reported	Post hoc discrimination between groups of convicted and non-convicted drivers: only 3 variables significant.

(1971) describes a technique for using self-reporting after normal driving as part of a driver rehabilitation program but no experience or data are given. Self-report measures may be useful for remediation training programs (student feedback). However, much more research is required before the utility of the technique can be assessed.

Summary

The assessment of driver performance has developed as a series of distinct tests, each addressing a supposedly separate phase of information processing. As the limited validation data indicated, no single test is very predictive of accidents. Accident causation, and the behavioral chain preceding an accident, are phenomena that are too complex to be ascribed to a single causal factor. To adequately assess human functioning in the driving task would require measurement methods which can provide a profile, or a relatively complete picture, of the entire process. It appears to be essential to develop such methods if a valid diagnosis of the many behavioral deficiencies which can lead to accidents is to be made.

HUMAN CONDITIONS AND STATES

As in the performance section of this chapter, Level III also provides a wealth of qualitative data about the various aspects of human conditions and states. The primary concern in this discussion will be the degree to which the various conceptual areas can add to present accident liability predictive capability.

BIOGRAPHICAL VARIABLES

The following section discusses biographical information which can be obtained directly from the individual, and is usually more descriptive than that found in Level I and Level II sources. This section has been grouped into the following categories:

- Family Relationships
- Socio-economic status
    - Occupation
    - Education
- Life Style

Family Relationships

A variety of descriptive information about family life and family relationships (e.g., family size, divorce of parents, etc.) has been shown to be significant predictors of driving record. These variables may reflect personal adjustment, social adjustment, or even socio-economic status. For example, one might speculate that family size, as well as being a socio-economic index, may also reflect psychological dimensions, such as sibling rivalry and personal attention. Similarly, marital status of parents (living with one or both parents) might indicate family discord, which in turn may be related to an individual's adjustment to life.

For young drivers, the correlations between parental relationships and driving record have usually been significant, but of very low magnitude. Harrington (1971) found small but significant relationships on both convictions and collisions for the items concerning both parents-- "parents alive" and "parents married." The conviction correlation was highest for "parents married," both for males ($r = -.12$) and females ($r = -.11$). For collisions, the item was only significant for males (r = -.06). Finkelstein and McGuire (1971) found that "negligent" drivers (most less than 25 years old) who lived with parents had significantly fewer convictions but more accidents. However, the relationships were concurrent and may have been artifactual due to the point system selection criteria (i.e., drivers with more convictions might have fewer accidents and vice versa). McGuire (1969, 1972) did not find a significant relationship for young drivers on a scaled question ranging from "lived with both parents" to "lived in an orphanage." Questions of "father alive," "mother alive," and "parents divorced or separated" were also not significant. However, the subjects were Air Force enlisted men, whose responses about home life did not necessarily reflect recent circumstances.

Several studies have used number of siblings to predict driving record. Asher and Dodson (1970) found that fatal accident victims had significantly larger families. Interestingly, they also had more older brothers and sisters than did a normative sample. Harrington (1971) found that number of children in family was significantly related to convictions (r = .13) and collisions (r = .05) for young males, but not for females. Correlations between the specific categories "number of brothers" and "number of older siblings" were slightly lower. Harano (1974), however, did not find a significant relationship for "number of children in family" in predicting driving record for negligent drivers (which may have resulted from the fact that negligent drivers are a more homogeneous sample). Whinery et al. (1972) did not find a significant difference between 16-18 year-old probationers and non-probationers on number of siblings in family. (The magnitude of this correlation is similar (r = .12) to those of most other studies, but non-significant using a smaller sample.) In another study comparing accident repeaters and collision-free drivers, Harano, McBride, and Peck (1973) also found small but significant differences on number of brothers/sisters, with the accident repeater having more. However, the variables also correlated significantly with a cluster of socio-economic measures (r = -.19), suggesting that any differences noted in driving record related to number of siblings may reflect only a relationship between larger family size and lower socio-economic status.

Table 3-9 summarizes some of the research findings relating family relationship variables and driving problems. Overall, the relationships of family biographical factors with driving records do not demonstrate high utility. The variables appear to be more useful for predicting driving records for young drivers, as demonstrated in the Harrington (1971) study. The higher correlations are found mainly for variables such as number of siblings, which are probably also related to socio-economic status.

Socio-Economic Status

Refined measures of socio-economic status, including education and

Table 3-9. Selected Studies Using Family Relationships as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	p	Sample Size	Validity: Accidents Type	r	p	Sample Size
[illegible]rrington [illegible]	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16-17. (Rand[illegible] Sample)	Number of children	4 Year Conviction Record				4 Year Accident Record			
				Males	.13	.05	5,015	Males	.047	.05	5,015
				Females	−.03	NS	4,378	Females	−.030	.05	4,378
			Number of brothers	4 Year Conviction Record				4 Year Accident Record			
				Males	.071	.05	5,009	Males	−.009	NS	5,009
				Females	−.01	NS	4,374	Females	−.043	.05	4,374
			Number of older siblings	4 Year Conviction Record				4 Year Accident Record			
				Males	.06	.05	4,986	Males	.018	NS	4,986
				Females	.01	NS	4,356	Females	−.012	NS	4,356
			Parents alive	4 Year Conviction Record				4 Year Accident Record			
				Males	−.04	.05	5,029	Males	−.031	.05	5,029
				Females	−.04	.05	4,383	Females	.003	NS	4,383
			Parents married	4 Year Conviction Record				4 Year Accident Record			
				Males	−.12	.05	5,029	Males	−.062	.05	5,029
				Females	−.11	.05	4,383	Females	−.026	NS	4,383
[illegible]kelstein & [illegible] (1971)		A large test battery was administered to a group of 950 negligent drivers. Cluster analysis done to identify types. Concurrent correlations of selected variables reported here (1 yr. driving record)	Live with parents	1 Yr. Concurrent Conviction Record	−.11	.01	950	1 Yr. Concurrent Conviction Record	.07	.05	950
F[illegible] McGuire (1969, 1972)	Questionnaire	Correlated test and questionnaire items with self reported accident frequency for young male (Air Force) drivers (ages 17-20) having a two year driving history. (Random Sample)	Whether father or mother ever divorced					Self-Reported Accidents (2 Yr)	.03	NS	1,481
			Father alive					Self Reported Accidents (2 Yr)	.00	NS	1,481
			Mother alive					Self-Reported Accidents (2 Yr)	.04	NS	1,481
			Live with parents, relatives, foster parents, or orphanage					Self Reported Accidents (2 Yr)	.04	NS	1,481
A[illegible]er and [illegible]dson (1970)	Test Battery	Contrasted fatally injured high school students vs. peers on Project TALENT Data items (Contrasted Sample)	Family Size					Fatality victims were from larger families	NR	.05	44
			Number of older brothers and sisters					Higher for fatals	NR	.05	44
			Number of children planned					Less for fatal sample	NR	.05	31

Continued

Table 3-9. Selected Studies Using Family Relationships as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions — Type	Convictions — r	Convictions — P	Convictions — Sample Size	Accidents — Type	Accidents — r	Accidents — P	Accidents — Sample Size
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting. Predicting future errors. (Cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Number of brothers & sisters	Total (1 Yr)	.06	NS	850	Total (1 Yr)	.06	NS	850
			Number Children		-.05	NS	850		-.04	NS	850
Whinery, Hilbert and Nicewander (1972)	Question-naire	Questionnaire administered to 16-18 year old male habitual violators and a matched sample of non-probationers. Tests of significance and bi-serial correlations computed by variables and group membership. Sample include n=116 probationers and n=160 non probationers	Mothers Expectations 5 (school success)	Probationers (3+ convictions in 1 yr) vs. non probationers	11	.31	276				
			Family Support		-.05	66	275				
			Number Siblings		.12	26	226				
Harano, McBride & Peck (1973)	Question-naire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Group, contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+acc: n=196; 0 acc n=231 Females 1+acc: n 50; 0 acc n=57	Number brothers/ sisters		.04	15	427	Male (female)	.10 (.04)	.05 NS	427 187

NR [illegible]
NS [illegible]

occupation, are available at Level III to predict driving record. Several general socio-economic measures have been employed as driving record predictors. Examining a sample of "negligent" drivers, Finkelstein and McGuire (1971) found that their composite measure of socio-economic variables labeled "social mobility index" did not significantly predict accidents or convictions. This result was apparently due to restricted variation among their sample.

Studying a similar sample, Marsh and Hubert (1974) estimated negligent drivers' income based on their occupation and education in conjunction with U.S. Census Bureau data.[7] This original estimate was then multiplied by the subjects' employment status (% full time employment) to produce the final estimate of income. These authors found that high estimated income was associated with having fewer accidents and convictions after a driver improvement contact (r = .05 and r = .11, respectively).

Using a much more broadly-based group of young drivers, Harrington (1971) found significant relationships predicting driving errors with both a social mobility index and the socio-economic status of the young driver's occupational goal. Interestingly, he also found that males [illegible] lower socio-economic status families had significantly more convictions, although fewer accidents. The latter result is not consistent with other studies. However, the magnitude of the relationship with accidents was very low. (r = .03). Correlations for females were generally smaller than for males. The relationship with socio-economic status of occupational goal was relatively high for males predicting convictions (r = -.19), but much smaller predicting accidents (r = -.05). The correlations for predicting convictions and accidents for females were -.08 and -.04, respectively.

In a study comparing accident-free vs. accident-repeating drivers, Harano et al. (1973) correlated a wide variety of potential predictors with driving criteria. A cluster of socio-economic variables proved to be by far the most important predictor in the study. The cluster contained such variables as education, socio-economic status of occupation, and vocabulary scores. Accident repeaters tended to be lower on the socio-economic scale (r = -.40).

Employment at an early age (which apparently reflects both exposure and socio-economic status) is often found to be predictive of driving problems. Kraus et al. (1970) found that 13% of the students in their sample were employed before age 17, compared to only 4% for an accident-free sample. Asher and Dodson (1970) found that age at which the student began earning money was significantly lower in their fatally-injured sample.

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[7] Robinson et al. (1969)

The socio-economic status of parents is also a potential predictor for young drivers. Whinery et al. (1973) found that young traffic probationers came from lower status families (r = .45) and had fewer sources of income (r = -.25). However, McGuire (1969, 1972) reports an opposite finding when correlating value of parents' home with accident frequency for a population of young enlisted airmen. He reported cross-validated coefficients of .11 for value of parents' home and .08 for average income of family wage earner for self-reported accidents. For this particular population (age 17-20, living away from home), it may have been that those airmen from higher socio-economic status families owned cars and had increased exposure (driving during liberty and off-hours), while lower status individuals used other means of transportation.

An interesting finding was reported by Baker (1970), who noted an unusually higher incidence of tattoos among white male fatal accident victims (22% of white males aged 20-49). Although any conclusions must be speculative since no controls were reported for incidence of tattoos in the non-accident population, the finding does suggest another correlate of socio-economic status.

As we have seen, socio-economic variables can also be an indirect measure of exposure. For example, Harano et al. (1973) reported a correlation between a socio-economic cluster and a mileage cluster of -.16, indicating that lower status individuals drive more. The relationships and interactions become clearer when occupational classes are inspected. The occupational groups of "professionals" and "service workers" had correlations with the mileage cluster of -.11 and .01 respectively. Obviously, mileage driven can interact with occupational class.

It is apparent that socio-economic variables can be among the most important Level III predictors of accident liability. This result is particularly striking in the regression results of the Harano et al. (1973) study, which employed a wide range of several hundred variables and found a cluster of socio-economic variables to be the best of all predictors. Other studies have produced less dramatic, although equally promising, results. A brief summary of research findings using these kinds of variables is presented in Table 3-10. In the following sections we will examine the related but more specific measures of socio-economic status--occupation and education.

Occupation

Research has also examined specific occupational variables, most of which also relate to socio-economic status.

For young drivers, Harrington (1971) found that "employment" was a useful variable in predicting a four year record. Unemployed males had significantly more convictions and collisions than those who were employed. Similarly, most specific types of occupation were significant conviction predictors for young males, although generally less

Table 3-10. Selected Studies Using Socio-Economic Status as Assessment Variables

Study	Type of Measure	Sample Description and Method	Variables	Convictions: Type	Convictions: r	Convictions: p	Convictions: Sample Size	Accidents: Type	Accidents: r	Accidents: p	Accidents: Sample Size
[illegible] (1971)	[illegible]	A large test battery was administered to a group of 950 negligent drivers. Cluster analysis done to identify types. Concurrent correlations of selected variables reported here. (1 yr. driving record)	Social Mobility Index		.02	NS	950		−.11	.01	950
[illegible]	Mailed Survey (2 testings)	Surveyed young drivers four years after licensing at ages 16-17. (Random Sample)	Social Mobility (ratio of status of occupational goal to status of parents' occupation)	Total Convictions (4 Yr.): Males / Females	−.03 / −.03	NS / NS	3,941 / 2,843	Total Accidents (4 Yr.): Males / Females	−.04 / −.04	.05 / .05	3,941 / 2,843
			Socio Economic Status of Occupational Goal	Total Convictions (4 Yr.): Males / Females	−.19 / −.08	.05 / .05	4,111 / 2,901	Total Accidents (4 Yr.): Males / Females	−.05 / −.04	.05 / .05	4,111 / 2,901
[illegible]	[illegible]	Information gathered as part of a Driver Improvement meeting from negligent drivers (2165 questionnaires) and negligent driver hearings (1210 interviews). Correlated items with driver record (20 months subsequent record) for 3375 male drivers	Estimated income by employment status	Hazardous driving convictions 20 months after hearing or meeting	−.11	.001	3,375	Total Accidents 20 months after hearing or meeting	−.05	.01	3,375
[illegible]	[illegible]	From young drivers under age 21, selected 100 with accidents, 100 matched accident free controls. (Contrasted Sample)	First fulltime employment, exclusive of school vacation time, at or before age 17, and before driving license					% in each group: Accident Group / Controls	13% / 4%	.05	100 / 100
[illegible] (1970)	Test Battery	Contrasted fatally injured high school students vs. peers on Project Talent data items. (Contrasted Sample)	Amount of spending money					Less for Fatal Sample	NR	.05	44
			Age at which began earning money					Lower for Fatal Sample	NR	.05	44
			Planned military career					More Frequent for Fatal Sample	NR	.05	44
			Age at which occupational choice made					Lower for Fatal Sample	NR	.05	44
[illegible] (1972)	Questionnaire	Correlated test and questionnaire items with self reported accident frequency for young male (Air Force) drivers (ages 17-20) having a two year driving history. (Random Sample) Cross validated r's reported	Value of parents' home (estimated by subject)					Self-reported Accidents (2 yr)	.11 / .10	.05 / .05	1481 / 1480
			Average income of major family wage earner for first five years (estimated by subject)					Self Reported Accidents (2 yr)	.08 / .09	.05 / .05	1481 / 1480

Continued

Table 3-10. Selected Studies Using Socio-Economic Status as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions p	Convictions Sample Size	Accidents Type	Accidents r	Accidents p	Accidents Sample Size
Hasano, McBride & Peck (1973)	Question-naire Interview	Correlated test and question-naire items with group mem-bership, based on accident fre-quency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ acc. n=190, 0 acc. n=231; Females 3 acc. n=50, 0 acc. n=57	Socio-economic Cluster Socio-economic status index (high scores—high status)	Convictions (3 yr. period) Male	28	01	427	Group Mem-bership, (0/3+ acc. in 3 yr. period) Male	−40	01	427
								"0" "3+"	48.4 35.4	01	427

significant for females, or for predicting accidents.

Among the general driving population, Harano et al. (1973) found that accident repeaters tended to have significantly more part-time employment, more frequent employment as operatives or laborers, and more years of seniority as professional drivers. The first two of these results seem to be indicative of lower socio-economic status, while the third, "years as a professional driver," would seem to measure primarily amount of driving exposure. Both types of measures are strongly related to accident liability.

Examining a more deviant driving population, those defined as "negligent operators," Finkelstein and McGuire (1971) found no significant relationship between their occupational index variable, and either accidents or convictions. Using a similar population, Harano (1974) found that their occupational status index significantly predicted both convictions and accidents (r = -.10 and -.08 respectively). Occupation reported as "student" also correlated slightly with convictions. Similar results were reported by Marsh and Hubert (1974), who also found that negligent operators with driving occupations had significantly more accidents (r = .06), but not convictions (r = .01).

Table 3-11 summarizes the results of these and other studies which [illegible] specific occupation variables. Relationships are usually significant, particularly with convictions for males. However, the magnitudes of these relationships are not generally as high as those discussed under general socio-economic variables, suggesting that specific occupational measures might be most appropriately employed as one indicator within a socio-economic cluster or index.

[illegible]

Lower educational levels usually characterize higher accident populations. In a study of drivers under 21, contrasted on accidents, Kraus et al. (1970) found that their accident group failed more grades before Grade 8 (30% vs. 17%), and took more vocational courses (18% vs. 7%), than an accident-free sample.

Asher and Dodson (1970) reported that their fatally-injured sample, compared to population norms, were more likely to have difficulty in understanding assignments, and more frequently planned to quit school. Similarly, Whinery et al. (1973) found that probationers were more likely to quit school to enlist (r = .44), have lower self-expectations regarding school (r =-.35), spend less time studying (r = .44), and feel that college is not essential (r = .29). (These relatively high correlations are apparently a result of the extreme contrasting of his sample. Probationers were young drivers with 3 or more violations, which should represent the worst young drivers, being compared with matched random controls). Pelz et al. (1971) also found that young male drivers who quit school had significantly more crashes (r =-.05).

Table 3-11. Selected Studies Using Occupation as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Finkelstein & McGuire (1971)		A large test battery was administered to a group of 950 negligent drivers. Cluster analysis done to identify types. Concurrent correlations of selected variables reported here. (1 yr. driving record)	Occupational Index		02	NS	950		.00	NS	950
Harano (1974)	Psychological Tests	A battery of psycho physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors (cluster analysis and data collection reported in earlier study Finkelstein and McGuire (1971))		(Total (1 yr)				Total (1 yr)			
			Student (1=yes, 0=no)		.09	.01	850		.01	NS	850
			Unemployed (1=yes, 0=no)		.05	NS	850		.03	NS	850
			Occupation (high score=high status)		−.10	.01	850		−.08	.05	850
			Father's occupation (high score=high status)		−.03	NS	850		−.01	NS	850
			Own home (1=yes, 0=no)		−.08	NS	850		−.03	NS	850
			Rent (1=yes, 0=no)		−.03	NS	850		−.03	NS	850
Whinery, Hilbert and Nicewander (1973)	Questionnaire	Questionnaire administered to 16-18 year old male habitual violators and a matched sample of non-probationers. Tests of significance and bi serial correlations computed by variables and group membership. Sample include n=116 probationers and n=160 non-probationers	Occupation	Probationers (3+ convictions in 1 yr) vs. non-probationers.	.45	.01	276				
			Other Sources of Income		−.25	.02	276				
McBride (1970)	Psychological Battery	A group of 75 negligent drivers who attended a Driver Improvement meeting was administered the Gordon Personality Profile and a biographical questionnaire. Driving performance 2 yrs. subsequent to attending the meeting was predicted from the battery. The criteria was combined accidents and violations which is an operational criteria "Negligent Operator Point" (NOP) for recidivism	Occupation	Negligent Operator Points (NOP) 2 year subsequent	−.125	NS	75				

Continued

NR Not Reported
NS Not Significant

r Correlation [illegible]. Occasionally mean values reported [illegible]
P Probability of [illegible]

Table 3-11. Selected Studies Using Occupation as an Assessment Variable *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Harano, McBride & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample Males 3+ acc: n=196 0 acc: n=231 Females 1 acc: n=50 0 acc: n=57	Occupation Type of degree (1=high school to 5=Ph.D)	Convictions (3 yr. period)				Group Membership. (0/3+ acc. in 3 yr. period) "0" "3+"	1.67 1.28	.01	427
			Full time employment					"0" "3+"	.78 .70	.10	427
			Part-time employment		09		.10		.12	.05	427
			Professional occupation		-.1?		.05		-.27	.01	427
			Employed as operative		09?		.10		.14	.01	427
			Professional driver, Years of job seniority		.06		.15		.13	05	427
Harrington (1971)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16 17 (Random Sample)	Student Status	Total Convictions (4 yr.). Males Females	 -.228 -.073	 .05 .05	 4928 4329	Total Accidents (4 yr.): Males Females	 -.115 -.040	 .05 .05	 4928 4329
			Housewife	Total Convictions (4 yr.): Females	 -.040	 .05	 4329	Total Accidents (4 yr.): Females	 -.022	 NS	 4329
			Unemployed Status	Total Convictions (4 yr.): Males Females	 .086 .037	 .05 .05	 5010 4375	Total Accidents (4 yr.): Males Females	 .044 .008	 .05 NS	 5010 4375
			Status of Parents' Occupation	Total Convictions (4 yr.): Males Females	 068 004	 .05 NS	 6018 4832	Total Accidents (4 yr.): Males Females	 -.028 026	 .05 NS	 6018 4832
			Military Service	Total Convictions (4 yr.) Males	 04?	 .05	 5721	Total Accidents (4 yr.): Males	 .026	 05	 5721
	Interview	From large random sample, interviewed those with 3 or more accidents, matched accident free controls. (Contrasted Sample)	Student					Predicting group membership ≥3 or no accident in 4 yrs.(males)	.23	.01	352
Burg (1974)	Driver Record	Correlated questionnaire responses to subsequent three year driving record. Random Samples of California drivers were survey (male subjects= 4 793, female subjects= 2,845)	Occupation					Total Three Year Accident			
			Occupation Continuous (high score = unskilled)					Male Female	049	.01	4793 2845
			Occupation Dichotomous: (0=no, 1=yes)								
			Professional					Male Female	-.031 .031	.05 NS	4793 2845
			Farming					Male Female	008 005	NS NS	4793 2815

Continued

NR Not Reported
NS Not Significant

* Correlation coefficient for [illegible] unless otherwise stated [illegible] mean values [illegible]
P Probability of significance [illegible] has been obtained

Table 3-11. Selected Studies Using Occupation as an Assessment Variable *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions: Type	r	P	Sample Size	Accidents: Type	r	P	Sample Size
			Armed Forces Qualification Test					Self-Reported Accidents (2 Yr)	.07	.05	1,481
								Cross	.06	.05	1,480
Marsh & Hubert (1974)	Interview/ Questionnaire Driver Record	Information gathered as part of a Driver Improvement meeting from negligent drivers (2165 questionnaires) and negligent driver hearings (1210 interviews). Correlated items with driver record (20 months subsequent record) for 3375 male drivers	Education	Hazardous driving convictions 20 months after hearing or meeting				Total accidents 20 months after hearing or meeting			
			Highest grade Attended		[illegible]	001	3,375		.00	NS	3,375
			High School Graduate		−.08	.001	3,375		−.01	NS	3,375
			Semesters in Grade School		.04	.05	3,375		.04	.05	3,375
			Semesters in High School		−.02	NS	3,375		.00	NS	3,375
			Semesters in College		−.10	.001	3,375		−.02	NS	3,375

NR Not Reported

NS Not Significant

Correlations for older drivers and young females, with either violations or crashes, were not significant. This agrees with the findings of Harrington (1971) who reported that young male drivers with fewer grades completed had significantly more convictions (r =-.31) and collisions (r =-.11). Although significant, the relationships were much lower for females (r =-.11) and (r =-.06). Comparing contrasted samples of accident and accident-free groups, Harano et al. (1973) found more years of education to be associated with fewer accidents (12.4 years vs. 13.5 years).

Findings have been similar in predicting recidivism among negligent drivers. Harano (1974) reported that negligent drivers with more education had fewer convictions (r =-.11) and accidents (r =-.06). In another negligent driver study, Marsh and Hubert (1974) found that more education was slightly associated with fewer convictions (r =-.06), but, they found no relation with accidents (r = .00). There was evidence that the relationship between education and driving might be curvilinear. The authors note that any relationship between these education variables and driving record may be a result of the interrelationships between these variables and age.

In general, educational variables have been shown to be significantly related to both convictions and accidents although the relationships are not large (See Table 3-12). Educational levels and attitudes toward education appear to be most important for young males. For any groups, however, relationships between education and driving record might only reflect the correlations of education with both age and socio-economic status.

Life Style

Life style variables discussed here include both social and individual activities, as well as life goals.

In general, attendance at religious and social functions appears to be inversely related to accident involvement. Accident repeaters in the Harano et al. (1973) study tended not to be involved in clubs (r =-.08) and religious organizations (r =-.12). Beamish and Malfetti (1962) also found that traffic offenders were less involved in religious activities, while their parents were both less politically and socially active ($P < .01$).

Of the activities in which they were involved, accident repeaters in the Harano et al. (1973) study tended to select more outdoor activities, those involving group rather than individual participation, and recreational activities involving more danger. The accident-free sample tended to have more goals related to vocations than did the accident-repeater group.

Among younger drivers, Asher and Dodson (1970) found that those

Table 3-12. Selected Studies Using Education as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	p	Sample Size	Validity: Accidents Type	r	p	Sample Size
Kraus, Steele, Ghent, and Thompson (1970)	Interview Questionnaire	From young drivers under age 21, selected 100 with accidents, 100 accident free matched controls. (Contrasted Sample)	Failed one or more grades, in or before Grade 8	% in each group				Accident Group	30%	.05	100
								Controls	17%		100
			Last high school course was vocational or occupational	% in each group				Accident Group	18%	.05	100
								Controls	7%		100
			One or the other of the above 2 variables	% in each group				Accident Group	39%	.05	100
								Controls	20%		100
Asher and Dodson (1970)	Test Battery	Contrasted fatally injured high school students vs. peers on Project Talent data items. (Contrasted Sample)	Numerous variables measuring educational aptitude, achievement, and difficulties such as:								
			Planned to quit high school					More Frequent for Fatal Sample	NR	.05	44
			Number of science courses					Less for Fatal Sample	NR	.05	44
			Difficulty understand assignments					More for Fatal Sample	NR	.05	44
Whitney, Hilbert and Nicewander (1973)	Questionnaire	Questionnaire administered to 16-18 year old male habitual violators and a matched sample of non-probationers. Tests of significance and bi serial correlations computed by variables and group membership. Sample include n=116 Probationers and n=160 non probationers	Number of school transfer	Probationers (3+ convictions in 1 yr.) vs. non probationers	−.09	.39	276				
			Average Study Time		−.44	.01	276				
			Quit School & Enlist		.47	.01	276				
			School Self Expectations		−.35	.01	276				
			College Essential		−.29	.01	276				
			Father Schooling		.10	.01	276				
Pelz and Schuman (1971)	Questionnaire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files.	Stopped School	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young male	.03	NS		Young male	−.05	.05	
				Older male	−.00	NS		Older male	−.04	NS	
				Young female	.07	NS		Young female	.01	NS	
				Older female	−.03	NS		Older female	.06	NS	
		Respondent Sample Young males: n=1672 Young females: n 483 Older males: n=303 Older females: n 315 Criteria adjusted for exposure (per 100 drivers/yr.)									

Continued

NR Not Reported
NS Not Significant

r Correlation [illegible] values reported [illegible]
p Probability [illegible]

Table 3-12. Selected Studies Using Education as an Assessment Variable *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Harrington 1971	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16 17. (Random Sample)	Highest Grade Completed	Total Convictions (4 Yr.) Males Females	-.305 -.110	.05 .05	5,046 4,388	Total Accidents (4 Yr.): Males Females	-.111 -.061	.05 .05	5,046 4,388
	Interview	From large random sample of young drivers, interviewed those with 3 or more accidents, matched accident free controls (Contrasted Sample)	Highest Grade Completed					Predicting group membership, ≥3 or no accident in 4 yr. (males)	-.21	.01	352
[illegible] McBride [illegible] Peck 1970	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted [illegible] 3 or more accidents vs accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted	Type of degree (1= high school, 5-Phd)					Group membership (0/3+ acc. in three yr. period) (males) mean value "0 group" 3+ group	 1.67 1.78	 .01	 231 196
[illegible]	[illegible]	A battery of psycho physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. Cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Vocabulary Test	Total (1 Yr)	-.20	.01	850	Total (1 Yr)	-.05	NS	850
[illegible] 1970	[illegible] Battery	A group of 75 negligent drivers who attended a Driver Improvement meeting was administered the Gordon Personality Profile and a biographical questionnaire. Driving performance 2 yrs. subsequent to attending the meeting was predicted from the battery. The criteria was combined accidents and violations which is an operational criteria "Negligent Operator Point" (NOP) for recidivism	Education	Negligent Operator Points (NOP) 2 year subsequent	.145	.10	75				
F. L. McGuire (1969 1972)	Aptitude Tests	Correlated test and questionnaire items with self reported accident frequency for young male (Air Force) drivers (ages 17 20) having a two year driving history. (Random Sample)	Mechanical Aptitude test					Self Reported Accidents (2 Yr) Cross	.11 .04	.05 NS	1,481 1,480
			Administrative Aptitude Test					Self Reported Accidents (2 Yr)	.04	NS	1,481
			General Knowledge Test					Self Reported Accidents (2 Yr)	.04	NS	1,481
			Electronics Aptitude Test					Self Reported Accident (2 Yr) Cross	.06 .01	.05 [illegible]	1,481 1,480

NR Not Reported
NS Not Significant

Table 3-12. Selected Studies Using Education as an Assessment Variable *(Cont.)*

*Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type		P	Sample Size	Accidents Type	r	P	Sample Size
			Sales					Male Female	−.002 .016	NS NS	4793 2845
			Skilled					Male Female	−.030 .018	.05 NS	4793 2845
			Semi-Skilled					Male Female	.059 .047	.01 .05	4793 2845
			Service					Male Female	.011 .017	NS NS	4793 2845
			Retired					Male Female	−.054 −.013	.01 NS	4793 2845
			Housewife					Male Female	-- −.077	 .01	4793 2845
			Student					Male Female	.035 .038	.05 .05	4793 2845

*NR - Not Reported
NS Not Significant

r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P Probability of significance (% has been dropped)

involved in fatal accidents read fewer magazines, less frequently read science, political, and history books, but read more comic books than their peers. In social activities, the fatal group attended fewer concerts, lectures, and plays. Harrington (1971) found that more involvement in school activities for males was associated with fewer convictions, but not collisions. Social activities (r =-.03), school functions (r =-.10), and academic clubs (r =-.13) also correlated significantly with convictions. The relationships were slightly lower for females. In a sub-sample studying contrasted groups, Harrington found accident repeaters to "play hooky" more often (r =.17). The best unique predictor of collisions using multiple regression analysis was Citizenship Grade, which correlated .12. Consistent with these results, Whinery et al. (1972) found that probationers held fewer school offices and belonged to fewer clubs than the non-probationers.

These studies all tend to support the inference that less individual, social, and cultural activity is associated with more deviant driver behavior, although the overall magnitude of these lifestyle variables is less than those found with most socio-economic status variables. (See Table 3-13). Income, family support and associated goal orientations and activities appear to interact to form the aspect of socio-economic status which is relevant to driving behavior. For example, in the Harano et al. (1973) study, "number of clubs" and "number of vocational activities," in addition to predicting driving problems, correlated strongly with the socio-economic cluster (r =.43 and .21) respectively.

Smoking

Smoking, particularly the amount of cigarette smoking, is one additional aspect of lifestyle which has been a consistently significant predictor of driving record. Adams and Williams (1966) suggest that smoking is an indirect measure of over-dependency. In a survey of 1,025 young male insurance applicants, they found highly significant differences by smoking habits on both convictions and accidents. McGuire (1969, 1972), analyzing self-reported data of young (age 17-20) enlisted airmen, found the relationship between amount of smoking and accident frequency to be significant even upon cross-validation (r =.104). Another young driver study by Kraus et al. (1970) found significant ($P \leq .05$) differences between accident (39%) and control (27%) groups in response to the variable "became a regular cigarette smoker at or before age 16." Harrington (1971) reports similar results. Questioning a random sample of young males on the number of cigarettes smoked, he obtained correlations of .18 for convictions and .10 for collisions. Females had slightly lower correlations with convictions (r =.16), and about the same with accidents (r =.11). Pelz and Schuman (1971) compared several samples of drivers and found a significant relationship between smoking and violations for young males. Both "amount smoked" and "changes in smoking" correlated .13 with violations. No significant relationships were shown for older males, older females, or

Table 3-13. Selected Studies Using Life Style Activities Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions: Type	r	p	Sample Size	Accidents: Type	r	p	Sample Size
Asher and Dodson (1970)	Test Battery	Contrasted fatally injured high school students vs. peers on Project TALENT Data Items (contrasted sample)	Frequency of attending concerts, lectures, plays					Less for fatal sample	NR	.05	44
			Frequency of making or repairing electrical equipment					Less for fatal sample	NR	.05	44
			Frequency of reading science, political, history books					Less for fatal sample	NR	.05	44
			Frequency of reading comic books					More for fatal sample	NR	.05	44
			Number books in the home					Fewer for fatal sample	NR	.05	44
			Number of magazines in home (assorted types)					Fewer for fatal sample	NR	.05	44
			Tidiness Scale					Lower for fatal sample	NR	05	44
Whinery, Hilbert and Nicewander (1973)	Questionnaire	Questionnaire administered to 16-18 year old male habitual violators and a matched sample of non-probationers. Tests of significance and bi-serial correlations computed by variables and group membership. Sample include n=116 probationers and n=160 non-probationers	Number of school Offices	Probationers (3+ convictions in 1 yr.) vs. non Probationers	18	.09	276				
			Club Membership		- 34	.01	276				
			TV Viewing		- 15	.16	276				
Harrington (1971)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16 17. (Random Sample)	Participation in school social clubs	Total Convictions (4 yr.): Males Females	 -.044 -.004	 .05 NS	 5053 4400	Total Accidents (4 yr.): Males Females	 -.006 .030	 NS .05	 5053 4400
			Participation in school academic clubs	Total Convictions (4 yr.): Males Females	 -.134 - 071	 05 .05	 5050 4399	Total Accidents (4 yr.): Males Females	 -.070 -.004	 05 NS	 5050 4399
			Participation in school functions	Total Convictions (4 yr.): Males Females	 - 097 043	 .05 .05	 5052 4401	Total Accidents (4 yr.): Males Females	 -.019 -.016	 NS NS	 5052 4401
			Participation in intramural activities	Total Convictions (4 yr.): Males Females	 029 033	 .05 05	 5054 4398	Total Accidents (4 yr.): Males Females	 .009 .007	 NS NS	 5054 4398
			Number varsity letters	Total Convictions (4 yr.): Males	 065	 05	 5048	Total Accidents (4 yr.): Males	 -.032	 NS	 5048
			Number non varsity letters	Total Convictions (4 yr.): Males Females	 - 055 000	 05 NS	 5051 0	Total Accidents (4 yr.): Males Females	 -.018 .000	 NS NS	 5051 0

Continued

NR Not Reported
NS Not Significant

[illegible]

Table 3-13. Selected Studies Using Life Style Activities Measures as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variable	Convictions: Type	Convictions: r	Convictions: P	Convictions: Sample Size	Accidents: Type	Accidents: r	Accidents: P	Accidents: Sample Size
	Interview	From larger random young driver sample interviewed those with 3 or more accidents, equal number of accident free controls (Contrast 1 Sample)	Frequency Playing Hooky						-.17	.02	352
Harrington, [illegible] (197[illegible])	Question[illegible]	Correlated test and question[illegible] items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs accident free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc. N 110; 0 Acc. N 231; Females 1+ Acc. N 59; 0 Acc. N 5[illegible]		Convictions (3 yr. Period)				Group Membership (0/3 + Acc. in 3 yr. Period)			
			Belongs to a club (1 = yes, 0 = no)	Male	-.11	.10	427	Male	-.08	.10	427
			Belongs to a religious organization (1 = yes, 0 = no)	Male	-.11	.10	427	Male	-.12	.05	427
			Low degree of physical activity or recreation (1 = yes, 0 = no)					Mean "0" / "3+"	.31 / .23	.10	427
			Degree of danger [illegible] activities (1 - [illegible] to 5 - [illegible] dangerous)					Mean "0" / "3+"	2.68 / 2.43	.10	427
			Outdoor or indoor hobby (1 outdoor, 1 indoor)					Mean "0" / "3+"	.91 / 1.60	.05	427
			Group or individual hobby (0 - individual, 1 group)					Mean "0" / "3+"	.75 / 1.51	.01	427
			[illegible] educational goal					Mean "0" / "3+"	.17 / .23	.10	427
			[illegible] vocational goal					Mean "0" / "3+"	.06 / .02	.05	427
			Father/mother difference score on activity (High score larger diff.)					Mean "0" / "3+"	10.4 / 11.0	.05	427
[illegible] and [illegible] (196[illegible])	Psychometric Test	A battery of psychological tests were administered to juvenile court offenders (94 males) and a comparison group of non offenders (136 males). Violators had 2 or more violations in 3 yr. period		Violator Group Group vs. Non Violator Group (3 yr.)							
		Siegel Biographical Inventory	Religious Activity	Violators vs. Non Violators	NR	.10	256				
		Guilford Zimmerman [illegible]	Social Activity	Recidivist Violators vs. Non Recidivist (3 yr.)	NR	.07	83				
		Siegel Biographical Inventory	[illegible] Activity	Recidivist vs.	NR	.20	83				

younger females. Harano et al. (1973) found significant relationships between smoking and accident group membership (r =.12) and (r =.11) convictions for males. No results were reported for females.

There are numerous explanations for the generally moderate relationships (see Table 3-14) between smoking and driving record. Based on correlations of smoking with other variables found in the Harano et al. (1973) study, the over-dependency theory of smoking may have some merit. Smokers were found to be less cautious (r =-.15) and less emotionally stable (r =-.09), as well as lower in socio-economic status (r =-.24). (They also drove more miles [r =.12].) There are, however, several alternative hypotheses for this relationship. One is the suggestion that smoking could be an indicator of lack of concern for one's own physical health, which has obvious implications for traffic accidents. Another alternative involves simply the distraction associated with smoking while driving (e.g., lighting a cigarette, dropping a lighted cigarette). McGuire (1972) has presented an additional alternative hypothesis that "the higher accident rate found among smokers may be partially the result of sufficient oxygen deficiency" as well as social or personality characteristics. In any event, these research findings suggest that the driver's smoking habits may be a useful and inobtrusive measure for accident liability prediction, in lieu of the more specific physiological or psychological factors which it apparently represents.

Summary

Individual Level III biographical variables appear to add little to the predictive capability which is possible using lower level biographical measures. However, potential utility for the Level III variables would appear to lie in multi-variate applications. When these variables are combined through cluster or other techniques, their utility is often magnified (e.g., the correlation of -.40 between a socio-economic cluster and accidents found by Harano et al. (1973). In addition, many of these measures appear especially valid for particular sub-populations. Interactive studies should eventually clarify these relationships, and it is possible that extremely valid measures for selected sub-groups will emerge. At present, some of the general measures of education, occupation, and socio-economic status would appear to be useful additions to a diagnostic assessment program.

PSYCHOLOGICAL, SOCIAL, AND ATTITUDE VARIABLES

The majority of psychological data on drivers must be obtained directly from the individual. Literally hundreds of research studies have attempted to relate these kinds of variables to driving behaviors, with many varied and interesting results. However, a major drawback to interpretation of this work has been that same variety in results. The lack of common methodologies makes it difficult to compare or even relate findings. In this review we have, therefore, tried to group such

Table 3-14. Selected Studies Using Smoking Measures as Assessment Variables

				Validity							
				Convictions				Accidents			
Study	Type of Instrument	Sample Description and Method	Variables	Type	r	P	Sample Size	Type	r	P	Sample Size
Adams and Williams (1966)	Questionnaire	Insurance applicant administered questionnaire. Applicants age ranged from 18-25. Items correlated with number of accidents/convictions on file	Smoking	Convictions On File	NR	.01	1025	Collisions on File	NR	.01	1025
Kraus, Steele, Ghent, and Thompson (1970)	Interview Questionnaire	From young drivers under age 21, selected 100 with accidents, 100 accident free matched controls (Contrasted Sample)	Became a regular cigarette smoker at or before age 16					Controls= vs. Accident Sample =	27% vs. 39%	.05	100 100
F. L. McGuire (1969, 1972)	Questionnaire	Correlated test and questionnaire items with self-reported accident frequency for young male drivers (ages 17-20) having a two year driving history (Random Sample cross validated)	Smoking habits (apparently not coded by amount smoked)					Self-Reported Accidents (2 Yr.)	.104	.05	
Harrington (1972)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16-17 (Random Sample)	Number of cigarettes per day	4 Year Conviction record. Males Females	 .184 .157	 .05 .05	 5021 4385	4 Year Accident record. Males Females	 .103 .110	 .05 .05	 5021 4385
	Interview	From large random young driver sample, interviewed those with 3 or more accidents equal number accident free controls. (Contrasted Sample)	Number of cigarettes per day.					Predicting group membership, ≤3 or no accidents in 4 yr. Males	.18	.01	352
Pelz and Schuman (1971)	Questionnaire interview	Probability sampling of driving population. Correlated test items with crashes and violations self reported and/or from official files. Respondent Sample Young males n=1672 Young females n=483 Older males n=303 Older females n=315 Criteria Adjusted for exposure (per 100 drivers/yr.)	Amount smoked	Violations & Warnings (1 yr. adj.) Young males Older males Young females Older females	 13 0? 04 .08	 .01 NS NS NS	(See method)	Crashes (1 yr. adj) Young males Older males Young females Older females	 .02 −.10 .01 .03	 NS NS NS NS	(See method)
			Changes in Smoking	Violations & Warnings (1 yr. adj.) Young males Older males Young females Older females	 .12 03 .05 10	 .01 NS NS NS		Young males Older males Young females Older females	.04 −.01 .01 .03	NS NS NS NS	
Harano, McBride & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc. N=?96 0 Acc. N=231 Females 1+ Acc. N=50 0 Acc. N=57	Smokes (1=yes 0=no)	Convictions (3 yr. Period)				Group Membership (0/3+ Acc. in 3 yr. period) "0" "3+"	Mean .48 .58	.05	427
			Smokes Cigarettes (1=yes, 0=no)					"0" "3+"	.37 .48	.05	427
			Smoking hazard index (0=doesn't smoke, 1=doesn't smoke cigarettes, 2=filter, 3=non filter		11	.05	427	*	.12	.05	427

NR Not Reported [illegible] Mean values reported in column [illegible]
NS Not Significant [illegible]

research results by apparent conceptual similarities to illustrate as clearly as possible the development of this area of investigation. The section will be divided into five sub-sections:

- Situational Stress Factors
- General Personality Characteristics
- Driver Specific Inventories
- Driver Specific Items
- Discussion

Situational Stress Factors

In addition to the relatively permanent "lifestyle" or biographical variables, many transitory situational factors can be measured by direct assessment of the driver. The situational factors which are related to traffic safety are primarily individual "stress" factors, such as unemployment or family problems. Studies which have assessed life stresses generally confirm the Level II findings that many accidents, particularly fatal accidents, are directly attributable to various forms of acute life stress. One study of fatal accident victims may help illustrate this point. Finch and Smith (1970) conducted in-depth interviews of the families, friends, and employers of fatal accident victims. Their findings on the emotional and physical states of the driver preceding the crash are presented in Table 3-15. Intoxication was found to be the most prevalent condition in the fatal sample often in combination with other pre-crash states. Depression and uncontrolled anger were the second most frequent categories. Plummer and Das (1973) also found accident repeaters to have significantly more conscious thoughts of suicide than controls ($P < .01$). Although not significant because of the small samples, 30% of the accident repeaters had contemplated suicide, compared to only 17% of the controls; 7% of the accident repeaters had previously attempted suicide, compared to none of the controls (again not significant).

Finch and Smith (1970) also obtained overall indices of more generalized social stresses. They found that one or more of job, financial, marital, and family stresses were present in 82% of their fatal sample, within 24 hours prior to the crash, compared to only 12% of the control sample. Similarly, Harano et al. (1973) found that overall dissatisfaction with life correlated with accident group membership for males (.19) and females (.23).[8]

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8 Predicting recidivism among problem drivers, however, none of the stress factors were significant (Harano, 1974). This apparently results from the fact that, since the population under study was already deviant in regard to driving (less than 5% of the driving population are classified as negligent drivers), the sample as a whole was relatively homogeneous.

TABLE 3-15 PRE-CRASH OR PRE-INTERVIEW STATE

	Driver Fatalities		Group Control	
Abnormal	92%		12%	
Depression		40%		4%
Suicidal		12		0
Uncontrolled Anger		32		12
Intoxicated		72		12
Car used as extension of ego		8		0
Psychotic		4		4
Impaired judgment or poor Impulse control		24		8
Preoccupied		12		12
Normal	0%		88%	
Unknown	8%		0%	

Source: Finch and Smith (1970)

Note: Some drivers had more than one pattern prominent, resulting in a total of more than 100 percent (i.e., depressed-suicidal).

In summary, any recent social stress information should be considered an important contributing factor to accident liability (particularly more severe accidents). Some representative findings of research studies measuring general life stresses are presented in Table 3-16.

The following sections will address some specific situational stress measures, such as occupational stress, marital stress and family stress.

Occupational Stress

As demonstrated in Chapter 2, stress factors related to employment, such as self-reported job problems, financial stress, and number of job changes, have often been related to accident liability. At Level III, more qualitative descriptions of these problems are available.

Finch and Smith (1970) found that drivers involved in fatal accidents experienced more job problems than controls. Six months prior to their collision, 40% of the fatals, compared to only 8% of control sample were experiencing on-the-job problems. Twenty-four hours prior to the crash a specific job problem was noted in 24% of the fatal cases, while only 8% of the controls noted such a problem. These investigators also found financial stress to be over-represented in the fatal sample (40%), compared to the controls (8%).

Conversely, Pelz and Schuman (1971), in studying a random population of drivers, found no strong evidence for the relationship between job-related events and driving. Among the variables "new responsibilities," "started working," "changed jobs," "stopped working," and "total events," only a few significant relationships were found. Younger males who changed jobs more often had slightly more violations ($r = .06$), while older females who changed jobs were involved in more crashes ($r = .14$). Acceptance of new responsibilities was negatively correlated with violations ($r = -.06$). (These relationships could merely reflect socioeconomic status.) No significant relationships with driving problems could be found for younger females or older males.

Studies of occupational stresses among negligent driving populations have consistently produced moderate but significant correlations. Harano (1974) found that ratings on amount of job stress and stress associated with financial problems were not significantly correlated with convictions or collisions. However, number of job changes was significantly correlated with convictions and collisions ($r = .08$ and .07 respectively). (Again, this finding might only reflect socioeconomic status.) Similarly, Harano et al. (1973) also found number of job changes to be significantly related to accident group membership. Accident repeaters had significantly more job changes over a three-year period than accident-free drivers (1.6 vs. 1.3). Accident repeaters also tended to be less satisfied with their financial status and with their job.

Table 3-16. Selected Studies Using General Life Stress Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variable	Validity: Convictions — Type	r	p	Sample Size	Validity: Accidents — Type	r	p	Sample Size
Plummer and Das (1973)	Question-naire	Compared high and low accident groups on questionnaire discussing suicidal thinking (Contrasted Sample)	Have no conscious suicidal ideas					Per cent of subjects responding yes			
								2+ Accident Group (1 yr)	63.3%	.05	30
								No Accident Controls (1 yr)	83.3%		30
			Had contemplated suicide					Per cent of subjects responding yes			
								2+ Accident Group (1 yr)	30.0%	NS	30
								Accident-Free Controls (1 yr)	16.6%		30
			Had attempted suicide					Per cent of subjects responding yes			
								2+ Accident Group (1 yr)	6.6%	NS	30
								Accident-Free Controls (1 yr)	0.0%		30
Harano, McBride and Peck (1973)	Question-naire Interview	Correlated test and question naire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc: N 196; 0 Acc N=231; Females 1+ Acc: N=50; 0 Acc: N=57	Satisfied with living quarters	Convictions (3 yr period)				Group Membership (0/3 & Acc. in 3 yr. Period) Male		.10	427
			Satisfied with life in general					Female	.19 (.23)	.01 .01	427 107
			Average satisfaction score (sum of preceding 5 items/5) (1=satisfied, 4=dissatisfied)		.14	.01	427		.19	.01	427
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors (cluster analysis and data collection reported in earlier study Finkelstein and McGuire, 1971)	Type of Stress (0=none to 3 severe).	Total (1 yr)				Total (1 yr)			
			Health		−.05	NS	850		.00	NS	850
			Personal		−.05	NS	850		−.04	NS	850
			Social, Domestic, World Related		−.09	.01	850		−.03	NS	850
			No residence change		.00	NS	850		.03	NS	850
			Satisfaction with life (1=satisfied, 5=unsatisfied)		.05	NS	850		−.02	NS	850

NR Not Reported
NS Not Significant

r Correlation ... unless otherwise specified. Occasionally mean values reported in r column.
P Probability ... dropped.

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Marsh and Hubert (1974) found that changing jobs or holding extra jobs is associated with more accidents ($r = .06$ and $r = .03$, respectively) and convictions ($r = .13$ and $r = .10$, respectively) after a driver improvement meeting or hearing. They also reported that the longer a person had been employed, the less his accident ($r = -.09$) and conviction ($r = -.5$) involvement. After assigning job satisfaction values to subjects, according to the subjects' occupations, and the findings of another study (Robinson et al., 1969), Marsh and Hubert found their "percent not satisfied" also correlated significantly with accidents ($r = .06$) and convictions ($r = .07$) indicating that occupations characterized by low job satisfaction are associated with poor driving record.

These studies (summarized in Table 3-17) suggest that job stresses are related to driving. The relationships are stronger for the more severe driving performance criteria, fatal accidents (Finch and Smith, 1970), and accident repeaters (Harano et al., 1973). Negligent operator samples (Harano, 1974) and random population studies showed significant but low relationships. Thus, acute job stress data would appear more useful than the generalized job stress data obtainable a priori by direct driver assessment.

Marital Stress

Level III measurement also provides more qualitative information on stressful marital events, such as divorce, which was demonstrated to be strongly related to accident liability in Level II.

The Finch and Smith study (1970) showed interpersonal factors, including marital disharmony, to be highly over-represented in the fatal sample. A general pattern of problems was evident in the fatal sample, with 36% having had marital problems for a period of 6 months preceding the crashes. More dramatic was the occurrence of an event (argument, etc.) in 56% of the fatal cases directly preceding the crash (24 hours). In contrast, only 12% of the control sample indicated similar problems. In the random sample of drivers, Pelz and Schuman (1971) found that positive marital events did not significantly relate to driving, but negative events did (e.g., divorce, arguments, etc.). Negative marital events correlated positively with violations for young males ($r = .08$), older males ($r = .21$), and young females ($r = .16$). In regard to collisions, correlations were in the expected direction, but the relationships were not significant. With a contrasted sample of accident repeaters and accident-free drivers, Harano et al. (1973) found that the item "satisfaction with spouse/girlfriend/boyfriend" was significantly related to both accident group membership and convictions. Accident repeaters were approximately 14% more frequently dissatisfied (1.56 vs. 1.37 on 4 pt. scale). In the same sample, 11% of the accident repeaters were recently divorced/separated, compared to 5% in the accident-free sample.

Among negligent drivers, Marsh and Hubert (1974) report that being

Table 3-17. Selected Studies Using Occupational Stress as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	p	Sample Size	Validity: Accidents Type	r	p	Sample Size
Finch and Smith (1970)	Interview/ Questionnaire	In-depth investigation of background characteristics of 25 drivers involved in fatal accidents and a control sample of 25 drivers.	Job Problems					Control			
								6 Mos.	8%		25
								24 Hrs.	8%		
								Fatals			
								6 Mos.	40%		25
								24 Hrs.	24%		
			Financial Problems					Control			
								6 Mos.	8%		25
								24 Hrs.	8%		
								Fatals			
								6 Mos.	40%		25
								24 Hrs.	36%		
Pelz and Schuman (1971)	Questionnaire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files.	New Responsibilities	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young males	−.06	.05	(See Method)	Young males	.01	NS	(See Method)
				Older males	−.07	NS		Older males	−.00	NS	
				Young females	01	NS		Young females	.03	NS	
		Respondent Sample		Older females	.03	NS		Older females	.09	NS	
		Young males: n=1672; Young females: n=483; Older males: n=303; Older females: n=315	Started Working	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young male	−.02	NS	(See Method)	Young male	.02	NS	
				Older male	−.02	NS		Older male	−.04	NS	
		Criteria adjusted for exposure (per 100 driver/yr.)		Young female	.03	NS		Young female	.03	NS	
				Older female	− 01	NS		Older female	−.06	NS	
			Changed Jobs	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young male	[illegible]	.05		Young male	.04	NS	
				Older male	− 07	NS		Older male	−.04	NS	
				Young female	03	NS		Young female	.03	NS	
				Older female	−.03	NS		Older female	.14	.05	
			Stopped Working	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young male	.01	NS		Young male	.04	NS	
				Older male	.05	NS		Older male	−.02	NS	
				Young female	− 01	NS		Young female	.06	NS	
				Older female	.02	NS		Older female	−.07	NS	
			Total Job Events	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young male	.04	NS		Young male	.04	NS	
				Older male	05	NS		Older male	−.05	NS	
				Young female	01	NS		Young female	.05	NS	
				Older female	01	NS		Older female	−.02	NS	

Continued

NR Not Reported
NS Not Significant

r [illegible] otherwise specified. Occasionally mean values reported in r column.
P [illegible]

Table 3-17. Selected Studies Using Occupational Stress as an Assessment Variable *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting. Predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Type of Stress (0=none to 3= severe).	Total (1 yr.)				Total (1 yr.)			
			Financial		.02	NS	850		−.03	NS	850
			Job		.05	NS	850		−.04	NS	850
			No. Job Changes		.08	.05	850		.07	.05	850
Harano, McBride & Peck (1972)	Question-naire Interview	Correlated test and question-naire items with group mem-bership based on accident fre-quency. Groups contrasted on 3 or more accidents vs. acci-dent free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc: N=196; 0 Acc: N=231; Females 1+ Acc: N=50; 0 Acc: N=57		Convictions (3 yr. Period)				Group Member-ship (0/3+ Acc. in 3 yr. Period)			
			Number of Job changes		.26	.01	427		.14	.01	427
			Satisfied with job (1=satisfied, 4=dissatisfied)				•	(mean) "0" "3+"	1.59 1.88	.01	427
			Satisfied with financial status (1=satisfied, 4=dissatisfied)		.18	.01	427		.20	.01	427
McBride (1970)	Psycho-logical Battery	A group of 75 negligent drivers who attended a Driver Improve-ment meeting was adminis-tered the Gordon Personality Profile and a biographical questionnaire. Driving per-formance 2 yrs. subsequent to attending the meeting was predicted from the battery. The criteria was combined accidents and violations which is an operational criteria. "Negligent Operator Point" (NOP) for recividism.	Number of Jobs	Negligent Operator Points (NOP) 2 year subse-quent	.234	.05	75				
Marsh & Hubert (1974)	Interviewed Question-naire; Driver Record	Information gathered as part of a Driver Improvement meeting from negligent drivers (2165 questionnaires) and negligent driver hearings (1210 interviews) Correlated items with driver record (20 months subsequent record) for 3375 male drivers.	Jobs	Hazardous driving con victions 20 months after hearing or meeting				Total Acci-dents 20 months after hearing or meeting			
			Job Changes		10	.001	3375		.03	.10	3375
			Extra Jobs		.13	.001	3375		.06	.001	3375
			Job satisfaction (value from in dependent sur-vey was assigned, not subjects response)		06	.001	3375		.07	.001	3375
			Length of Employment		15	.001	3375		−.09	.001	3375

NR Not Reported [illegible]

NS Not Significant [illegible]

divorced and separated was negatively correlated with future accidents (r = -.05), but not significantly related to future convictions.

As noted in Chapter 1, a multidisciplinary accident investigation (Institute for Research in Public Safety, 1973) found divorced drivers were over-involved in general accidents by a factor of 4.7 and in alcohol-related accidents by 9.1. Separated drivers, on the other hand, were over-involved in general accidents by a factor of 4, but over-involved in alcohol-related accidents by a factor of 30. (The involvement ratio is computed by dividing the number of actual drivers involved, by the "expected" number, based on the population distribution). These findings suggest that the "separated" category reflects more recent critical events than "divorced."

Table 3-18 summarizes some of the relevant research results. In general, the findings from these studies on marital stress support the conclusion that marital stress is an important factor in accident causation. As may be recalled, in a review of the driving records of 410 persons involved in divorce proceedings (McMurray, 1968), accident and violation rates were found to be highest three months after filing for divorce. Trauma associated with recency of the events appears especially critical, as supported by the Finch and Smith study (1970) and the Institute for Research in Public Safety study (1973). Both specificity and recency of information appear to be critical. In situations where such recent, accurate information can be obtained, and current marital stress and recent driving errors are present, alternatives such as license suspensions must be considered viable countermeasure options. In this regard, asking the driver directly about problems may be a useful supplement to Level II information, although as in all direct assessment of the driver's personal life, it cannot be assumed valid in all settings.

Family Stress

Several research studies have measured the influence of family relationships and events on driving problems. These studies have often addressed both the relationship of the driver with his parents (historically), as well as his current family situation.

Based on an extensive literature review, Harano et al. (1973) developed a Parent Child Inventory to measure the driver's relationship with his parents (for the most part historical). Several dimensions were found to discriminate between accident repeaters and accident-free drivers. Accident repeaters described their parents as using more punishment (r = .10), regarded their fathers as less permissive (r =-.08), rated their mothers as less "good/valuable" (r = .07), reported more family dissension (r = .09), and revealed larger discrepancies between their ratings of mother and father on a good/valuable dimension (r = .14). Of additional interest are the moderate correlations of family dissension with other variables in the study. Those who indicated more family

Table 3-18. Selected Studies Using Marital Stress as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Finch and Smith (1970)	Interview/ Questionnaire	In-depth investigation of background characteristics of 25 drivers involved in fatal accidents and a control sample of 25 drivers.	Interpersonal Problems					Fatals (Percent Sample) Control 6 Mo 24 Hrs Fatal 6 Mo 24 Hrs	 12% 12% 36% 56%	 NR NR	 25 25
Pelz and Schuman (1971)	Questionnaire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files.	Positive Marital Events	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .02 .02 −.06 −.02	 NS NS NS NS	(See Method)	Crashes (1 yr. adj.) Young male Older male Young female Older female	 .03 −.07 −.04 −.01	 NS NS NS NS	(See Method)
		Respondent Sample Young males: n=1672 Young females: n=483 Older males: n=303 Older females: n=315 Criteria adjusted for exposure (per 100 drivers/yr.)	Negative Marital	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .08 .21 .13 −.04	 .01 .01 .05 NS		Crashes (1 yr. adj.) Young male Older male Young female Older female	 .04 −.06 .16 	 NS NS .01 NS	
Harano, McBride & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident-free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc: N=196 0 Acc. N=231 Females 1+ Acc: N=50 0 Acc: N=57	Married (1=yes, 0=no)	Convictions (3 year period)				Group Membership (0/3+ Acc. in 3 yr. Period) Males	−.26	.01	427
			Single (1=yes, 0=no)					(mean) "0" "3+"	 .13 .27	.01	427
			Divorced/ Separated (1=yes, 0=no)						.16	.01	427
			Number of children (1=yes, 0=no)					(mean) "0" "3+"	 1.93 1.60	.10	427
			Recent marital status change (1=yes, 0=no)					(mean) "0" "3+"	 .15 .21	.10	427
			Recent divorce (1=yes, 0=no)					(mean) "0" "3+"	 .05 .11	.05	427
			Satisfied with spouse, girl or boy friend (1=satisfied, 5=unsatisfied)					(mean) "0" "3+"	 1.37 1.56	.05	427

(Continued)

NR Not Reported [illegible]
NS Not Significant [illegible]

Table 3-18. Selected Studies Using Marital Stress as an Assessment Variable *(Cont.)*

Study	Type of Instrument	*Sample Description* and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Questionnaire Date	Total Convic-tions (1 yr.)				Total Colli-sions (1 yr.)			
			Single (1=yes, 0=no)		.11	.01	850		.02	NS	850
			Married (1=yes, 0=no)		–.09	.01	850		.02	NS	850
			Divorced (1=yes, 0=no)		–.05	NS	850		–.02	NS	850
			Marital Status Change (=yes, 0=no)		–.03	NS	850		–.02	NS	850
			Marital Stress (0=none to 3=severe)		.00	NS	850		–.05	NS	850
Marsh & Hubert (1974)	Interviewed Question-naire Driver Record	Information gathered as part of a Driver Improvement meeting from negligent drivers (2165 questionnaires) and negligent driver hearings (1210 interviews) Correlated items with driver record (20 months subsequent record) for 3375 male drivers	Divorced or Separated	Hazardous driving con-victions 20 months after hearing or meeting	–.02	NS	3375	Total Acci-dents 20 months after hearing or meeting	–.05	.01	3375

NR Not Reported
NS Not Significant

r Correlation coefficient for [illegible] otherwise specified. Occasionally mean values reported in r column)
P Probability [illegible]

dissension were less responsible (r =-.21), less emotionally stable (r =-.23), and less cautious (r =-.19) as measured by the Gordon Personal Inventory. These variables in turn have also been shown to relate to both accidents and convictions. Similarly, Harrington (1971) found relationship-with-parent variables to be related to accident involvement. Those drivers involved in accidents reported that they did not get along with parents (r =.16), mother lost temper often (r =-.18), were babied by mother (r =-.17), and parents did not approve of friends (r =.20).

The number of family events and problems have also been shown to be useful predictors. Pelz and Schuman (1971) found a small relationship between the number of family events and violations (r =.05) for young males only. However, this variable did not clearly delineate positive and negative events. Small differences were reported in the Finch and Smith (1970) study on the relationship of current family problems between the fatal and control samples. Parent-child problems were reported in 16% of the fatal sample, compared to 8% in the control sample. Loss of a friend or relative was found for 16% of the fatal sample, and was not found at all in the control sample.

Some research studies assessing family stress are summarized in Table 3-19. Historical information on family relationships appears to be but one aspect of the overall psycho-social complex of variables associated with life adjustment. The recent family stress concept may have more utility, particularly for assessing the younger driver, providing the same assessment function that marital stress provides for adult drivers. An accurate recent history of family stress would appear indicative of increased accident liability.

General Personality Characteristics

The concepts of personality and attitude as they relate to driving problems has been a topic of numerous research investigations for the past three decades. Several studies have identified personality and attitude factors which appear to be related to accident involvement, but their predictive utility in an operational setting remains questionable. There are several reasons for the demonstrated low utility of psychometric prediction including the (1) instability of accidents as criterion measures; (2) lack of a useful theoretical framework for conceptualizing patterns of driver attitude and personality factors, as well as types of driving errors; and (3) experimental/methodological flaws in research studies. These issues will be discussed throughout this section. To provide a framework within which to compare research results, this review will discuss the utility of various instruments within the following somewhat loosely-defined conceptual areas:

- Emotional Stability
- Hostility/Aggression/Non-Conformity
- Impatience/Impulsiveness

Table 3-19. Selected Studies Using Family Stress as an Assessment Variable

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (Cluster analysis and data collection reported in earlier study Finkelstein and MeGuire 1971)	Type of Stress (0=none to 3=severe): Children related	Total (1 Yr)	.00	NS	850	Total (1 Yr).	–.03	NS	850
Finch and Smith (1970)	Interview/Question naire	In-depth investigation of background characteristics of 25 drivers involved in fatal accidents and a control sample of 25 drivers.	Parent-Child Problems					Control 6 Mo. 24 Hrs.	 8% 8%	 NR	 25
								Fatal 6 Mo. 24 Hrs.	 16% 12%	 NR	 25
Harano, McBride & Peck (1973)	Question-naire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc: N=196 0 Acc: N=231 Females 1+ Acc: N= 50 0 Acc: N= 57	Parent-Child Inventory	Convictions (3 Yr Period)				Group Membership (0/3 + Acc. in 3 Yr Period)			
			Parents' use of punishment (high scores=greater use)		.09	.10	427		.10	.05	427
			Family dissension (high scores=more dissension)		.09	.10	427		.09	.10	427
			Mother rated good/valuable (high scores=less valuable)		04	.15	427		.07	.05	427
			Father permissiveness rating (high score=more permissiveness)		.06	.15	427		–.08	.10	427
			Father/mother difference score on good/valuable (high score=larger diff)		.05	.15	427		.14	.01	427
Harrington (1971)	Interview	From large random sample of young drivers, interviewed those with 3 or more accidents for high accident group, interviewed equal number of accident free drivers as controls. (Contrasted Sample)	How well did you get along with parents at ages 16-17?					Predicting group membership ≤3 or no accidents in 4 Yr. (Males)	.16	.01	352
			Did your mother lose temper often?					Predicting group membership ≤3 or no accidents in 4 Yr. (Males)	–.18	.01	352

Continued

NR Not Reported
NS Not Significant

r Correlation coefficients [illegible] otherwise specified. Occasionally mean values reported in r column
P Probability [illegible]

Table 3-19. Selected Studies Using Family Stress as an Assessment Variable *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions — Type	r	P	Sample Size	Validity: Accidents — Type	r	P	Sample Size
			Were you babied by mother?					Predicting group membership ≤3 or no accidents in 4 yr. (Males)	−.17	.02	352
			Did your parents approve of your friends?					Predicting group membership ≤3 or no accidents in 4 yr. (Males)	.20	.01	352
Pelz and Schuman (1971)	Questionnaire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files. Respondent Sample Young males. n=1572 Young females. n 483 Older males: n=303 Older females. n 315 Criteria adjusted for exposure	Family Events (Number of events)	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .05 .06 .04 −.02	 .03 NS NS NS	(See Method)	Crashes (1 yr. adj.) Young male Older male Young female Older female	 .03 −.03 .04 −.01	 NS NS NS NS	(See Method)

NR Not Reported   r [illegible] otherwise specified. [illegible] mean values reported [illegible]
NS Not Significant   P Probability [illegible]

- Sociability
- Interpersonal Relations
- Interaction of Social and Psychological Variables

Emotional Stability

The early studies assessing the relationship between various measures of emotional stability and accident involvement produced very few positive results. One such study by Moffie et al. (1952) compared a small sample of truck drivers on the 13 scales of the Minnesota Multiphasic Personality Inventory (MMPI). None of the comparisons between accident repeaters (n =30) and accident-free drivers (n =30) were significant on any of the 13 MMPI scales. Also using the MMPI, McGuire (1956a) compared a contrasted sample of accident-repeater and accident-free enlisted men and found only one scale of the MMPI (Schizophrenic) to significantly differentiate between the two groups of drivers. Similarly, Conger et al. (1959), using a psychological battery of personality tests, found no significant differences between accident repeaters and accident-free drivers, but their sample was also small (n =20). However, objective tests combined with clinical observation revealed the accident repeater to exhibit more "fantasy" and poorer overall personality adjustment ($P<.10$). Rommel (1959) also used the MMPI to compare two matched groups of 25 high school students. Accident-repeating youths tended to score higher on the Psychopathic Deviate (Pd) scale and the Hypomania (Ma) scale, although the scores were still within the normal range. The authors interpret these findings as indicators of the accident repeaters' disregard of social mores, their defiance of authority (Pd), and their tendency toward excessive activity and enthusiasm (Ma).

A major limitation of all of the above studies was the lack of sufficient subjects to produce significant results. In a slight improvement, Beamish and Malfetti (1962) compared young violators and non-violators (N =270) and found violators to be less emotionally stable (as measured by the Guilford-Zimmerman Temperament survey), and to have more extensive mood changes (as measured by the Minnesota Counseling Inventory). These results appear more stable than those in the previous studies discussed, since a somewhat larger sample was used, and comparisons were made on violations, rather than accidents.

A slightly earlier study, the first which appears to have had a sufficiently large sample to produce reliable relationships between accident involvement and personality factors, was conducted by Brown and Berdie (1960). Driving records were obtained for 993 male college students, who were then administered the MMPI. Traffic violations and accidents accumulated over a 4-6 year period were then correlated with the MMPI scales. Similar to Rommel's (1959) findings, the Psychopathic Deviate scale (Pd) and Hypomania scale (Ma) correlated significantly with accidents ($r = .08$ and $.10$). With violations, the correlations were .10 and .08, respectively. A significant correlation with accidents was also found on the "F" validity scale (r =.08). For violations, the F scale correlated .09 and the Social Introversion scale correlated negatively (r =-.08). The authors speculate that one type of poor driver is characterized by lack of conformity, lack of respect for rights of others, and is generally self-centered. Another driver type (inferred from the Ma scale) is the driver in a hurry to reach his destination, paying little attention to the social consequences of his acts. Although a relatively large sample was used in this study, other methodological flaws appear to cloud an interpretation of these relationships. No adjustment for exposure is reported. This would seem to be a critical issue, since the time periods used in the analysis (4-6 years) varied for different subjects. The correlations may reflect exposure biases, as well as personality factors.

In a re-analysis of Brown and Berdie data, Fine (1963) attempted to test Eysenck's hypothesis that extroverts should have more accidents and violations than introverts. On the basis of scores on Welsh's MMPI-derived Internalization Ratio, subjects were divided into extrovert, intermediate, and introvert groups. Significant differences on accidents and violations were found among the three groups ($P < .02$), and the hypothesis was confirmed. As in the original study, the issue of exposure adjustment was not addressed.

Similarly, in a detailed series of studies conducted over more than ten years, which employed personality tests as screening criteria for South African bus driver applicants, Shaw et al. (1971) examined Eysenck's two factor theory by categorizing items into Extroversion (E) and Neuroticism (N). Correlations of the two scales with the accident criteria were .61 and .47 for E and N, respectively[9] Such exceptionally high correlations have never been duplicated with American subjects. A principal factor in these highly significant results is the fact that the South African accident rates were extremely high (approximately 2.5 per 10,000 miles driven), which provided a more stable estimate of driving behavior than in most experimental studies. Other factors, such as high variation among subjects, a relatively unsophisticated driving environment, and extended and well-measured driving exposure (since bus drivers had fixed routes), all contributed to the increased potential for identifying human factors.

Since these South African results have shown strong relationships between personality factors and driving behavior which are rather unique, Shaw's work will be reviewed in some detail.

Shaw's search for a culturally acceptable psychological assessment instrument led to the rejection of the common standardized personality

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9 Combining E and N items resulted in a correlation coefficient of .79 with accident criteria.

inventories and suggested the more generalizable projective techniques. Initially, the Rorschach test was found unsuitable for urbanized African subjects. The instruments finally selected were:

1. Thematic Apperception Test (TAT)--the African version developed by de Ridder (1961).

2. The Social Relations Test (SRT)--a comic strip technique developed by de Ridder (Shaw, 1965).

The combined tests were then administered to summarize an individual's personality pattern. The test administrators rated the subjects on a five point scale (1 = Excellent, 2 = Good, 3 = Fair, 4 = Poor, 5 = Bad).

The mean time interval (in days) between accidents was used to create a subsequent driving criterion. No attempt was made to weight this criterion by either crash culpability or severity. The author defends this criterion with the statement:

> "....that irrespective of the degree of blameworthiness that could be attributed to the driver, or of the outcome of the accident, the very fact that he was involved in a situation leading to an accident was very significant; and the rate of involvement was even more so." (Shaw, 1965)

Shaw does note that accident rate is unusually high for new bus drivers, and with increased driving experience the rate subsequently stabilizes. Consequently, Shaw calculated accident rates only after the initial high-accident period. A driver's accident rate was then compared with group norms for the region in which he worked. This comparison yielded an accident rating on a similar 1-5 scale (1 = Excellent--5 = Bad). (Much of Shaw's work is also concerned with other non-traffic, on-the-job criteria such as disciplinary problems. These will not be described here).

During the initial validation of Shaw's testing program, the TAT rating correlated strongly with the driver's subsequent accident rating ($r = .57$, $N = 163$). (Shaw prefers to discuss distributions of ratings, rather than correlation coefficients.) After the initial validation, the projective testing program was then used as a selection criteria for job applicants. Since applicants with low TAT ratings were not hired, the range of TAT ratings among new employees was more restricted. Consequently, the first follow-up evaluation (Shaw, 1965) resulted in a much lower TAT rating/accident rating correlation ($r = .24$ or $.27$, $n = 212$). A comparison with a control group also showed significant differences, but the comparison was hampered by differences in exposure, driving experience, age, and aptitude. By the next follow-up study, selection criteria had been relaxed due to a driver shortage, and the TAT rating/accident rating correlation again increased (r =.66, n =1139).[10]

However convincing these results on the predictive validity of projective testing in a driver diagnostic setting may be, they are nevertheless subject to one most important criticism: there are no reported reliability data, either test - retest or other inter-rater reliability. Since projective testing is based on observer ratings, such reliability measures are crucial for interpretation of results. An additional consideration is the ability to generalize Shaw's results to more sophisticated driving populations, such as in the United States. This issue is particularly relevant to the concept of "accident proneness" (see Introduction). The most plausible explanation is that Shaw's high correlations of personality tests with driving records and South Africa's high incidence of "accident proneness" both result from the country's relatively inexperienced drivers and unsophisticated highway system. Thus, there is little indication that Shaw's results are generalizable to more sophisticated driving environments. Finally, Shaw's criterion measure, mean time between accidents, may be operationally useful in a privately-operated transportation agency setting, but is limite' in applicability to other situations. It does not consider types of driving errors, accident severity, or driver culpability.

To obtain a more sensitive criterion measure of driver performance, Quenault et al. (1971) studied the relationship between scores on a battery of psychological tests and actual performance of drivers. The 20 subjects were first rated by observers on their driving over a 15 mile route. They were then classified into four groups on the basis of their performance in use of signals, mirror usage, overtaking, risk-taking, and near accidents. The four groups were then labeled "safe," "injudicious," "unsafe dissociated active," and "unsafe dissociated passive."

The drivers were administered the following battery of tests:

1. P.E.N. Inventory--A 78-item questionnaire concerned with self and other judgments of personal behavior.

2. Thematic Apperception Test (TAT) (7 cards)

3. Social Relations Test--Cartoon drawings used as stimuli for the subject to write a story. (8 sets)

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10 In their review of accident proneness, Shaw and Sichel (1971) discuss some of the implications of lowering selection criteria and increasing prediction. They conclude that the low predictive utility of many driver diagnostic instruments in America is a product of the highly controlled American driving environment. Deviant drivers are more often removed from the highway system. Thus, accidents result more often from chance events, and less often from recurrent driver errors.

4. The Raven Marticer (Intelligence Test)

5. The Two-Hand-Coordination Test

6. Reaction Test (Weiner Determinationsgerat)-- a measure of subject's performance under stress

When the results of the measures were compared, the only significant difference among the four groups was found on the P.E.N. Inventory, where the Extroversion scale discriminated between the safe and unsafe group. No reliability or cross-validation results are reported in the study, and the sample was too small for reliable interpretation.

In another small study (n =44) conducted in Sweden, Anderson et al. (1970) attempted to discriminate between low and high accident groups on Extroversion (E) and Neuroticism (N) dimensions using the Maudsley Personality Inventory and a battery of other tests. A perceptual test, Spiral After-Effect (SAE) as a measure of social-emotional adjustment, and a color-word test (Smith and Nyman, 1964), were also administered. Accident subjects were found significantly more hypersensitive and lower on emotional adjustment ($P<.01$). The authors suggest that accident subjects could be classified as "anxiety-hysteric" based on the significant differences on the neuroticism (N) scale. Most of the analyses are difficult to interpret, and it appears that the significant results could have occurred by chance alone, since several dimensions were tested.

Plummer and Das (1973) contradicted these findings in studying two groups contrasted on accidents (n =30 each). The Maudsley Personality Inventory-Neuroticism scale did not significantly discriminate between the groups. In a similar study using contrasted groups, Bracy (1970) found slight evidence that accident repeaters were more apprehensive, using the Sixteen Personality Factors test, but significant results again could have been the result of chance, since several dimensions were tested on this small sample (n =40 each group).

As a supplementary study to Project TALENT,[11] Asher and Dodson (1970) found that fatal accident victims (identified over a ten-year period) had been significantly less mature in personality. The specific test to measure personality was not cited. The study methodology contains several problems, such as no control for exposure and attrition due to mobility of students. However, these findings were confirmed by Harrington (1971) in a longitudinal study predicting a four-year driving record for high school students. He found that accident repeaters tended to rate themselves significantly more emotional

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11 Project TALENT subjects (Flanagan et al., 1964) were administered a broad range of assessment instruments. Over 800,000 subjects (2% of U.S. high school students) were tested in this program.

(r =.14) than accident-free drivers. McBride (1970) reported similar results in an exploratory study of negligent drivers, using the Gordon Personal Profile. He found that recidivists over a two-year period were less emotionally stable (r =-.36) and less responsible (-.41). Harano (1974) was unable to confirm these results using a much larger negligent driver sample. However, he reported results for only a one-year follow-up period. Apparently, the fact that the negligent drivers represented a rather homogeneous group (the pre-selection criteria reduces variability within the sample) combined with the brief (only one year) follow-up period to produce the negative finding.

In another study using the Gordon Personal Profile, Harano et al. (1973) found that accident repeaters were less emotionally stable (r =-.11). This study used extreme criteria for contrasting samples (0 vs. 3+ accidents) and a relatively large sample (n =427) and also included cross-validation. However, generalization to a random population would probably result in a reduced relationship, since the contrasted methodology represents a "ceiling" of expected relationship.

In a sub-analysis of an on-going project, Whinery et al. (1973) administered the "F" validity of the MMPI to a group of 16-18 year-old habitual offenders and a matched control sample. The offender group was found to be less emotionally stable, as inferred from the high score on the MMPI validity scale (r =.17). Although this result was marginally significant ($P < .11$), a preliminary analysis showed that different MMPI variables predicted recidivism among five different sub-populations. However, at this stage of development in the project, results would be expected to be relatively unstable because of the relatively small samples and lack of cross-validation. The study results are currently being cross-validated to provide an assessment of stability of these predictors.[12]

In general, some evidence supporting the assumption that emotional stability is related to accident and violation involvement has been provided by the studies reviewed. (See Table 3-20). Inconsistent results appear to be due to small samples, lack of control for exposure and unstable criteria. The stable criteria and extreme subject variability found in Shaw's work demonstrated much more predictive power than in American studies, where accidents are less frequent (unstable) and subjects more homogeneous. More evidence for the relationship of emotional stability measures and driving performance (as measured by driving record) is found in studies using relatively large samples (e.g., Brown and Berdie, 1960; Harrington, 1971; and Harano et al., 1973). Additional aspects of emotional stability will be discussed in the following sections.

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12 Private communication with Judge Whinery, March 1975.

Table 3-20. Selected Studies Using Emotional Stability Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions: Type	r	p	Sample Size	Validity: Accidents: Type	r	p	Sample Size
McBride (1970)	Psychological Battery	A group of 75 negligent drivers who attended a Driver Improvement meeting was administered the Gordon Personality Profile and a biographical questionnaire. Driving performance 2 yrs. subsequent to attending the meeting was predicted from the battery. The criteria was combined accidents and violations which is an operational criteria "Negligent Operator Point" (NOP) for recividism.	Responsibility	Negligent Operator Points (NOP) 2 year subsequent	-.410	.05	75				
			Emotional Stability		-.359	.05	75				
Harano (1974)	Psychological Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Gordon Personal Profile; Emotional stability (high score=more stable)	Total (1 yr.)	-.03	NS	850	Total (1 yr.)	-.01	NS	850
Harano, McBride & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ acc n=196; 0 acc n=231; Females 1+ acc n=50; 0 acc n=57	Gordon Personal Profile; Emotional stability (high score=more stable)	Convictions (3 yr. period) Males	-.05	.10	11	Group Membership (0/3+ acc in 3 yr. period) Males	-.11	.05	427
Whinery, Hilbert and Nicewander (1973)	Questionnaire	Questionnaire administered to 16-18 year old male habitual violators and a matched sample of non probationers. Tests of significance and bi-serial correlations computed by variables and group membership. Sample include n=116 probationers and n=160 non probationers	MMPI Validity (F)	Probationer (3+ convictions in 1 yr.) vs non probationers	17	.11	276				
McGuire, F (1956a)		Two matched groups, 67 each contrasted on accidents (1+) and accident/violation free groups, were compared on a battery of psychological tests. Accident subject selected on recency (months). Rosenzweig Picture Frustration Study: 1 hsernal and total score	MMPI; Schizophrenic (Sc)						NR	.05	134

(Continued)

NR Not Reported
NS Not Significant

Table 3-20. Selected Studies Using Emotional Stability Measures as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Rommel (1959)	Psychological Test	A comparison of accident repeaters (2+) vs. accident free high school students 25 subjects in each group. MMPI scales were administered.	Psychopathic Deviate (Pd)					pt. biserial or group membership	.35	.05	50
			Hypomania (Ma)						.43	.01	50
Peamish and Malfetti (1962)	Psychological Tests	A battery of psychological tests was administered to juvenile court offenders (84 males) and a comparison group of non-offenders (186 males). Violators had 2 or more violations in 1 yr. period.		Violator Group vs. Non-violator Group (1 yr.)							
		Minnesota Counseling Inventory	Mood		NR	.01	256				
		Guilford-Zimmerman Temperament Inventory	Emotional Stability		NR	.05	256				
Brown & Berdie (1960)		Correlated MMPI Inventory with 4-6 year driving record of 993 male college students. Age range from 18-22	MMPI	(Violation 4-6 years)				Accidents (4-6 years)			
			Psychopathic Deviate (Pd)		.10	.01	993		.09	.01	993
			Hypomania (Ma)		.08	.01	993		.10	.01	993
			Social Introversion (Si)		−.08	.01	993		−.01	NS	993
			Validity Score (F)		.09	.01	993		.08	.01	993
Plummer and Cas (1973)	Adjective Rating Scale	Compared high and low accident groups on scale measuring emotional disturbance. (Contrasted Sample)	Maudsley Personality Inventory= Neuroticism Scale					Mean Score 2+ Accident Group (1 yr.)	20.50	NS	30
								No Accident Controls (1 yr.)	22.81		30
Bracy (1970)	Psychological Tests	Personality Characteristics of accident repeaters (2+ accident and accident free male college students) studied. The study employed the "Sixteen Personality Factor Questionnaire and Impulsiveness Scale" of "How well do you know your self" to measure personality characteristics.	Apprehensive					Group Membership (2+ responsible accidents vs "0")	NS	.05	80
Asher and Dodson (1970)	Test Battery	Compared fatally injured high school students vs. peers on Project TALENT Data items. (Contrasted Sample)	Mature in personality					Lower for fatality victims	NR	.05	44
Harrington (1971)	Interview	From large random young driver sample, interviewed those with 3 or more accidents, equal number accident free controls. (Contrasted Sample)	Self Rating: Emotional (From adjective sort)					Predicting group membership ≤ 3 or no accidents in 4 yr. (Males)	.14	.05	352

NR Not Reported

NS Not Significant

Hostility/Aggression/Non-Conformity

The concept of aggression and hostility has a great deal of face validity as a predictor of driving behavior. The stereotype of the unyielding driver, disregarding the rights of others, and using a car to vent his hostility has been suggested in many studies. Conger et al. (1959), in a small study, found the accident-repeating driver to be significantly more hostile ($P<.05$). Examining military personnel, McGuire (1956a) found accident-repeating enlisted men to score significantly higher on the Psychopathic Deviate (Pd) scale of the MMPI ($P<.05$). Rommel (1959) confirmed this finding in his study of accident-repeating youths, who scored significantly higher on the Psychopathic Deviate (Pd) scale ($r = .35$, with $n = 50$). Rommel interprets this finding as an indication of the individual's disregard for social mores and defiance of authority. An earlier study by Moffie et al. (1952) also showed the Psychopathic Deviate scale to correlate with accidents in a small truck driver sample ($r = .15$), but this result was not significant.

Since previous research had demonstrated that humor was a correlate of aggression and aggressive tendencies, Kole and Henderson (1966) developed a test of 150 motoring-related cartoons, to examine the possibility that a humor-related test might be a better predictor of driving behavior than traditional paper and pencil tests. Problem and non-problem drivers were compared on their reaction to the cartoons. Significant differences ($P<.006$) were found between the experimental and control groups, on 35 of the 150 cartoons. Upon cross-validation, 75 of 100 "good" drivers were accurately identified. Although the study appears to have been well-designed, the samples were small and predictive validity studies are needed, since future prediction of collisions was not addressed.

Heimstra et al. (1967) administered a Mood Adjective Checklist measuring such factors as aggression, anxiety, concentration, fatigue, social affection, sadness, and egotism to 175 male and 175 female drivers. Each subject then spent 70 minutes performing in a driving simulator device, yielding measures on four dimensions ostensibly relevant to driving: vigilance, reaction time, tracking performance, and speed maintenance. Normalized coefficients were computed between performance and mood measures for the entire sample of 350. Correlations ranged from .10 to .18 between simulator performance measures and personality factors, suggesting that no single performance measure was related to any great extent to any of the mood measures. When examined separately, males show smaller relationships than females. On the performance measures, females missed more signals than men and had more tracking errors. Males had more speeding errors. (This is similar to Level I findings concerning types of traffic convictions by sex.)

In another study examining young male violators ($n = 84$) and non-violators ($n = 186$), Beamish and Malfetti (1962) found violators to be significantly more non-conforming ($P<.10$) and ascendant ($P<.001$) than non-violators. Hostility, as measured by the Minnesota Counseling Inventory and the Psychopathic Deviate scale of the MMPI, was not a significant discriminator. Harrington (1971) did report young accident repeaters to be significantly more aggressive ($r = .20$) and assertive ($r = .16$).

More driving-related measures of defiance of authority have been employed in the recent studies of Harrington (1971), Pelz and Schuman (1971), and Harano et al. (1973). Harrington, in his four-year young driver follow-up study, found that among males, negative attitudes toward courts, enforcement, and the Department of Motor Vehicles correlated .23 for convictions and .07 for collisions. For females, the correlations were lower for both convictions ($r = .11$) and accidents ($r = .02$). These relationships are probably quite stable since the sample for males was $n = 5057$ and for females $n = 4403$. Similarly, the Harano et al. (1973) study reported that accident repeaters tended to have more negative attitudes toward law enforcement ($r = .12$), and violators from both samples (accident and control) had more negative attitudes ($r = .16$). These findings may reflect an important disadvantage of the retrospective study--the attitudes being measured might have been the result of the past accidents or convictions, instead of the cause. These authors also found that the accident repeaters were less responsible, as measured by the Gordon Personal Profile ($r = -.19$).

In another recent study which employed a variety of psychological assessment measures, Pelz and Schuman (1971) derived an index based on attitudes toward authority called the Rebellion Index. In addition, separate scales were derived for "anger toward things," "anger toward people," and the ratio of the two "anger overt/covert." Since this analysis examines both violations and crashes by different sub-populations, some of the results are presented in Table 3-21. Significant but small correlations were found for young males on both violations ($r = .06$) and crashes ($r = .07$). Young females show a similar relationship, but the results are not significant. No relationships were found for older males (actually middle-aged), but older females having higher rebellion scores had significantly more violations.

Interestingly, younger males and older females show similar results on anger toward things, where both younger males and older females higher on this scale have more violations ($r = .10$ and .16) and more crashes ($r = .05$ and .10). Anger toward people revealed a significant relationship for young males ($r = .14$) and young females ($r = .09$) with violations. No other relationships were significant. The ratio of anger, overt/covert, revealed similar results, with young males who scored higher on this scale having more violations ($r = .14$) and crashes ($r = .06$). Young females and older females had significant correlations with violations ($r = .11$ and .18 respectively). The general results indicate a high level of hostility and rebellion in young males which markedly declines as they reach middle age. Young female drivers also have relatively high hostility levels (though not as high

TABLE 3-21 CORRELATIONS OF REBELLION INDEX WITH TRAFFIC SAFETY CRITERIA

	Violations and Warnings	Crashes
Males:		
Young (age 16-24) (n=1672)	.06*	.07**
Older (age 35-44) (n=483)	-.03	.01
Females:		
Young (age 16-24) (n=303)	.08	.15
Older (age 35-44) (n=315)	.21**	.11

Source: Pelz and Schuman (1971)

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

as young males), but they score even higher on most measures in middle-age. On many of the scales, the older females appear comparable to the younger males.

In general, these studies (as summarized in Table 3-22) seem to suggest that both the accident repeater and violator tend to be more aggressive and more hostile toward authority and peers, and they have a higher level of disregard for social mores. The magnitude of the relationships, however, is slight, and as a unitary concept this dimension has low practical utility.

Impatience/Impulsiveness

Another conceptual dimension which appears frequently in studies relating personality factors to driving behavior is the measure of impatience or impulsivity. Plummer and Das (1973) speculate that unthinking and impulsive use of the motor vehicle when frustrated or upset seems to indicate the operation of dichotomous (or black and white) thinking, which in turn facilitates the choice of extreme alternatives. To test their hypothesis, they administered an adjective rating scale (Osgood et al., 1957) of dichotomous thinking to two groups (30 each) of accident repeaters and accident-free subjects. Accident repeaters were found to be significantly higher on the activity scale (26% higher), potency scale (21%), evaluation scale (7%) and total scale (13%).

In an earlier study, Conger et al. (1959) found accident repeaters to have less tension tolerance ($P<.01$) than accident-free subjects. Williams and Malfetti (1970) used an instrument similar to that used by Plummer and Das. Adjective checklists (Osgood Semantic Differential--Osgood et al., 1957) were developed to assess attitudes and cognitive meaning, especially with respect to driving symbols. Two successive studies were concerned with defining the dimensions and structure of the items. In addition, preliminary attempts were made to determine the ability of the test to discriminate between violation/accident groups and incident-free drivers (Study 1: N =1000, Study 2: N =1025). Although the test consistently demonstrated the dimensions of evaluation, potency, activity, sensitivity, stability, and aggressiveness, comparisons among accident violators and accident-free violators did not demonstrate clear differences. The semantic differential items were cross-validated on small "good driver" and "bad driver" groups of telephone employees. Only 10 of 112 items significantly discriminated between the groups. The authors conclude that the test may be useful for group identification but did not demonstrate utility for individual diagnosis. Test-retest reliabilities of .65 to .80 were reported, although a sub-experiment to determine effects of faking showed that the test can be faked.

Further support for the tension tolerance concept was provided by the Asher and Dodson (1970) study, in which fatal accident victims were

Table 3-22. Selected Studies Using Hositlity, Aggression, and Non-Conformity Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Conger et al. (1959)	Psychiatric Interview and Psychological Tests	A psychological test battery and in-depth psychiatric interview were used to compare two groups of airmen (10 subjects each) on accidents. The accident repeater group had 2 or more accidents. Variables are based on a combination of clinical and psychological tests.	Aggressive					Group Membership (0 vs 2+)	NR	.05	20
McGuire, F (1956a)		Two matched groups, 67 each, contrasted on accidents, (1+) and accident/violation free groups, were compared on a battery of psychological tests. Accident subject selected on recency (months) Rosenzweig Picture Frustration Study 1 biserial and total score	MMPI Psychopathic Deviate (Pd)						NR	.05	
Rommel (1959)	Psychological Test	A comparison of accident repeaters (2+) vs. accident free high school students 25 subjects in each group. MMPI scales were administered.	Psychopathic Deviate (Pd)					pt. biserial or group membership	.35	.05	50
Beamish and Malfetti (1962)	Psychological Tests	A battery of psychological tests were administered to juvenile court offenders (84 males) and a comparison group of non-offenders (186 males). Violators had 2 or more violations in 1 yr. of period.		Violator Group vs. Non-Violator Group (1 yr)							
		MMPI	Psychopathic Deviation		NR	.20	256				
		Minnesota Counseling Inventory	Hostility			NS	256				
		Minnesota Counseling Inventory	Ascendency		NR	.10	256				
		Minnesota Counseling Inventory	Non-Conformity			.001	256				
Harrington (1971)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16-17. (Random Sample)	Attitudes towards courts, enforcement, DMV	Total Convictions (4 Yr) Males Females	 .225 .112	 .05 .05	 5,057 4,403	Total Accidents (4 Yr) Males Females	 .067 .018	 .05 .05	 5,057 4,403
	Interview	From large random young driver sample, interviewed those with 3 or more accidents, equal number accident free controls (Contrasted Sample point biserial correlations)	Aggressive (self-rate)					Predicting group memberships ≥3 or no accidents in 4 yr.	.20	.006	352

Continued

NR Not Reported
NS Not Significant
r Correlation coefficient [illegible] unless otherwise specified. Occasionally mean values reported in r column.
P Probability of significance [illegible]

Table 3-22. Selected Studies Using Hostility, Aggression, and Non-Conformity Measures as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Pelz and Schuman (1971)	Question-naire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official file: Respondent Sample Young males: n=1672 Young females: n=483 Older males. n=383 Older females. n=315 Criteria adjusted for exposure (per 100 drivers/yr.)	Anger things	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .10 -.02 08 16	 .01 NS NS .01	(See Method)	Crashes (1 yr. adj.) Young male Older male Young female Older female	 .05 .06 .08 .10	 .05 NS NS .10	(See Method)
			Anger-People	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .14 -.04 .09 .07	 .01 NS .05 NS		Crashes (1 yr. adj.) Young male Older male Young female Older female	 .05 -.03 .04 .04	 NS NS NS NS	
			Anger-Overt/Covert	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .14 -.03 .11 .18	 .01 NS .05 .01		Crashes (1 yr. adj.) Young male Older male Young female Older female	 .06 .01 .05 .09	 .05 NS NS NS	
			Rebellion Index	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 06 -.03 08 .21	 .05 NS NS .01	(See Method)	Crashes (1 yr. adj.) Young male Older male Young female Older female	 .07 .01 .15 .11	 01 NS .01 .05	(See Method)
Harano, McBride & Peck (1973)	Question-naire Interview	Correlated test and question-naire items with group mem-bership based on accident frequency. Groups contrasted on 3 or more accidents vs. acci-dent free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc: N=196 0 Acc N=231 Females 1+ Acc: N= 50 0 Acc: N= 57	Attitude toward law enforcement	Convictions (3 Yr Period) Males	 .16	 .01	 427	Group Mem-bership (0/3 + Acc. in 3 Yr Period) Males	 .12	 .01	 427
			Gordon Personal Profile Responsibility (high score=more responsible)	Males	-.13	.05	427	Males	-.19	.01	427

NR Not Reported
NS Not Significant
r [illegible] Occasionally mean values reported in r column
P [illegible]

found to be significantly less calm. Harrington (1971) found accident repeaters to rate themselves as more adventurous (r =.20). Using the Sixteen Personality Factors Questionnaire, Bracy (1970) found accident repeaters to be significantly more impulsive. The cautiousness scale from the Gordon Personal Inventory was found to significantly differentiate between accident repeaters and accident-free subjects (r =.20) in the Harano et al. study (1973). Violators from both groups were found to be less cautious (r =-.24).

Other studies have produced contradictory results. Whittenburg et al. (1973), using the Thurstone Temperament Schedule, found that among Coast Guard recruits, the accident-free drivers scored higher on the impulsive scale. In the follow-up study of negligent drivers, Harano (1974) found cautiousness was not a significant predictor of recividism. However, as mentioned earlier, pre-selection probably reduced variability within the sample.

Once again, the overall results of the analyses conducted on the relationship of the impulsivity personality dimension and driving behavior (See Table 3-23) does not demonstrate very clear-cut results. Relationships are generally low, but significant. The relationships of this factor with other personality dimensions are also unclear. At this time, therefore, the impulsivity personality dimension must be viewed as a useful area for further research, particularly in its interactions with other variables, but is presently of little operational utility.

Sociability

As a possible extension of the tension tolerance hypothesis, sociability and activity levels also tend to be related to driving behavior. In the Brown and Berdie study (1960), significant correlations between the MMPI Hypomania (Ma) scale and traffic convictions (r =.08) and accidents (r =.10) were interpreted as evidence of more excessive activity among violators and accident repeaters. Social extroversion also correlated significantly with convictions (r =.08). Rommel (1959) found accident repeaters to score significantly higher on the Ma scale (r =.43), similar to the Brown and Berdie results. These findings were confirmed in Beamish and Malfetti's study (1962), where remedial violators scored higher on the Guilford-Zimmerman Temperament Survey Sociability scale and the Minnesota Counseling Inventory Social Activity scale. Bracy (1970),using the Sixteen Personality Factors Questionnaire (16 PF), found accident repeaters to be more outgoing and happy-go-lucky ($P<.05$). Harrington's (1971) follow-up study added further support for this concept. His accident repeaters rated themselves as more lively (r =.15) and more assertive (r =.16). In a two-year follow-up study of negligent drivers, McBride (1970) reported a significant relationship between Sociability (as measured by the Gordon Personal Profile) and recidivism (r =.20).

Table 3-23. Selected Studies Using Impatience/Impulsiveness Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Plummer and Das (1973)	Adjective Rating Scale	Compared high and low accident groups on degree of dichotomous (Black-and-White) thinking. (Contrasted Sample)	Osgood's Semantic Differential Method. Measuring Dichotomous Thinking					Mean Score (Higher is more dichotomous)			
			--Evaluative Scale					2+ Accident Group (1 Yr)	1.72	.05	30
								No Accident Controls (1 Yr)	1.61		30
			--Potency Scale					2+ Accident Group (1 Yr)	1.63	.01	30
								No Accident Controls (1 Yr)	1.35		30
			--Activity Scale					2+ Accident Group (1 Yr)	1.54	.01	30
								No Accident Controls (1 Yr)	1.22		30
			Total Score					2+ Accident Group (1 Yr)	1.65	.05	30
								No Accident Controls (1 Yr)	1.46	.19	30
Conger et al (1959)	Psychiatric Interview and Psychological Tests	A psychological test battery and in-depth psychiatric interview were used to compare two groups of airmen (10 subjects each) on accidents. The accident repeater group had 2 or more accidents. Variables are based on a combination of clinical and psychological tests.	Tension Tolerance					Group Membership (0 vs 2+)	NR	.01	20
Asher and Dodson (1970)	Test Battery	Contrasted fatally injured high school students vs. peers on Project TALENT Data items. (Contrasted Sample)	Student Activity Inventory Scales:								
			Calm					Lower for fatality victims	NR	.05	44
Herrington (1971)	Interview	From large random young driver sample interviewed those with 3 or more accidents, equal number of accident-free controls. (Contrasted Sample)	Adventurous					Predicting group membership ≥ 3 or no accidents in 4 yrs. (Males)	.20	.01	352
Harano, McBride & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3 + acc: n=196; 0 acc n=231; Females 1 + acc: n=50; 0 acc n=57	Gordon Personal Inventory: Cautiousness (high score = more cautious)	Convictions (3 yr. period)	-.24	.01	11	Group Membership (0/3+ acc. in 3 yr. period)	-.20	.01	427

Continued

NR - Not Reported
NS - Not Significant
r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P Probability of significance (. has been dropped)

Table 3-23. Selected Studies Using Impatience/Impulsiveness Measures as Assessment Variables *(Cont.)*

				Validity							
				Convictions				Accidents			
Study	Type of Instrument	Sample Description and Method	Variables	Type	r	P	Sample Size	Type	r	P	Sample Size
Bracy (1978)	Psycho-logical Tests	Personality Characteristics of accident repeaters (2+ accident and accident free male college students studied. The study employed the "Sixteen Personality Factor Questionnaire and Impulsiveness Scale" of "How well do you know your self" to measure personality characteristics	Outgoing					Group Membership (2+ responsible accidents vs "0")	NR	.05	80
			Happy-go Lucky						NR	.05	80
			Apprehensive						NR	.05	80
			Group Dependency						NR	.05	80
Harano (1974)	Psycho-logical Tests	A battery of psycho physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting <u>future</u> errors (Cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Gordon Personal Inventory	Total (1 Yr)				Total (1 Yr)			
			Cautiousness (high score = more cautious)		−.03	NS	850		−.05	NS	850
Finkelstein & McGuire (1971)		A large test battery was administered to a group of 950 negligent drivers. Cluster analysis done to identify types. Concurrent correlations of selected variables reported here (1 yr. driving record)	Gordon Personal Inventory								
			Cautiousness		.06	.10	950		−.05	NS	950

NR — Not Reported
NS — Not Significant

r — [illegible] coefficient [illegible] product moment unless otherwise specified. Occasionally <u>mean</u> values reported in r column)
P — Probability [illegible] has been dropped)

Whittenburg et al. (1973) found an opposite relationship among Coast Guard recruits. Using the Thurstone Temperament Schedule, they found accident-free drivers to score higher on the Sociable scale. (These findings are, however, apparently the result of peculiarities within the Thurstone instrument, since these authors, using the same subjects, found accidents positively related to the Mann Inventory sociability items).

Harano (1974), using a much larger sample predicting recidivism (accidents and convictions) among negligent drivers, did not find significant relationships with the Sociability, Ascendency, or Vigor scales of the Gordon Personal Profile Inventory. The non-significant findings on these scales had also been found in the earlier study on accident repeaters (Harano et al. 1973), although other personality dimensions from the Gordon Profile and Inventory were significant (e.g., Responsibility).

Some of these research findings are summarized in Table 3-24. Relationships are frequently significant, but their magnitudes are low. None of these studies address the interaction between sociability and other driving-related behaviors. Thus, there are probably several aspects of sociability and activity which cannot currently be determined. For example, does excessive activity result in non-productive behaviors? If accident repeaters are more sociable and outgoing, how do their personal relationships affect their driving? Some of these issues will be discussed in the following pages.

Interpersonal Relations

Many research findings (some discussed previously under "Social Stress") indicated that interpersonal problems seemed to be over-represented in accident-repeater, violator, and fatal-accident samples. Finch and Smith (1970), as may be recalled, found interpersonal relation problems to have been present in 56% of their fatal sample, compared to only 8% of a control sample. Many other studies have shown further evidence of relationships between interpersonal variables and driving problems. Asher and Dodson (1970) found fatal accident victims to be more active, but less socially sensitive ($P<.05$). Accident repeaters in the Harrington (1971) study rated themselves as more assertive ($r=.19$). Bracy (1970) found accident repeaters to be more outgoing but high on group dependency as measured by the 16 PF ($P<.01$). Beamish and Malfetti (1962) also found violator recidivists to be significantly higher on the dependency scale ($P<.01$) of the Guilford-Zimmerman Temperament Survey. As a dependency measure, Conger et al. (1959) found accident repeaters to score significantly higher on separation anxiety ($P<.01$).

Accident repeaters in the Harano et al. (1973) study were found to participate in group rather than individual activities almost two times more often than the accident-free group, but were more dissatisfied with life in general, and with their spouse/girl or boyfriend. Blind ratings of subjects by interviewers indicated the accident repeaters were

Table 3-24. Selected Studies Using Sociability Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	p	Sample Size	Validity: Accidents Type	r	p	Sample Size
Brown & Berdie (1960)	.	Correlated MMPI Inventory with 4-6 year driving record of 993 male college students. Age range from [illegible] 22	MMPI	Violation. (4-6 yrs.)				Accidents (4-6 yrs.)			
			Hypomania (Ma)		.08	.01	993		.10	.01	993
			Social Introversion (Si)		−.08	.01	993		−.01	NS	993
Rommel (1959)	Psychological Test	A comparison of accident repeaters (2+) vs. accident free high school students 25 subjects in each group. MMPI scales were administered.	Hypomania (Ma)					pt. biserial or group membership	.43	.01	50
Beamish and Malfetti (1962)	Psychological Tests	A battery of psychological tests were administered to juvenile court offenders (84 males) and a comparison group of non-offenders (186 males). Violators had 2 or more violations in 1 yr. period		Recidivist Violators vs Non-Recidivist (1 yr.)							
		Guilford-Zimmerman	Sociability	Recidivist score higher	NR	.05	83				
		Siegel Biographical Inventory	Social Activity		NR	.02	83				
		Guilford-Zimmerman	Social Activity		NR	.02	83				
Bracy (1970)	Psychological Tests	Personality Characteristics of *accident repeaters* (2+ accident and accident free male college students studied. The study employed the "Sixteen Personality Factor Questionnaire and Impulsiveness Scale" of "How well do you know yourself" to measure personality characteristics.	Outgoing					Group Membership (2+ responsible accidents vs. "0")	NR	.05	80
			Happy-go Lucky						NR	.05	80
Harrington (1971)	Interview	From large random young driver sample, interviewed those with 3 or more accidents, equal number accident free controls. (Contrasted Sample)	Lively					Predicting group memberships ≤3 or no accidents in 4 yr. (Males)	.15	.04	352
			Assertive						.16	.03	352
McBride (1970)	Psychological Battery	A group of 75 negligent drivers who attended a Driver Improvement meeting was administered the Gordon Personal Profile and a biographical questionnaire. Driving performance 2 yrs. subsequent to attending the meeting was predicted from the battery. The criteria, combined accidents and violations is "Negligent Operator Point" (NOP) *for recidivism.*	Sociability	Negligent Operator Points (NOP) 2 year subsequent	201	.05	75				

Continued

NR Not Reported
NS Not Significant

r [illegible] (product moment unless otherwise specified) Occasionally mean values reported in r column
p Probability [illegible] has been dropped

Table 3-24. Selected Studies Using Sociability Measures as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire, 1971)	Gordon Personal Profile: Ascendancy (high score=more ascendant)	Total (1 yr.)	.01	NS	850	Total (1 yr.)	−.01	NS	850
			Sociability (high score=more sociable)		.01	NS	850		.01	NS	850
			Personal Inventory, Vigor (high score=more vigorous)		.02	NS	850		.02	NS	850

NR - Not Reported
NS - Not Significant

r - Correlation coefficient (Product moment unless otherwise specified. Occasionally mean values reported in r column)
P - Probability of significance (% has been dropped)

significantly less calm and less well-oriented during their participation in the research program. On the Personal Relations scale of the Gordon Personal Profile, accident repeaters were less personal (r =-.10), as were violators from both samples (r =-.07).

In the study by Marsh and Hubert (1974), driver improvement analysts were asked to rate 1210 male "negligent operators" on 11 pairs of bipolar adjectives. These ratings were scored on 5 scales. Subjects rated at the "cold" end of the warm/cold scale, and "negative" end of the positive/negative scale, were found to have more convictions after their hearings (r =-.09) and r =-.08, respectively. None of the scales or individual items correlated significantly with accidents.

In contrast to these findings, Beamish and Malfetti (1962) in a small study of violators (n =50) did not find significant relationships on thoughtfulness, personal relations, and family relations using assorted personality inventories (Minnesota Counseling Inventory and Guilford-Zimmerman Temperament Survey). A significant but small relationship was shown on dependence.

In a much larger study (n =993), Pelz and Schuman (1971) correlated their Peer Hostility Index (items relating to arguments or quarrels with friends) with violations and crashes. The index correlated significantly with violations and accidents for both young males and older females. Males with higher scores on the Peer Hostility Index had significantly more violations (r =.10) and crashes (r =.07). For older females, these correlations were .16 and .12 respectively. Although slight correlations were present for young females and older males, the relationships were not significant.

A one-year follow-up study of driver education students (Ohio Department of Education, 1973) found students involved in accidents and violations to have lower scores on items measuring social desirability, sociability, acceptance of peer values attitude scales, and acceptance of social authority or control. No statistical tests were performed on these relationships, however, so it is difficult to determine the utility.

Studies using personality inventories to measure sociability and personal relationships have demonstrated several significant but small relationships (summarized in Table 3-25). In general, the results are consistent with findings in other areas that social adjustment problems are slightly related to driving behavior, the magnitude of the relationship declining with age for males, but increasing with age for females. Again, further research is needed before these findings can be made operational.

Interaction of Social and Psychological Variables

Psycho-social adjustment factors have been shown to play an important role in accident involvement. One of the earliest studies

Table 3-25. Selected Studies Using Interpersonal Relations Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Harano, McBride, & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ acc: n=196; 0 acc. n=231; Females 1+ acc: n=50; 0 acc: n=57	Gordon Personal Inventory Personal relations (high score=more personal)	Convictions (3 yr. period) Males	-.07	.10	427	Group Membership (0/3+ acc in 3 yr. period) Males	-.10	.10	427
			Belongs to a club		-.11	.10	427		-.08	10	427
			Belongs to a religious organization		-.11	.10	427		-.12	.05	427
			Satisfied with life in general)					(female)	.19 (.23)	.01 .01	427 107
Pelz and Schuman (1971)	Questionnaire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files Respondent Sample Young males: n=1672 Young females: n=483 Older males: n=303 Older females: n=315 Criteria adjusted for exposure (per 100 drivers/yr.)	Peer Hostility Index	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .10 -.01 .05 .16	 <.01 NS NS <.01	(See Method)	Crashes (1 yr. adj.) Young male Older male Young female Older female	 .07 .05 .08 .12	 <.01 NS NS <.05	(See Method)
Whinery, Hilbert and Nicewander (1973)	Questionnaire	Questionnaire administered to 16-18 year old male habitual violators and a matched sample of non-Probationers. Tests of significance and bi-serial correlations computed by variables and group membership. Sample include n=116 probationers and n=160 non-probationers	No Male Friend	Probationers (3+ convictions in 1 yr.) vs. non-probationers	.19	.08	276				
			No Female Friend		.13	.20	276				
			No Other Significant		-.27	.01	276				
Harano (1974)	Psychological Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting. Predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Gordon Personal Inventory Personal relations (high score= more personal)	Total (1 yr.)	-.02	NS	850	Total (1 yr.)	-.07	.05	850
Finch and Smith (1970)	Interview/ Questionnaire	In-depth investigation of background characteristics of 25 drivers involved in fatal accidents and a control sample of 25 drivers.	Interpersonal Problems					Fatals (Percent Sample) Control 6 Mo. 24 Hrs. Fatal 6 Mo. 24 Hrs.	 12% 12% 36% 56%	 NR NR	 25 25

Continued

NR = Not Reported
NS Not Significant

r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P Probability of significance (% has been dropped)

Table 3-25. Selected Studies Using Interpersonal Relations Measures as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Asher and Dodson (1970)	Test Battery	Compared fatally injured high school students vs. peers on Project TALENT Data items (Contrasted Sample)	Social Sensitivity Scale					Contrasted Samples - Lower for fatality victims	NR	.05	44
Harrington (1971)	Interview	From large random young driver sample, interviewed those with 3 or more accidents, equal number accident free controls. (Contrasted Sample)	Assertive					Predicting group memberships 3 or no accidents in 4 yrs. (Males)	.16	.03	352
Bracy (1970)	Psychological Tests	Personality Characteristics of accident repeaters (2+ accident and accident free male college students studied. The study employed the "Sixteen Personality Factor Questionnaire and Impulsiveness Scale of "How well do you know yourself" to measure personality characteristics.	Outgoing					Group Membership (2+ responsible accidents vs. "0") Accident repeaters higher	NR	.05	80
			Group Dependency						NR	.05	80
Beamish and Malfetti (1962)	Psychological Tests	A battery of psychological tests were administered to juvenile court offenders (84 males) and a comparison group of non-offenders (186 males). Violators had 2 or more violations in 1 yr. period.		Recidivist Violators vs. Non-Recidivist (1 yr.)							
		Guilford-Zimmerman	Dependence	Recidivist lower on scale	NR	.01	83				
		Minnesota Counseling Inventory	Thoughtfulness		NR	.20	83				
		Minnesota Counseling Inventory	Personal Relations		NR	.20	83				
		Siegel Biographical Inventory	Family Relations		NR	NS	83				
Conger et. al. (1959)	Psychiatric Interview and Psychological Tests	A psychological test battery and in-depth psychiatric interview were used to compare two groups of airmen (10 subjects each) on accidents. The accident repeater group had 2 or more accidents. Variables are based on a combination of clinical and psychological tests.	Separation Anxiety					Group Membership (0 vs. 2+) Accident involved higher on anxiety	NR	.01	20
Marsh & Hubert (1974)	Interview/ Questionnaire Driver Record	Information gathered as part of a Driver Improvement meeting from negligent drivers (2165 questionnaires) and negligent driver hearings (1210 interviews) Correlated items with driver record (20 months subsequent record) for 3375 male drivers	Analyst rating of subject on bipolar adjectives	Hazardous driving convictions 20 months after hearing or meeting				Total accidents 20 months after hearing or meeting			
			warm/cold scale		-.09	.01	1210		.01	NS	1210
			positive/negative scale		-.08	.01	1210		.00	NS	1210

NR Not Reported
NS Not Significant

r Correlation coefficient (product moment) unless otherwise specified. Occasionally mean values reported in r column.
P Probability of sampling ... [illegible]

(Tillman and Hobbs, 1949) demonstrated that accident repeaters were known to other agencies much more frequently than accident-free drivers. Of their accident repeaters, 66% had at least one previous contact with other agencies, compared to only 10% for the controls. Court/agency records also indicated that accident repeaters had more major traffic convictions, minor traffic offenses, offenses against other persons, offenses against self and against property. In-depth interviews with employers, family, and friends, were conducted to determine background, social, and psychological information on victims of fatal accidents. The accident repeaters were characterized as more aggressive, more impulsive, less able to delay gratification, more exhibitionistic, more extensively used projection, and often evidenced serious problems with authority, accompanied by social stress and social maladjustment.

A similar study (Schmidt et al.,1972) conducted an in-depth investigation of a small sample of driver fatalities. The Katz Adjustment Scales (Katz et al., 1963), an instrument used for interviewing persons who knew the subject, was used to collect data. The authors found five scales which significantly discriminated between single vehicle fatalities and a random population represented by test norms. The fatality victims were found to have significantly higher scores on Belligerence, Negativism, General Psychopathology and Hyperactivity, but they scored lower on Withdrawal. A finding which has implications for alcohol assessment was that none of the drinking driver fatals had ever been convicted of a previous drinking/driving offense. The authors suggest that methods other than prior driving record be used to identify drivers with drinking problems. The Katz Adjustment Scale appears to be a useful technique for screening high-risk drivers.

In a replication of the above study, Shaffer et al. (1974) examined 50 fatal accident victims. Table 3-26 (adapted from Shaffer) gives the results of the comparison of fatal samples with a norm. The fatality victims were rated significantly higher on the Belligerence, Verbal Expansiveness, Negativism, General Psychopathology, and Hyperactivity scales, and lower on Withdrawal and Retardation when compared to a control group. Correlational analysis with other factors (e.g., age, race, BAC) did not show strong relationships, primarily due to the small sample.

Similar results were shown in the Finch and Smith study (1970) using somewhat different personality dimensions. These authors interviewed relatives and employers of fatal accident drivers, using a 165 item questionnaire and interview. Evidence of maladaptive functioning was found for 20 of the 25 fatally-injured drivers. Table 3-27 provides comparative data between the fatal and control samples. Anti-social (sociopathic) personalities were highly over-represented in the fatal sample. This is consistent with the general trend for the Psychopathic deviate (Pd) scale of the MMPI to correlate with membership in accident-repeater groups. As discussed previously, precipitating stresses (job, marital, etc.) were present 24 hours prior to the crash in 80% of fatals, compared to 12% of the control sample.

TABLE 3-26 MEAN T SCORES OF MALE DRIVER FATALITIES ON THE KATZ ADJUSTMENT SCALES--R FORM

Katz Adjustment Scales	Combined Samples, N=50
Belligerence	60.3**
Verbal expansiveness	56.0**
Negativism	56.8**
Helplessness	53.2
Suspiciousness	56.2
Anxiety	57.1
Withdrawal and retardation	46.9*
General psychopathology	56.2**
Nervousness	52.9
Confusion	49.8
Bizarreness	54.3
Hyperactivity	58.3**
Stability	49.0
Level of performance of socially expected activities	49.3
Level of expectations for performance of social activities	46.1
Level of free-time activities	50.7
Dissatisfaction with free-time activities	50.4
Dissatisfaction with performance of socially-expected activities	47.6*

Source: Shaffer et al. (1974)

*Significantly different from normative mean of 50 at .05 level.

**Significantly different from normative mean of 50 at .01 level.

TABLE 3-27. PERSONALITY DISORDERS AMONG FATALITIES

	Fatalities	Controls
PERSONALITY DISORDERS	80% (20)	8%(2)
NORMAL	20% (5)	88% (22)
Anti-social personality (sociopath)	24% (6)	4% (1)
Alcoholic	60% (15)	8% (2)
Paranoid personality	4% (1)	
Obsessive-compulsion personality	8% (2)	
Hysterical personality	8% (2)	
Passive-dependent personality	4% (1)	
Passive-aggressive personality	4% (1)	4% (1)
Schizoid personality	4% (1)	

Source: Finch & Smith (1970)

Note: Sub-types of personality disorders exceed the totals because multiple diagnoses were made for some subjects.

Summary

Research studies using standardized personality inventories have not consistently demonstrated strong relationships between personality factors and driving behavior. This lack of consistency has been primarily due to methodological problems such as sample size, failure to cross-validate results, and a disregard for test reliabilities. The lack of strong relationships appears to be more related to the poor criteria (e.g., accidents/violations) on which tests were validated. More successful results have been demonstrated either when accidents occur at a rapid rate to produce stable estimates of liability, or when extreme groups are used for analysis, thus maximizing differences and reducing non-chance factors.

It may be useful at this point to summarize the research findings on personality factors and driving behavior, by test instruments most frequently employed. The Minnesota Multiphasic Personality Inventory (MMPI) has been used most frequently in studies relating personality to driving behavior. Rommel (1959) found that accident-repeating high school students were high on the Psychopathic deviate (Pd), Paranoia (Pa), Psychosthenia (Pt), Schizophrenia (Sc), and Hypomania (Ma) scales. Brown and Berdie (1960) found significant correlations with accidents among a similar young group (college freshmen). Those with accidents were high on the Psychosthenia (Pt) and Hypomania (Ma) scales.

Conger et al. (1959) found several psychological dimensions of the Allport-Vernon-Lindzey Study of Values which could discriminate accident repeaters, including the esthetic, theoretical, and religious scales. Although clear differences were not demonstrated using the adjective check-list method (Williams and Malfetti, 1970), the "bad" drivers tended to have more aggressive responses indicating unstable traits.

Using the Sixteen Personality Factors Questionnaire (16 PF), Bracy (1970) found accident-repeating students to be more outgoing, apprehensive and dependent. Heath (1957), using the Thurstone Temperament Schedule, found that drivers with accidents/violations were more sociable, less reflective and more impulsive.

Generalization based on the studies reviewed, however, should be viewed with the perspective that several scales on the various inventories did not consistently demonstrate significant differences between contrasted groups of drivers. For example, Beamish and Malfetti (1961), using over seven instruments resulting in 27 scales, found only 12 to significantly discriminate between violators and non-violators.

Using the MMPI, Brown and Berdie (1960) reported only three MMPI scales (out of 13) were significantly related to accidents and four significantly related to traffic violations. Of 257 items on the MMPI, Rommel (1959) found only eight which discriminated between accident-repeating and accident-free youths.

Driver Specific Inventories

Several instruments have been developed specifically for the prediction of high-risk drivers. Most of these instruments are based on item analysis of more standardized personality techniques discussed in the last section plus items which were considered to be indicative of high-risk driving. Since these instruments employ widely varying kinds of items, they will be discussed separately.

Haner Personal History and Inventory of Driver Attitudes

Haner (1963) developed a personal history form and inventory of driver attitudes for use in classifying high-risk drivers for insurance assignment. In an experimental study, he obtained split-half reliability coefficients ranging from .84 to .89, with a sample of 310 insured drivers (all males under 25). Several criteria were then used to validate the instrument: frequency of accident claims, settlement amount of claims, seriousness of injuries, and license suspensions and revocations. Significant chi-square differences were found by premium groups classified on these criteria. However, some analyses were not conducted because of low criterion frequencies. Subjects were also classified on the basis of closed culpable claims against them. Categories were statistically equated for "car years of coverage." Using the cross-validation sample, theoretically expected frequency of claims for each category was compared with actual frequency, and in each case, the chi-square differences were significant ($P<.01$) for predicting the risk categories. The author notes that the small number of cases were inadequate to run sound statistical analyses. To the knowledge of these reviewers, no other results have been reported on the utility of this instrument.

McGuire Safe Driver Inventory

The McGuire Safe Driver Inventory (MSDI) was developed to discriminate between "good" and "bad" male driver groups according to their accident/violation driving history (McGuire, 1956b). The inventory was derived by an item analysis of several psychological tests: MMPI, Army General Classification Test, Kuder Preference Record, Bell Adjustment and Rosenzweitg Picture Frustration Study, as well as items developed by the author. One score, denoting risk level, is derived from the 89-item inventory.

In a comparison of three separate samples of accident/violators and non-accident/violators, efficiency of prediction ranging from 61 to 88 percent was obtained. Split-half reliabilities ranged from .76-.89 for the inventory. Although the inventory was replicated on different samples (a form of cross-validation), the samples for each comparison were relatively small, ranging from 119 to 204 subjects.

Driver Attitude Survey

The Driver Attitude Survey (DAS) developed by Schuster and Guilford (1962) is concerned with several aspects of driving. It contains specific scales to predict accidents and violations, personal relations scales, an alcohol scale, and three faking scales. Schuster et al. (1962) administered the DAS to 121 male traffic violators before and after attending a safety program, to evaluate attitude change as a result of the program. A biographical and driving exposure questionnaire was also administered. Multiple regression analysis predicting accident and violation attitude scores resulted in multiple R's of .81 and .84, respectively. Initial attitudes were found to be the most important predictors of post-test attitude scores. Only ostensible attitudes toward safety were found to change as a result of attending the meeting. In a more recent study, Schuster (1970) compared two groups of driver education and study hall students. Surface safety attitudes were again found to change as a result of students being exposed to driver education. The faking attitude score was also found to increase after attending driver education.

These studies offer little in the way of predicting subsequent driving behavior. There appear to be more germaine questions. Is attitude change related to subsequent driving behavior? Do "surface attitude changes" result in actual behavior change? Do any attitude changes result in actual behavior change? The DAS appears to be of sufficient potential utility to warrant further evaluation.

In a comparative study of both the Driver Attitude Scale (DAS) and the McGuire Safe Driver Inventory (MSDI), McGuire et al. (1964) administered both inventories to 123 driver license applicants. Table 3-28, reproduced from this study, gives the relationships found between the scales of these instruments. The negative correlations are due to a reversal in scales (high score on MSDI = safe driving, high on DAS = unsafe). Multiple regression analysis resulted in a multiple R =.51. No analysis was conducted to determine differential predictability of accidents or violations. In view of the relatively low correlations between the tests, the authors suggest that they may measure different attitudes. However, since the MSDI has only one score, it might also be that similar concepts to the DAS are incorporated but are masked by the total score, thus accounting for the relatively low correlations. A re-examination using factor analysis of items from both tests would help clarify the conceptual structure of the instruments.

California Inventory of Driver Attitudes and Opinions (CIDAO)

In the study of accident liability prediction by Harano et al. (1973), a three-part inventory similar to the DAS and MSDI was developed. The CIDAO consists of Part A (items dealing with feelings or thoughts about driving, self, other people, life in general), Part B (preference for occupation and activities), and Part C (estimation of the

TABLE 3-28 MEANS AND STANDARD DEVIATIONS FOR THE DAS SCALES AND CORRELATIONS BETWEEN THE MSDS AND DAS SCALES

DAS Scale	Mn.	S.D.	Correlation with MSDS
A	11.04	2.80	.14
AL	1.62	1.09	-.38*
D	1.04	1.57	-.42*
F	15.44	2.58	.44*
V	8.56	2.32	.02
X	4.85	1.77	.06

Source: McGuire et al. (1964)

Note: Mn. of MSDS =54.40; S.D.=5.35
* Significant beyond the .01 level of confidence

probabilities that certain socially deviant events will occur, e.g., dishonesty, robbery, etc.). A pilot study was first conducted (n =100) to select discriminating items. The final inventory was then used in a larger study. CIDAO Part A was a highly significant and unique predictor of accident group membership (r =-.34), second to socio-economic status. It also correlated with convictions (r =-.19). Part A was also correlated with other variables such as socio-economic status, "driving for fun," and with these Gordon Personal Profile and Inventory scales: Responsibility (r =.21), Emotional Stability (r =.21), Cautiousness (r =.22) and Personal Relations (r =.21).

CIDAO is currently being used in a follow-up study to differentiate high-risk drivers within the negligent driver population.[13] To date, Part A again appears to be most useful.

The Mann Inventory

The Mann Inventory is a compilation of 63 items reflecting students' feelings toward police, school, cars, family, etc. In developmental work, teacher ratings of students on safe/unsafe driver dimensions were used to validate the instrument (Kenel, 1967). Refinement of the test resulted in six behavioral categories:

(1) Behavior characterized by well-adjusted interaction with persons and consistent with the norms of the society in which the individual lives.

(2) Behavior generally characterized by satisfactory interaction with persons and society, but with periodic withdrawal from contact with people.

(3) Behavior generally characterized by satisfactory interaction with persons and society, but with periodic efforts toward assertive action.

(4) Behavior characterized by forceful, outgoing action or vigorous efforts to assert oneself over others.

(5) Behavior characterized by withdrawal from contact with other persons.

(6) Behavior characterized by a pendulum effect, vacillating between extremes of aggression and withdrawal.

In an initial validation effort the Inventory was administered to 523 males and 534 females. Students in behavioral categories 1, 2, 3

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[13] Study evaluation currently being conducted by the California Department of Motor Vehicles.

(better adjusted) as compared to categories 4, 5, 6 (deviate behaviors) were compared by a 30-month follow-up of their driving records. The following percentages of students in groups 1, 2, 3 were found to be accident/violation free: 73, 74, and 63 percent, respectively. In contrast, the percentages for Groups 4, 5, 6 were: 17 percent, 38 percent, and 12 percent, respectively. Combining groups 1, 2, 3 vs. 4, 5, 6, 19 percent of the first group had violations compared to 65 percent in the second group. For collisions, the figures reported were 12 percent vs. 52 percent. Reliability coefficients of .70-.76 were also reported.

In a retrospective study, Guyer (1970) related the Mann Inventory to three-year driving records of 200 college students. Significant differences were found by behavioral categories. 70-80% of students in categories 4 and 6 were involved in collisions. In contrast, only 43% in categories 1, 2, and 3 were involved in collisions. Unexpectedly, the lowest collision rate was 12% for category 5. This group was categorized as more "withdrawn," and it is possible that they had less exposure.

In another study, Wa:ttenburg et al.,(1974) administered the Mann Inventory to 3,266 Coast Guard Recruits. A factor analysis of the instrument resulted in three basic dimensions--Sociability, Risk-Taking, and Asocial Behavior. Correlations with follow-up accidents were very low, ranging from .04 to .06.

Siebrecht Attitude Scale

The Siebrecht Attitude Scale (Siebrecht, 1941) is designed to measure attitudes toward safe driving. It contains 72 scales dealing directly with driving attitudes. Split-half reliability of .81 was reported, using 100 students. Although Beamish and Malfetti (1962) employed the scale, specific reference is not made to its utility. We are aware of no other studies that report using it.

Specific Inventories

Wallace (1969) developed a 60-item background and attitude questionnaire which was administered to problem drivers prior to attending one of four driver improvement or treatment programs, as well as to control groups. The questionnaire was based on items from the Mann Inventory, as well as items submitted by staff members. The following personality dimensions were included in the questionnaire.

1. Environmental support/attitudes toward authority, manipulativeness/conformity

2. Rationalization/feeling of guilt

3. Reflective/impulse, analytical/concrete self-reliance/reliance on structure

4. Four general adjustment/isolated driving problem

5. Sociability/withdrawal, faith in group effort/individual effort

6. Attention factors/distractability

A total of 782 problem drivers who had valid licenses, no prior contact with the licensing agency during the previous six months, and from 2-3 previous traffic convictions, comprised the study group. The subjects were randomly assigned to one of four treatment groups or to a control group. The attitude instrument was administered at the beginning of treatment, to predict subsequent "success." Of the 60 items, only 10 items significantly ($P<.10$) predicted failure (violations/accidents) in a six-month follow-up period. The "failures" tended to be single, had more job changes, had more violations at night, denied drinking and driving, denied being depressed, rarely recognized dangerous actions, drove to think out problems, and felt they were not good at "talking their way out of trouble." Analysis of items within each of the treatment groups indicated that varying items were predictive of subsequent success. No consistent patterns were demonstrated. Although significant relationships were found for ten items, the study does not provide strong support for predictive utility for this instrument. At the $P<.10$ level, six significant relationships would be expected by chance. No reliability data were reported. In addition, the results were not cross-validated, nor was exposure controlled. In view of the short follow-up period (six months), perhaps stronger relationships could be demonstrated with longer follow-up periods.

Discussion

The review of driver-specific inventories indicates that generally they fare no better in regard to predictive utility than general personality inventories. (Some of these research findings are summarized in Table 3-29). No single test appears to have been adequately standardized for different sub-populations, and none have undergone rigorous cross-validation, replication, or reliability studies. Most have used criterion-keying approaches to item analysis, which may result in reduced reliability of "concepts" measured by the inventories (see Nunnally, 1967).

A subtle and biasing factor in retrospective studies is the influence of prior driving behavior (i.e., accident/violations) on item responses relating directly to safe or unsafe driving. For example, prior accidents may influence a subject's response to an item such as "safe drivers are rarely involved in accidents."

Of course, the same criticism can be made about any instrument used in retrospective studies, but more direct methods should minimize this problem. Schuster et al. (1962) and Williams and Malfetti (1970) found that

Table 3-29. Selected Studies Using Driver Specific Inventories As Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	p	Sample Size	Validity: Accidents Type	r	p	Sample Size
Harano, McBride & Peck (1973)	Question-naire Interview	Correlated test and question-naire items with group member-ship based on accident frequency. Groups contrasted on 3 or more accidents vs. accident-free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ acc: n=196; 0 acc: n=231 Females 1+ acc: n=50; 0 acc: n=57 Part A included items relating to thoughts about driving, self, other people and life in general. Part B indicated preference for certain types of occupa-tions and activities. Part C consisted of subjective probability estimate of deviant events.	CIDAG Part A (low scores=agreement with accident-keyed items)	Convictions (3 yr. period) Male	–.19	.01	427	Group Mem-bership (0/3+ acc. in 3 yr. period) Male	–.34	.01	427
			Subscale A (sup-pressor variable)		.05	.10	427	(female)	(–.29) .10	.05	427
			Part B (high scores=agreement with accident keyed items)		–.09	.05	427		–.19	.05	427
			Part C (high scores=agreement with accident-keyed social deviance items)		.36	.01	427	(female)	(–.07) .32	.01	427
			Number of "very sure" responses on Certainty scales (Part A)		.02	.20	427		+.09	.05	427
			Number of "fairly sure" responses on Certainty scales (Part A)		–.01	.20	427		– .2	.01	427

NR Not Reported
NS Not Significant

r Correlation coefficient (product moment unless otherwise specified). Occasionally mean values reported in r column.
p Probability of significance ("p" has been dropped)

scores on driver-specific inventories could be significantly faked after exposure to safety material. Therefore, faking scales on such instruments would appear essential for interpretation.

Driver-Specific Items

In addition to studies using driver-specific inventories, several studies have included specific individual items on driving attitudes, but little can be said about their reliability. It should be recognized that responses, especially in retrospective studies, may be a function of previous driving experience and may therefore be spurious. Final determination of their utility can only be made at the conclusion of predictive studies.

Emotions and Driving

A number of studies have shown that drivers who express their feelings through the use of a car tend to be more frequently involved in both accidents and violations. In the Harano et al. (1973) study, accident repeaters tended to drive to "blow off steam," "think about a problem," and simply "drive for fun" ($P<.01$). They combined several of these items into an emotional driving cluster, which correlated both with accidents ($r = -.19$) and violations ($r = -.21$). These findings are consistent with those of Harrington (1971) who reported that young accident repeaters tended to drive more to "think about problems" ($r = .17$) and drove to "get away from people" ($r = .15$).

Driving "after an argument" and "escape driving" were found to be significant correlates of both violations and crashes for most sub-populations in the Pelz and Schuman study (1971). For young drivers, "driving after an argument" was found to correlate with both violations and crashes (.09 and .10, respectively). For older males, the correlation was significant for crashes ($r = .16$), but not violations. The items correlated significantly with violations ($r = .14$) and crashes ($r = .13$) for young females, but no significant correlations were found for older females. "Escape driving" also correlated significantly with violations ($r = .13$) and crashes ($r = .06$) for young males. For older males, significant correlations for violations and crashes were .09 and .13. For young females, the items correlated significantly with crashes ($r = .10$). Among the sub-populations studied, older females evidenced the highest correlation, with .16 for violations and .18 for crashes. (Some of these findings are summarized in Table 3-30).

Risk-Taking

Generally, young drivers tend to demonstrate the highest relationship between self-perception of risk and driving record. Harrington found accident repeaters indicated that they "drove recklessly too

Table 3-30. Selected Studies Using Emotions and Driving Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions – Type	Convictions – r	Convictions – P	Convictions – Sample Size	Accidents – Type	Accidents – r	Accidents – P	Accidents – Sample Size
Harano McBride & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free driver over 3 year period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+ Acc. N=196; 0 Acc: N=231; Females 1+ Acc: N= 50; 0 Acc: N= 57	Emotional Driving Cluster	Convictions (3 Yr Period) Male	–.21	.01	427	Group Membership (0/3 + Acc. in 3 Yr Period) Male	–.19	.01	427
			Drives to blow off steam (1= frequently to 4=never)					Means "0" "3+"	 3.74 3.53	.01	427
			Drives to think about a problem (1=frequently to 4=never)					Means "0" "3+"	 3.28 2.98	.01	427
			Driving for fun		.24	.01	427	 (female)	.23 .09	.01 .10	427 107
Harrington (1971)	Interview	From large random young driver sample interviewed those with 3 or more accidents, equal number accident-free controls. (Contrasted sample)	Driving while worried					Predicting group membership, ≥3 or no accidents in 4 yr. (males)	.22	.01	352
			Drove to think about problems Ages 16-17						.17	.02	352
			Drove to get away from people, at Age 16-17						.19	.01	352
Pelz and Schuman (1971)	Questionnaire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files. Respondent Sample Young males: n=1672 Young females: n= 483 Older males: n= 303 Older females: n= 315 Criteria adjusted for exposure (per 100 drivers/yr.)	Driving after argument	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .09 .01 .14 .02	 .01 NS .01 NS		Crashes (1 yr. adj.) Young male Older male Young female Older female	 .10 .16 .13 .09	 .01 .01 .01 NS	
			Escape Driving	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .13 .09 .08 .16	 .01 .05 NS .05		Crashes (1 yr. adj.) Young male Older male Young female Older female	 .06 .13 .10 .18	 .05 .05 .05 .01	

NR = Not Reported
NS = Not Significant

r = Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P = Probability of significance (≤ has been dropped)

often" ($r = .19$), and enjoyed driving on winding roads ($r = .15$). Accident repeaters also indicated that they attended "car races frequently" ($r = .15$), would previously have liked to have been a race driver ($r = .22$), or would currently like to be a race driver ($r = .18$). Competitive driving was found to correlate significantly with violations ($r = .16$) and crashes ($r = .09$) for young males in the Pelz and Schuman study (1971). Older males scoring high on this item had more violations ($r = .12$), but the relationship was not significant for crashes. Conversely, young females scoring high on this item had significantly more crashes ($r = .09$), but no significant relationship was found for violations. The item did not correlate with either criterion for older females. The assertive driving index was found to be a significant predictor of violations for young males ($r = .07$) and young females ($r = .09$). The only significant relationship with crashes was for single females ($r = .09$).

Some of these results are summarized in Table 3-31. The generally low but significant relationships for young drivers and males would suggest that this might be a fruitful area for further research, particularly examining interactions between risk-taking, age, sex, and types of driver errors.

Seat Belt Usage

Seat belt usage can certainly be considered a measure of underlying safety attitude. Since seat belts are required in newer-model cars, their usage is probably becoming a better measure of safety attitudes than in the past.

Simply driving a vehicle with seat belts was found to correlate significantly with violations ($r = .09$) for males in the Harrington (1971) study. No significant correlations were found with collisions. The item did not correlate with either criterion for females. This item apparently only reflects the age of the driver's vehicle, which in turn reflects the driver's socio-economic status. However, the individual use of seat belts is somewhat more sensitive. Harrington asked "Do you wear seat belts?" and found significant correlations for males (-.12 for violations and -.05 for collisions). Young females who reported not wearing seat belts also had more violations ($r = -.08$). Similarly, young males who seldom wore seat belts had significantly more violations in the Pelz and Schuman (1971) study. No significant relationship with violations and crashes were found for older males, younger females, or older females. In the Harano et al. (1973) study, "seat belts in car" did not correlate with accidents. However, accident repeaters tended not to use seat belts on long trips ($P < .10$), or on short trips ($P < .05$).[14]

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[14] On a five-point scale, higher values = less usage. The means for these two items for accident repeaters vs. accident-free drivers were: short trips, 3.3 vs. 2.8; long trips, 4.0 vs. 3.5.

Table 3-31. Selected Studies Using Risk-Taking Measures as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Harrington (1971)	Interview	From large random young driver sample interviewed those with 3 or more accidents, equal number of accident-free controls. (Contrasted Sample)	Enjoyed winding roads, Ages 16-17					Predicting group membership, ≥3 or no accidents in 4 yr. (males)	.15	–.04	352
			Drove Recklessly too often, Ages 16-17						.19	.01	352
			Attended car races, ages 16-17						.15	.04	352
			Would have liked to be race car driver at ages 16-17.						.22	.01	352
			Would like to be race car driver						.18	.01	352
Pelz and Schuman (1971)	Question-naire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files.	Competitive Driving	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young male	.16	.01		Young male	.09	.01	
				Older male	.12	.05		Older male	.06	NS	
		Respondent Sample		Young female	.07	NS		Young female	.09	.10	
				Older female	–.05	NS		Older female	.05	NS	
		Young males: n=1672 Young females: n= 483 Older males: n= 303 Older females: n= 315	Assertive driving index	Violations & Warnings (1 yr. adj.)				Crashes (1 yr. adj.)			
				Young male	.07	.01		Young male	.03	NS	
		Criteria adjusted for exposure (per 100 drivers/yr.)		Older male	.02	NS		Older male	.01	NS	
				Young female	09	.10		Young female	.09	.10	
				Older female	–.01	NS		Older female	–.03	NS	

NR = Not Reported
NS = Not Significant

r = Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P = Probability of significance (≤ has been dropped)

A summary of some research findings concerning seat belt variables is presented in Table 3-32. Results are usually low, and do not appear to have practical utility at this time.

Attitudes Toward the Motor Vehicle

In Chapter 1, the possibility was mentioned that simple ownership of a motor vehicle is an indicator of increased driving exposure, and that type of motor vehicle owned might indicate underlying personality motivations, as well as socio-economic status. At Level III, further refinement of attitudes toward motor vehicles is possible. Presumably researchers have included items on car accessories, car-type, etc. on the assumption that involvement with the car could reflect an underlying attitude in regard to traffic safety. One might speculate that if the car is an extension of ego, these items would be related to emotional characteristics, which in turn may be related to driving performance.

In regard to characteristics of a car most preferred, Harano et al. (1973) found young accident repeaters to prefer cars that go faster (r =.10), high performance cars (r =.07), and found them to be less concerned with economy (r =-.07) than other characteristics.

These findings are summarized in Table 3-33. Although the demonstrated relationships are of low magnitude, it would appear that there is some potential utility for these variables, particularly within the younger age groups as shown in the Harrington (1971) study.

Rating of Self/Others as Drivers

A few studies have used items which ask the respondent to rate himself and others as drivers. Both Harrington (1971) and Harano et al. (1973) found that accident repeaters more frequently rated older drivers as poorer drivers than themselves, than did controls. Accident repeaters, in Harrington's study, thought older drivers drove too slowly (r =.17). Accident repeaters also rated themselves as better drivers (r =.12)[15] However, on a single item rating self only, both males and females who tended to be involved in collisions rated themselves as more unsafe (r =.13 and .09, respectively). Of course, items such as these may reflect a spurious relationship since those involved in collisions may, after the fact, rate themselves as unsafe.

McBride (1970) found that a driver's attitude toward driver improvement was a very strong predictor of recidivism. His attitude measure of "recognizes need for improvement in driving" was non-significant, presumably due to an excess of positive responses. However, his

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15 This measure was termed the Elderly Driver Index, assessing deviance between self-rating and rating of older drivers.

Table 3-32. Selected Studies Using Seat Belt Measures as Assessment Variables

Study	Type of Instrument*	Sample Description and Method	Variables	Validity: Convictions Type	Convictions r	Convictions P	Convictions Sample Size	Accidents Type	Accidents r	Accidents P	Accidents Sample Size
Harrington (1971)	Mailed Survey Questionnaire	Surveyed young drivers four years after licensing at ages 16-17. (Random Sample)	Is most frequently driven vehicle equipped with seat belts?	Total Convictions (4 Yr.): Males Females	 –.093 –.016	 .05 NS	 5,026 4,388	Total Accidents (4 Yr.): Males Females	 .016 .022	 NS NS	 5,026 4,388
			Do you wear seat belts?	Total Convictions (4 Yr.): Males Females	 –.115 –.081	 .05 .05	 3,490 3,180	Total Accidents (4 Yr.): Males Females	 –.050 –.016	 .05 NS	 3,490 3,180
Harano, McBride & Peck (1973)	Questionnaire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample *included* males and females meeting criteria. Age range not restricted. Sample: Males 3 + acc: n=196 0 acc: n=231 Females 1 + acc: n= 50 0 acc: n= 57	Seatbelt use on long trips (1=always to 5=never)					Group Membership (0/3 + Acc. in 3 Yr Period) Males mean "0" "3+"	 2.80 3.26	.10	427
			Seatbelt use on short trips (1=always to 5=never)					Males mean "0" "3+"	 3.47 3.97	.05	427
Pelz and Schuman (1971)	Questionnaire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files. Respondent Sample Young males: n=1672 Young females: n– 483 Older males: n= 303 Older females: n– 315 Criteria adjusted for exposure (per 100 drivers/yr.)	Seldom use seat belts	Violations & Warnings Young males Older males Young females Older females	 .14 –.03 .07 .10	 .01 NS NS NS		Crashes (1 yr. adj.) Young males Older males Young females Older females	 .05 –.05 –.02 –.06	 NS NS NS NS	

NR - Not Reported
NS - Not Significant

r - Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P - Probability of significance (% has been dropped)

Table 3-33. Selected Studies Using Attitudes Toward Motor Vehicle as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	Maximum car speed (00=under 70MPH to 10=160+ MPH)	Total (1 yr)	.088	.05	850	Total (1 yr.)	.095	.01	850
			Prefers economy car (1-yes, 0=no)		.023	NS	850		–.072	.05	850
			Prefers standard car (1=yes, 0=no)		–.045	NS	850		–.010	NS	850
			Prefers high performance car (1-yes, 0=no)		.049	NS	850		.072	.05	850
Harrington (1971)	Interview	From large random young driver sample interviewed those with 3 or more accidents, equal number of accident-free controls. (Contrasted Sample)	Car at age 16-17 had custom accessories					Predicting group membership, 3 or no accidents in 4 yr. (males)	.18	.01	352
			Car at age 16-17 had speed accessories						.21	.01	352
Pelz and Schuman (1971)	Question-naire	Probability sampling of driving population. Correlated test items with crashes and violations self-reported and/or from official files. Respondent Sample Young males: n=1672 Young females: n=483 Older males: n=303 Older females: n=315 Criteria adjusted for exposure (per 100 drivers/yr.)	Time Working On Cars	Violations & Warnings (1 yr. adj.) Young male Older male Young female Older female	 .12 .02 .06 –.03	 .01		Crashes (1 yr. adj.) Young male Older male Young female Older female	 .02 .04 .03 .03	 NS NS NS NS	

NR - Not Reported
NS - Not Significant

r Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column).
P - Probability of significance (P> has been dropped)

variable "attitude toward driver improvement: grateful" was a very significant predictor of subsequent convictions (r =-.283).

An indirect measure of driving performance evaluation may be reflected in an item concerned with parental restrictions on the young driver (Harrington, 1971). Young drivers who indicated that a parent had previously restricted or suspended their driving had more collisions (r =.14). However, again, restrictions may have been a result of collisions and/or violations, and thus represent a spurious relationship.

Table 3-34 presents some of the research findings on self-rating items as predictors of driving. Most results are sufficiently low to be considered inconsequential, except for those of Harrington (1971) on a sample of young drivers. It appears that self-rating items, along with items on attitudes toward motor vehicles, are useful predictors only for the younger drivers (for whom prediction is especially needed). In addition, the McBride (1970) study demonstrates the utility of these kinds of measures in a driver improvement setting.

Summary

The role of personality traits, attitudes, and social characteristics in accident involvement has been examined in a multitude of research studies. In general, those studies examining the more transient social characteristics have produced the more significant findings. For example, life stress factors were found to be strongly related to driving criteria, especially very severe accidents. Unfortunately, data for these studies were almost invariably collected after-the-fact. While this research does suggest the need to collect as much current life stress information as possible, the retrospective data collection approach does not provide any clear indication of the operational usefulness (future prediction) of these data.

The research examining specific personality traits has been less promising. Investigators have used a variety of assessment techniques including psychiatric interviews, projective techniques, scores of standardized personality inventories, and inventory items based mainly on intuition, which have revealed numerous statistically significant relationships between person-centered traits and driving criteria. However, none of the studies (at least none of the United States studies) have demonstrated relationships of sufficient magnitude to warrant practical applications, such as classification of drivers on the basis of personality or attitude tests for either licensing or predicting recidivism among "negligent" drivers. There are numerous indications, however, that some of these variables may eventually prove useful predictors for specific sub-populations of drivers, despite low correlations among the general driving population.

Table 3-34. Selected Studies Using Ratings of Self/Others as Assessment Variables

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
Harano (1974)	Psycho-logical Tests	A battery of psycho-physical tests was administered to 850 negligent drivers who attended a driver improvement meeting, predicting future errors. (Cluster analysis and data collection reported in earlier study Finkelstein and McGuire 1971)	DIM Self-Evaluation Sheet	Total (1 Yr)				Total (1 Yr)			
			Negligent driving (1=not negligent to 5=very negligent)		.06	NS	850		.08	.05	850
			Improvement needed (1=none to 7=a lot)		–.01	NS	850		.08	.05	850
			Rating of meeting (1=very poor to 7=excellent)		.03	NS	850		–.01	NS	850
			Reaction to test taking (1=very unpleasant to 5=very pleasant)		–.04	NS	850		–.03	NS	850
			Interest in test results (1=definitely not to 5=definitely)		–.05	NS	850		–.02	NS	850
			Confidence of improvement (1=not confident to 5=very confident)		–.02	NS	850		–.05	NS	850
			Driving stress (1=none to 7=a lot)		[illegible]	NS	850		.00	NS	850
			Benefit of meeting (1=not beneficial to 5=very beneficial)		[illegible]	NS	850		–.04	NS	850
Harrington (1971)	Interview	From large random young driver sample interviewed those with 3 or more accidents, equal number accident-free controls. (Contrasted Sample)	Do you think old people drive too slowly? (1=yes, 2=no)					Predicting group membership, 3 or no accidents in 4 yr. (males)	.17	.02	352
			Did parents ever restrict driving? (1=yes, 2=no)						–.14	.04	352
			Did parents suspend driving? (1=yes, 2=no)						.14	.04	352
			Did accident change your driving behavior? (1=yes, 2=no)						–.36	.01	352
			Any problems with DMV? (1=yes, 2=no)						–.18	.01	352
	Mailed Survey Question-naire	Surveyed young drivers four years after licensing at ages 16-17. (Random Sample)	Safety self-rating (high=unsafe)	Total Convictions (4 yr.): Males Females	.120 .104	.05 .05	5,034 4,383	Total Accidents (4 yr.): Males Females	.132 .092	.05 .05	5,034 4,383

Continued

NR - Not Reported
NS - Not Significant

r - Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P - Probability of significance (% has been dropped)

Table 3-34. Selected Studies Using Ratings of Self/Others as Assessment Variables *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Accidents Type	r	P	Sample Size
Harano, McBride & Peck (1973)	Question-naire Interview	Correlated test and questionnaire items with group membership based on accident frequency. Groups contrasted on 3 or more accidents vs. accident free drivers over 3 yr. period. Sample included males and females meeting criteria. Age range not restricted. Sample: Males 3+acc: n=196; 0 acc n=231; Females 1+acc: n= 50; 0+acc: n= 57	Elderly driver index rating (self vs. older drivers)	Convictions (3 yr. period)	.09	.05	427	Group Membership (0/3+ acc in.	.12	.01	427
			Rating of self as driver (1= excellent to 5=poor)		.00	.50	427		.12	.01	427
McBride (1970)	Psychological Battery	A group of 75 negligent drivers who attended a Driver Improvement meeting was administered the Gordon Personality Profile and a biographical questionnaire. Driving performance 2 years subsequent to attending the meeting was predicted from the battery. The criteria was combined accidents and violations which in an operational criteria, "Negligent Operator Point" (NOP) for recidivism.	Attitude toward driver improvement: Upset	Negligent Operator Points (NOP) 2 year subsequent	-.092	NS	75				
			Scared		.057	NS	75				
			Angry		.202	.05	75				
			Grateful		-.283	.05	75				
			Recognizes Need for Improvement in Driving		-.072	NS	75				

NR = Not Reported
NS = Not Significant

r = Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P = Probability of significance (%) has been dropped)

Also discussed in this section were research studies examining attitude variables, particularly attitudes toward driving. Many of these results were encouraging. Harano et al. (1973), for example, reported a correlation of -.34 between accident group membership and a scale of the California Inventory of Driver Attitudes and Opinions. However, further research will be needed to determine the predictive utility of such variables for specific groups of drivers. Additional problems, such as "fakability" of these scales, must be addressed.

Generally, the research on psychological, social, and attitude variables has produced many interesting and potentially useful findings. Unfortunately, most of these studies have suffered from recurring methodological deficiencies which limit the generalization of their results to other populations. These deficiencies will be discussed in detail in Chapter 4.

MEDICAL/PHYSIOLOGICAL VARIABLES

Most variables concerning a driver's physical condition are based on a report by a physician. Although obtained from various sources, they have been discussed in Chapter 1, since they frequently are recorded in the driver license file.

This chapter will discuss two areas of physiological measurement which can be assessed by non-medical personnel:

- Alcohol-Related Driver Problems, and
- Fatigue Effects

Alcohol-Related Driver Problems

As demonstrated in the previous chapters, alcohol usage and its relationship to driving is a critical area of investigation. Extensive efforts are currently underway to identify problem drinkers and provide effective countermeasures, especially through Alcohol Safety Action Project, National Safety Council, and Alcoholics Anonymous programs for drinking drivers. These efforts have each demonstrated the need for valid and reliable alcohol diagnosis.

The major sources of alcohol diagnostic information are:

Level I	• Alcohol-related traffic arrests (DWI,DUI,etc.)
Level II	• BAC at time of arrest
	• Non-traffic alcohol-related arrests
	• Prior alcoholism treatment
Level III	• Psychometric testing, questionnaires, interviews, etc.

As we have seen, the Level I information is strongly related to subsequent problems, but occurs so rarely that many problem drinkers cannot be identified (false negatives). The Level II information, while equally rare, provides a better qualitative estimate of extent of the drinking problem, when available. This section will, of course, be concerned with the Level III information--psychometric testing, questionnaires, and interviews--which permits assessment among a broader-based population, but as yet has generally demonstrated less predictive utility.[16]

[16] It should be noted that many alcohol-related Level III assessment applications also contain variables from Levels I and II.

In recent years, the field of alcohol assessment has progressed from largely exploratory studies of the characteristics of the drinking population, to more concerted applied research aimed at the development of a practical driving-related alcohol diagnostic instrument. These efforts have demonstrated that the diagnostic assessment of alcohol problems is more complex than simply quantifying the frequency of an individual's alcohol consumption. Differing psychological and social factors may cause two individuals to consume equal quantities of alcohol for entirely different reasons, for whom different treatments may be indicated. The concept of diagnostic assessment is useful primarily in two driving-related contexts: (1) to reliably predict a subsequent driving criterion which isolates high-risk driver sub-populations; and (2) to reliably predict treatment responsiveness, i.e., identify target groups which may be most responsive to a given treatment.

To accomplish these objectives, the following issues must be addressed:

- Item Selection and Scoring. Items chosen for diagnosis should reflect the broad range of psychological and social factors which apparently determine alcohol consumption patterns.

- Target Populations. Should include both the general driving population, and specific "problem" or countermeasure sub-populations.

- Reliability Analysis. Must be conducted for every assessment technique.

- Validation Strategies. Validation is also essential to any diagnostic assessment application.

Since researchers have employed numerous strategies to validate diagnostic techniques, these should be carefully examined. The principal distinctions among the approaches to driver assessment validation are the temporal distinction of concurrent vs. "true" predictive, and the conceptual distinction of driving-related vs. non-driving-related criterion measures. The following is a generalized list of the strategies which can be employed to validate alcohol-related diagnostic assessment instruments:

1. Non-Driving-Related Validation (or External Validity)

   Do the results of this instrument relate to other current diagnostic information? (Conduct of this phase is not always possible, and it is non-essential for driver applications.) Variations include:

   - Response Verification. Do drivers respond truthfully?

- Diagnosis Verification (i.e., Construct Validity). Does classification based on this instrument correspond to other available diagnoses?

Non-driving-related validation can also be divided into concurrent vs. future predictive, but most analyses are concurrent; "true" predictive non-driving-related validation has little apparent relation to driver assessment.

2. Driving-Related Validation

Are responses related to driving problems? This question can be further divided into:

- Concurrent Validity. Are responses related to current or past driving problems? (This phase is non-essential, but a useful precursor to the next phase.)

- Predictive Validity. Do responses enable future prediction of driving problems? (This phase is ultimately essential.)

The following section will examine some of the recent driver-related alcohol-diagnostic development efforts, with particular emphasis on their approaches to the above issues of item selection, target populations, reliability, and validity.

Alcohol Consumption Classification Systems

The principal classification techniques to assess extent of alcohol involvement which have been developed by driver-oriented research teams consist of:

1. Michigan Alcohol Screening Test (MAST); Selzer et al. (1970, 1971)

2. Detecting the High Risk Driver: The Development of a Risk Questionnaire; Selzer and Vinokur (1974)

3. HSRI Protocol; Mortimer et al. (1970, 1971)

4. Vermont Driver Profile; Perrine (1974)

5. Life Activities Inventory; Human Factors Laboratory (1975)

The following pages will review the development of these instruments in some detail.

1. Michigan Alcohol Screening Test (MAST)

A major operational classification technique is the Michigan Alcoholism Screening Test (MAST). The design and development of the

MAST was reported by Selzer (1970,1971), and by Selzer and Chapman (1970). These reports discuss the development of a scoring system, and subsequent validation efforts.

Item Selection and Scoring. The original MAST items were incorporated with items which had appeared on prior alcoholism surveys (Barley et al. , 1965; Guze et al., 1962; and Mulford et al., 1966). The complete instrument consists of 25 questions in a structured interview format requiring a "Yes" or "No" response, which generally deal with the attitudes and behavior associated with drinking alcohol and the consequences of over-indulgence. Selzer attempted to frame these questions to be easily understood, and sufficiently neutral to elicit the truth from cautious respondents. Questions concerning quantities of alcohol consumed were eliminated "because of the vague and dilatory responses evoked."

For the initial development of the scoring system, the instrument was administered to two groups of subjects--hospitalized alcoholics selected from treatment centers for alcoholism, and controls. Items which discriminated between alcoholics and controls were assigned different point values, in proportion to the degree of discrimination. Selzer describes the development of the scoring system as:

> "On the basis of a visual analysis of the percentage distributions of the responses of the hospitalized alcoholics and controls as well as clinical knowledge of the alcoholism syndrome, the most discriminatory questions were given greater weight as reflected in the point system..." (Selzer, 1970)

He further explains that though

> "discriminant analysis techniques were originally applied to the data to provide statistically sophisticated scoring, the resulting system was cumbersome and abandoned when the results proved similar to the scoring system obtained from contrasted groups." (Selzer, 1970)

Target Population. Validation was conducted using five different samples, including: (1) hospitalized alcoholics; (2) controls; (3) drivers convicted of driving under the influence of liquor ("DUIL's"); (4) drivers convicted of drunk and disorderly behavior ("D&D's"); and (5) drivers undergoing license review because of excessive accidents and violations incurred during a two-year period ("LR's"). Significant age differences were noted between the groups, while their socio-economic status was described as "comparable."

Reliability Analysis. None of the reports on the development of the MAST reviewed here contain any discussion of reliability analysis.

Validation Strategies. To demonstrate non-driving-related ("external") validity, a "validation alcoholism score" for each subject was derived from the data obtained from county medical facilities and social agencies, the county probation office, and arrest and traffic records. The validation score included:

- The MAST criteria applied to records; plus
- Additional points for descriptions of uncontrolled drinking; and
- Additional points for each additional DUIL or D&D arrest.

A tabular comparison made among the percentage distributions of suspected alcoholics for the four relevant samples is presented in Table 3-35.

On the basis of these percent distributions, and the fact that only 15 of the 526 subjects were not classified as "alcoholic" by the MAST, but were found alcoholic by the validation score (i.e., 15 false negatives), Selzer (1971) concludes that the instrument "appears to provide an effective means of finding alcoholics in the populations used in this study." The present reviewers find little data in these reports to substantiate this statement. Selzer's percent distributions, while showing some validity, provide no indications of the magnitude of the correlation between MAST diagnosis and validation score diagnosis, which was not presented. This correlation would provide a more accurate validity estimate. Selzer's low number of false negatives (i.e., drivers incorrectly classified as having no problems) might represent merely an excessive number of false positives, the number of which was also not presented.[17] Thus the available data provide no convincing evidence of an acceptable degree of external validity.

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17 Since lowering cutoff scores to reduce the number of false negatives invariably results in an increase in the number of false positives, this latter figure is crucial to any estimate of operational utility. Unneccessary treatment of false positives (i.e., drivers incorrectly classified as alcoholic) will usually reduce the cost-effectiveness of an assessment program.

TABLE 3-35. PERCENT CLASSIFIED ALCOHOLIC BY THE MAST AND BY EXTERNAL CRITERIA

	Test MAST	Criteria Validation Score
Controls	5%	1%
DUIL's	55%	25%
D&D's	59%	40%
LR's	11%	11%

Source: Selzer (1970)

Retrospective analyses using three years of accident and violation rate data to demonstrate concurrent driving-related validity were reported by Selzer and Chapman (1970). While differences in accident and violation rates were noted between the various sample groups (D&D, DUIL, etc.), no significant correlations were found between either driver record criterion (accidents or violations) and total MAST scores, individual MAST items, or combinations of MAST items.

In view of these pessimistic findings, no "true" or future predictive validity studies have apparently been conducted.

Discussion. These authors conclude that the MAST, administered alone, is useful for a rapid diagnosis of alcoholism, although not useful for prediction of high-risk driving behaviors, and recommend further development of the latter. While this recommendation seems appropriate, the use of the MAST even for alcoholism diagnosis does not appear warranted. Further validation and reliability analyses are needed. However, the instrument appears conceptually well-constructed and may eventually be found useful to assess some of the many dimensions that are related to both alcoholism and alcohol-related problem driving. At present, there are no apparent diagnostic applications.

2. Detecting The High Risk Driver: The Development of a Risk Questionnaire

After previous failures, during the development of the MAST, to discriminate the high-risk driver from the general driver population, Selzer and Vinokur (1974) incorporated the MAST into a questionnaire battery to identify the alcoholic risk-prone driver.

Item Selection and Scoring. Items selected were primarily transient factors, or "life changes," such as divorce, job change, and financial difficulty, since earlier findings using more fixed individual characteristics had not been promising. After initial pretesting and revision, the final self-administered questionnaire battery was comprised of the foll wing:

1. A modification of Holmes and Rahe's (1967) Life Events Checklist.
2. Items concerned with life stresses (e.g., marriage, job, health, etc.)
3. Items from the Buss aggression scale as well as other questions regarding physical aggression.
4. Items related to paranoid thinking.
5. Twelve items from the Zung scale assessing depression.

6. Questions on suicidal thoughts or acts.

7. Quantity and frequency questions about drinking.

8. The MAST.

9. Items regarding driving history during previous year (e.g., recent accidents, mileage, etc.).

10. Biographical and demographic items (e.g., education, employment, income, etc.).

Some items with similar content were combined into sub-scales, or "indices." Thus, analysis were conducted on 18 variables, including both individual items, and combined indices. (Scoring methods for these indices were not reported.) Multiple regression analysis then facilitated the computation of one overall "accident-risk score." This scoring method was also not reported.

Target Populations. Preliminary analyses were conducted on samples of alcoholics (n=258), and non-alcoholics (n=274). After subsequent revision of the battery, it was again administered to groups of alcoholics (n=285) and non-alcoholics (n=774).

Reliability Analysis. The authors report no reliability statistics for either the preliminary or the revised test battery.

Validation Strategies. The 18 variables which result from scoring the test battery were correlated with accidents (apparently within the past year, and apparently self-reported) to demonstrate concurrent driving-related validity. Six of the variables were found significantly ($P<.05$) related to accidents for the non-alcoholic sample. Four of these variables, and two others, were significant for the alcoholic sample. Number of drinks consumed per sitting, problems with parents or in-laws, physical stresses, and aggression were significant for both samples. However, correlations were generally low. Following these analyses, the questionnaire was expanded in promising content areas and reduced elsewhere to shorten administration time.

To examine predictive validity, stepwise multiple regressions were also computed for each group. These were used to compute a "predicted accident-risk score" for each subject. These scores were then correlated with follow-up accidents (one year), and follow-up violation-accident points (one year--Michigan point system). The only significant relationship found was for the control group, predicting violation points ($r = .21$). No significant relationships were found with accidents. Selzer and Vinokur believe these low correlations were the result of unreliable accident records, since self-reported accidents per driver were found to be substantially more frequent than recorded accidents per driver. While this is certainly a possible explanation, there are several other factors to be considered. One is exposure. Many of the alcoholic subjects were hospitalized, which must reduce their accident probability, and probably accounts for Selzer's inability to predict even violation points for the alcoholic group. Secondly, the homogeneity of the alcoholic sample probably reduced potential for prediction. Finally, the predictive criteria being employed (especially accidents) are relatively rare events. It is difficult to demonstrate a relationship between any variable and accidents, using only a one-year accident sample (except in very high accident jurisdictions, or using highly deviant subjects). A longer follow-up period would probably reveal the relationship with future accidents (at least for the control group) which is suggested by the significant prediction of violation points.

Discussion. Selzer and Vinokur conclude:

> "The results of the prospective analysis of accidents which appeared on the driver's record for the 12 month period following the completion of the questionnaire demonstrated no correlation between our accident-risk score and the accidents in either group. Using a new combination of best predictors only weak correlations could be obtained. Thus, the predictive validity of our risk score hasn't been demonstrated. Consequently, it would be premature and unjustified, at the moment, to use our questionnaire and its accident-risk score for practical use in prevention programs. We therefore reached the conclusion that more intensive research will be needed in order to find out whether our approach and its resultant accident-risk score does indeed lack any validity or that its validity could only be demonstrated with a more reliable and refined measure of accidents as our analysis seems to indicate."
> (Selzer and Vinokur, 1974)

We would add that predictive validity for non-alcoholic samples appears quite possible. Predictive utility for alcohol-related driving problems (or driving problems among those who also have alcohol problems, for that matter) is definitely unknown, and not necessarily suggested by the data presented here. Further research should focus on the interactions of individual items (not indices, or total scores) with other alcohol-related variables (e.g., DWI convictions, alcoholism diagnosis). Methods for combining items are also not clearly reported, but it is apparent that more reliable factors are needed.

3. The HSRI Protocol

Another diagnostic classification instrument, currently the most widely-employed, is the HSRI Protocol, commonly referred to as the Mortimer-Filkins Test (reported in Mortimer et al., 1971; Mudge et al., 1971; Kerlan et al., 1971; and Lower et al., 1971).

The authors address the need for identification and countermeasure assignment of problem drinkers, since this group may be over-represented in alcohol-related crashes.

Item Selection and Scoring. Biographical variables and life style variables were selected on the basis of previous studies indicating differences between DWI and random samples of drivers (e.g., marital status, residence, age, previous arrests, habits, conflicts with relatives/family). (An initial pool of 135 items and supporting rationale for induction into the battery is found in Mudge et al. 1971).

Discriminating items, "initially validated" from previous studies spanning some ten years of work, were then item-analyzed and reviewed. The final questionnaire consisted of 58 items (Form A). It includes items within the following conceptual areas:

Biographical	Mental Health
Age	Abnormal Problems
Marital Status	Nervousness
Health	Sadness or Depression
Financial	Self-Denunciation
	General Dissatisfaction
	Sleeping Problems
	Worry, Fear
	Boredom

The interview contains items on physical health, present arrest situation, previous arrest and driving history, drinking history, marital, family and work history. The interview was designed to give broader coverage of life style patterns than does the questionnaire.

Specific problems encountered during interview development included the need for a structured format, for objectivity, for uniformity of procedures in different settings, and for flexibility to allow the interviewer and interviewee to develop rapport and pursue promising areas.

The final interview (Form B) contains 58 items from the following areas:

Poor Physical Health	Physical Dependence on Liquor
Disability	Marital Problems
Previous Arrest	Family Problems
Had Been Drinking	Poor Work History
Poor Drinking Controls	

Scoring procedures are a straightforward summation of all responses indicative of alcohol risk, followed by weighting of sub-scales. Weightings were determined by regression analysis.

Target Populations. Validation subjects were paid volunteers, including 297 controls and 192 "problem" drinkers, selected from various alcohol-rehabilitative and other social agencies. Demographic characteristics showed the problem drinkers were older, more frequently male, and less frequently married than controls.

Reliability Analysis. Reliability was determined by pairing similar items, thus creating equivalent forms, as well as by the traditional split-half method. These coefficients are presented in Table 3-36.

Split-half reliability estimates in operational use have ranged from moderate to high, with slight differences noted by test site, as shown in Table 3-37.

Validation Strategies. Concurrent non-driving-related validation was initially conducted by comparison of group membership by classification scores derived from the questionnaire with those of the interview. These correlations were very high (.85 - .92) on the contrasted sample. However, since the operational validity of the device could not be readily generalized because of pre-selection methods, the necessity for developing an external criterion for validation was recognized.

Several alternative methods for further validation of the HSRI test (non-driving concurrent) were considered. A comparison of expert diagnosis with the results of the HSRI was rejected as a validation procedure, since the method would have little operational utility, and a staff with extensive clinical alcoholism background was not available at the test site. Specific information on previous history of drinking offenses was also rejected as the sole criterion due to unreliability of record systems. The final criteria was a composite score of BAC level at arrest, previous DWI offenses, and number of other alcohol-related offenses. This composite criterion was termed CRIT. Three levels of drinking were classified by the CRIT criterion. Therefore, validation coefficients reported are based on the relationship of the HSRI device with three levels of problem drinkers on the CRIT (social, excessive, problem drinkers).

The criterion classifications--Social, Excessive, and Problem are:[18]

SOCIAL DRINKER - Arrest BAC less than .15% and no DWI or other related offenses.

EXCESSIVE DRINKER - Arrest BAC of .15% to .19% or one pr or DWI arrest or one-two other alcohol-related offenses.

[18] Further discussion of the disadvantages of this "criterion" can be found in Filkins et al. (1973)

TABLE 3-36. RELIABILITIES OF HSRI PROTOCOL

	Equivalent Forms	Split-Half
Questionnaire Scale 1	0.897	0.946
Questionnaire Scale 2	0.887	0.940
Questionnaire Overall	0.825	0.904
Interview	0.948	0.973
Total Score	0.954	0.976

Source: Mortimer et al.,(1971)

TABLE 3-37. SPLIT HALF CORRECTED ESTIMATES OF RELIABILITY FOR UNWEIGHTED KEYS AND WEIGHTED PREDICTORS OF THE HSRI TEST IN TWO ASAPs

Scale	Fairfax County ASAP	San Antonio ASAP
Key 1	0.86	0.68
Key 2	0.91	0.83
Key 3	0.92	0.66
Questionnaire Score	0.77	0.60
Interview Score	0.92	0.66
Questionnaire and Interview Total Score	0.93	0.74

Source: Mortimer et al.,(1971)

PROBLEM DRINKER - Arrest BAC of at least .20% or two or more prior DWI arrests, or at least three other alcohol-related arrests, or possession of any two characteristics listed under EXCESSIVE DRINKER.

The mean percent of drivers classified in each of the criterion categories on the HSRI test are shown in Tables 3-38, 3-39, and 3-40.

A survey of 57 interviews from 12 Alcohol Safety Action Projects (ASAP's) was conducted to determine the necessity of revision for future use. Overall high ratings were given by field personnel on operational feasibility, diagnostic capability, and usefulness of the HSRI tests in recommending treatments. Interviewers recommended some changes in vocabulary/terminology in the questionnaire to improve clarity.

A comparison of the diagnostic utility of the Mortimer-Filkins (M-F) Procedure and loosely structured interview technique developed by the Hennepin County ASAP[19] was conducted with a sample of 149 DWI's. Using the CRIT criteria discussed earlier, the diagnostic utility of these techniques were compared. Table 3-41 gives the distribution of the M-F and HCASAP on the CRIT criteria.

Based on these comparisons neither of the two methods shows an optimal fit to the CRIT criteria. The M-F results in a higher percentage of classification for Problem Drinkers and Social Drinkers as compared to both the CRIT and HCASAP. An extremely small percentage of DWI's are classified as excessive by the M-F. Another means of comparing the techniques is to examine their rates of agreement. These are: HCASAP vs. M-F, 56.3%; HCASAP vs. CRIT, 56.6%; and M-F vs. CRIT, 55.7%. These figures indicate some degree of correlation between the classification methods compared. However, it also indicates a substantial amount of disagreement. Both the HCASAP and the M-F yielded over 40% disagreement with the externally-based CRIT criterion.

The author concludes:

> "This field study did not determine that either method--HCASAP or Mortimer-Filkins--was clearly superior and suggests additional research employing a more valid and reliable criterion measure of drinking problem severity."

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19 A joint effort between the Hennepin County Alcohol Safety Action Project (HCASAP) and the School of Public Health, University of Minnesota (1974).

TABLE 3-38. PERCENT CLASSIFICATION OF ASAP SAMPLES BY COMPOSITE CRITERION AND HSRI TESTING USING RECOMMENDED CUT-OFF SCORES: Q + I

HSRI Test Classification	Fairfax County			New Orleans			San Antonio		
	SD	ED	PD	SD	ED	PD	SD	ED	PD
Social Drinkers (≤39)	62.2	44.8	13.5	66.6	51.6	18.0	73.3	61.0	19.8
Presumptive Problem Drinkers (40-49)	8.1	14.2	7.3	11.1	22.2	21.1	13.3	13.9	7.7
Problem Drinkers (≥50)	29.7	41.0	79.2	22.3	26.2	60.9	13.4	25.1	73.2

Source: Mortimer et al. (1971)

TABLE 3-39. MEAN PERCENT CLASSIFICATION OF ASAP SAMPLES BY COMPOSITE CRITERION AND HSRI TEST USING REVISED CUT-OFF SCORES: Q + I

HSRI Test Classification	Criterion Classification		
	SD	ED	PD
Social Drinkers (≤39)	67.4	52.5	16.9
Presumptive Problem Drinkers (40-49)	10.8	16.8	12.0
Problem Drinkers (≥50)	21.8	30.8	71.1
Potential Correct Identification	78.2	16.8	83.1

Source: Mortimer et al. (1971)

TABLE 3-40. CORRELATIONS OF TEST SCORES WITH THE COMPOSITE CRITERION (CRIT) IN THE ASAP SAMPLES

Scale	ASAP		
	Fairfax	New Orleans	San Antonio
Questionnaire Score	.35	.30	.35
Interview Score	.50	.41	.45
Total Score	.50	.41	.46

Source: Mortimer et al. (1971)

TABLE 3-41. DISTRIBUTIONS OF DIAGNOSTIC CLASSIFICATIONS

	CRIT	HCASAP	Mortimer-Filkins
Social Drinker	16.8%	3.4%	23.5%
Excessive	29.0%	46.9%	6.0%
Problem	54.2%	47.6%	70.5%

Source: Hennepin County Alcohol Safety Action Project (1974)

Although the M-F and HCASAP are similiar in several respects (conceptual areas covered), the HCASAP appears to offer some advantages over the M-F in this particular setting. The authors state:

"The major differences between the two procedures appear to be that:

1. A more formal structure is used in the Mortimer-Filkins questionnaire and interview. In the Mortimer-Filkins format, specific questions are asked by the interviewer or covered in the questionnaire. Also, a standardized scoring format is used which does not provide for data not explicitly covered in the questions. In contrast, the HCASAP format requires only that certain subject areas (e.g., "impact of drinking on family") be covered and does not provide a set of standard questions to be asked. While this format allows the interviewer to utilize a more individualized series of questions, it lowers the likelihood that the same questions will be asked by each probation officer of each client. Similarly, the HCASAP format uses a "scoring guide" which can direct, <u>but does not</u> independently determine, the diagnosis. In other words, the probation officer's subjective diagnosis, based on responses and/or observations, may overrule the score placed on the interview.

2. The Mortimer-Filkins procedure does not require a skilled staff. It does require 45 to 90 minutes to administer both the questionnaire and interview. On the other hand, the HCASAP format requires a staff skilled in interviewing and knowledgeable about alcohol and other drug problems. Also, the HCASAP interview and collateral check usually take no longer than 45 minutes. Most cases are completed in 25 to 30 minutes. The HCASAP format includes recommendation for treatment, while the time stated for use of the Mortimer-Filkins format does not include scoring time or review for recommended treatment.

3. The HCASAP format places a fairly high emphasis on a "collateral check" (i.e., interview verification with family, friends, and/or employer). This data is used not only to validate the response provided by the client but also to elaborate upon the data collected. There is no similar procedure within the Mortimer-Filkins format."

(HCASAP, 1974)

The primary advantages of the HCASAP are that it takes less time to administer and emphasizes a "collateral check." The major drawback as compared to the Mortimer-Filkins is the requirement for skilled staff, while the M-F is automatically scored and the items structured so as not to require a highly-skilled staff.

Other comparative studies have been conducted. Epperson et al. (1975) inspected the relationship between scores on the revised version of M-F (written only) and the problem drinker ratings done by California Department of Motor Vehicles Driver Improvment Analysts. The results of this comparison yielded a correlation of .43 between the two rating methods. The California study also compared the revised M-F score with an independent alcoholism test known as the R.A.P., developed in Monterey County. Results of this comparison indicated a correlation of .72 between the two psychometric tests.

Discussion. The HSRI Protocol (M-F), both the interview and the questionnaire, represents a comprehensive coverage of drinking items, as well as all life activity dimensions that have been shown related to drinking problems. The Protocol has been administered to a large number of subjects through the ASAP rehabilitation efforts.

Extensive research has been conducted in constructing the final version of the instrument, and reported reliabilities are moderately high. High ratings were also given by field personnel on the technique's operational feasibility.

Most validation to date has been confined to concurrent non-driving-related methods, but several follow-up evaluations are in progress (extension of the ASAP programs, supported by NHTSA) to determine the predictive capability of the M-F.

4. Vermont Driver Profile

Perrine et al. (1971) selected biographical variables, drinking history variables and personality/attitude inventories to develop a diagnostic test battery for problem drinker identification. The combined instrument was then validated by contrasted group comparison of various alcohol and control samples.

Item Selection and Scoring. Perrine reports that items were initially selected in the following areas:

1. Biographical Data: 104 items on parents, earlier years, education, occupation, military service, home, marriage, religion, smoking history, and health.

2. Drinking History: 73 items on parents' drinking behavior and attitudes, as well as on respondent's current drinking; preferred beverage, frequency, quantity, occasions, companions, reactions, and problems.

3. Alcohol Attitude Scale: 24 Likert-type items.

4. Driving History: 39 items on driving education, experience, occasions, companions, exposure and mileage, record of crashes and citations, and vehicle information.

5. Test of Driving Skill: 29 four-alternative items, half of which involve error choices.

6. Driver Attitude Survey: 126 items developed by Schuster and Guilford (1962)

7. Semantic Differential: ratings of 20 concepts relating to drinking, drinking-and-driving, death, accidents, hostility, and risk-taking.

8. Rules and Regulations Schedule: 29 items on the respondent's delinquency, vandalism, theft, gambling, aggression behavior, etc.

9. Eysenck Personality Inventory: Form B, 57 items. (Perrine et al., 1971)

Target Populations. Subjects included clear-driving-record controls, roadblock controls, a non-alcohol citation group, and an alcohol (DWI) citation group.

Reliability Analysis. No reliability analyses were reported in the study.

Validation Strategies. Several univariate comparisons among the various groups indicated differentiation on alcohol usage. A discriminant analysis correctly classified 95% of clear-record drivers and 87% of DWI drivers. Twelve variables were selected for discriminant analysis between these two groups:

Sex	Number of jobs
Age	Marital status
Lifetime citations	Frequency of beer consumption
Citations in past five years	Quantity of beer consumption
License suspension	Frequency of liquor consumption
Occupation	Quantity of liquor consumption

Only four of these variables significantly discriminated the groups ($P < .025$):

Number lifetime citations

Occupation

Frequency of beer consumption

Quantity liquor consumption ($P < .10$)

Perrine found that the DWI group had significantly higher scores than the clear-record drivers on the violation-attitude scale of the Driver Attitude Survey (Schuster and Guilford, 1962). Other differences among the groups were noted on the accident-attitude-alcohol and personal relations scale. He found no significant or unequivocal differences based on the Eysenck Personality Inventory. The study was exploratory, and the author recommended larger samples and refined analysis.

In a more recent study, Perrine (1974) employed an abridged battery, based on his previous work, of biographical and driving history variables and personality profiles, which was administered to driver licensing applicants. The applicants were subsequently labelled as learners, operators, DWI, and State employees. Comparisons were then made among these groups.

Analyses were confined to driving-related concurrent prediction. No attempts to validate items on external non-driving-related criteria were made.

The study was designed to further identify useful predictors of high-risk drinking and to validate the Driver Profile. The areas selected for study include the Biographical Data Schedule and abridged Driver Profile, drinking history and attitudes. The following is a list of variables used:

- Driving History
  - Experience
  - Exposure
  - Previous crashes
  - Suspensions
  - Violations
- Drinking History
  - Frequency and quantity of alcohol
  - Preferred alcohol beverage
  - Crashes after drinking
- Social (Stability-Instability)
  - Marital partner
  - Jobs

- Psychological

  Selected items from the Vermont Error-Choice Test of Driving Skills
  Driver Attitude Survey (DAS)

  - Accident attitude
  - Violation attitude
  - Alcohol attitude

Four analyses were reported: (a) between-group comparisons of DWI's with all other groups; (b) factor analysis; (c) discriminant analyses; and (d) multiple regression. Table 3-42 presents the comparison of DWI's with all other drivers. These variables are reported by Perrine as significant $P < .05$.

The subsets of the Driver Profile variables (20) were then submitted to factor analysis to clarify the structure of variables. The five factors which emerged accounted for 65% of the total variance: quantity-frequency alcohol, 25.6%; education and type of drink, 15.6%; driving record, 9.2%; marital status, age, and mother's education, 7.6%; and accident attitude score (DAS), 6.8%.

The same variables, with the exception of the preferred beverage variables used in the factor analysis, were employed in the discriminant analysis. In order to conduct the analysis with a complete data set, the sample pool of 398 was reduced to 130 cases with complete data. The discriminant analysis results provide additional support for the univariate analysis reported earlier--that the DWI's tend to have more driving history incidents (accident/violations), and tend to be older, have less education and drink only slightly more.

These variables were again used to predict self-reported crashes during three previous years. Significant predictors were crash-after-drinking, age, error choice, no citations, and marital status. The author concludes that this study has demonstrated that the Driver Profile is "technically feasible" as an approach for identifying high-risk drivers and "is sufficiently valid to warrant continued refinement." He recommends that the battery be shortened, that the number of items on the Vermont error-choice test be increased, and that new scales be developed.

In the regression analysis predicting reported crashes in the last three years, concurrent crashes after drinking, age, risk-taking attitude, number of citations, and marital status were found to be the most important predictors. In another regression, crash-after-drinking was used as the dependent variable. Significant predictors were combined crashes, violations, suspensions, age, error choice item (people who take risks), quantity--beer, and quantity--wine.

TABLE 3-42. CHARACTERISTICS OF DWI COMPARED TO OTHER DRIVERS

VARIABLE	TREND
BIOGRAPHICAL VARIABLES	
Age	Older
Education	Less education, parents less, etc.
Marital Status	Widowed, separated, divorced
Employed	Less likely employed
Occupation	Other occupation than student
DRIVING VARIABLES	
Crash	More crashes
License suspension	More suspensions
Driver Education	Less often reported Driver Education
DRINKING PATTERNS	
Consumption	More beer, liquor, preferred beer Less wine
ACCIDENT AND ALCOHOL ATTITUDE SCALES	
DAS (Scale)	DWI's tended to respond toward "safe" driver items on scale (may be attributable to faking)

Source: Perrine (1974)

These results, unfortunately, are based on contaminated criteria since total crashes in part are a function of drinking-related crashes and vice versa. The use of the variables as both predictors and dependent variables appears to be a highly questionable method. In both cases these driver records would be expected to explain the majority of "unique" variance. Perhaps the factor analysis gives a better indication of the relationship of variables and group classifications. Five factors emerged: (1) quantity/frequency (beer); (2) quantity/frequency (wine and liquor); (3) driving record variables (convictions, accidents); (4) biographical variables; and (5) DAS attitudes. Group membership did not load high on any factor.

The discriminant analysis is subject to the same limitations as the regression analysis. That is, suspension was included as a predictor of DWI when in fact it would be expected to be in part a function (administrative) of DWI classification. Aside from this spurious effect, DWI's were found to be older, less well-educated, and had more suspensions. Some general univariate group comparison results are reproduced in Table 3-43.

Discussion. This study was useful for exploring the relationships between several variables and self-reported driving behaviors. The selection of test instruments appears quite comprehensive. However, there are some serious methodological flaws.

First, the administrative utility may be seriously questioned, since there were marked reductions in samples for analysis because of incomplete data (n=390 reduced to n=130). Secondly, self-reported crashes were used as a criterion without reference to reliability or other problems associated with self-report criteria. There was apparently no external validation of the criterion measure (although actual accident data would be expected to be available in a driver license setting). No efforts were made to determine predictor or instrument reliability. Additionally, several of the analyses did not clearly distinguish between predictors and criterion measures. Thus, the results were contaminated by interdependent criteria such as suspensions and convictions for DWI.

A more concerted research effort will be required before the battery is operationally feasible for "screening would-be drivers." The efforts should include follow-up criteria for predictive validation and cross-validation.

5. Life Activities Inventory

An instrument for measuring life changes, the "Life Activities Inventory" (Human Factors Laboratory, 1975) was developed for evaluation of ASAP programs and a model program, "Power Motivation Training." The instrument contains 24 items covering most of the life areas found in other instruments (e.g., MAST, HSRI Protocol). The items refer to recent changes in health, job situation, income, volunteer/outside

TABLE 3-43. GROUP COMPARISONS ON VERMONT DRIVER PROFILE ITEMS

	Others		DWI	
	N	%	N	%
Number of Crashes				
None	209	63.7	28	35.9
One	53	16.2	26	33.3
Two or more	19	5.8	13	16.7
N/A Unknown	47	14.3	11	14.1
	328		78	
Crashes After Drinking				
Yes	23	7.0	32	41.0
No	276	84.1	40	51.3
N/A Unknown	29	8.8	6	7.7
	328		78	
No. Motor Vehicle Convictions				
None	204	62.2	18	23.1
One	49	14.9	29	37.2
Two +	27	8.2	25	32.1
N/A Unknown	48	14.6	6	7.7
	328		78	
No. of Suspensions				
"0"	254	77.4	16	20.5
One	22	6.7	24	30.8
Two or more	4	1.2	30	38.5
N/A Unknown	48	14.6	8	10.3
	328		78	
Beer Quantity				
None	45	13.7	4	5.1
1-2	72	21.9	13	16.7
3-4	84	25.6	19	24.4
5 or more	105	32.0	30	38.5
N/A Unknown	22	6.7	12	15.4
	328		78	

	Others N	Others %	DWI N	DWI %
Wine Quantity				
None	111	33.8	42	53.8
1-2	96	29.3	11	14.1
3-4	58	17.7	3	3.8
5 +	24	7.3	2	2.6
N/A Unknown	39	11.9	20	25.6
	328		78	
Liquor Quantity				
None	94	28.7	17	21.8
1-2	86	26.2	15	19.2
3-4	76	23.2	16	20.5
5 +	42	12.8	13	16.7
N/A Unknown	30	9.1	17	21.8
	328		78	
Preferred Beverage Quant.				
None	2	.6	--	--
1-2	40	12.2	8	10.3
3-4	65	19.8	18	23.1
5 +	56	17.1	25	32.1
N/A Unknown	165	50.3	27	34.6
	328		78	
Age				
< 20	26	7.9	--	--
20-24	105	32.0	12	15.0
25-39	130	39.6	35	45.0
40 +	65	19.8	31	40.0
	328		78	

Source: Adapted from Perrine (1974)

activities, marital status, family activities, drinking habits, etc. A manual has been developed to provide semi-structured guidelines for interviewers and coding procedures.

Further Developments. NHTSA plans to use the instrument along with driver record data to evaluate the effectiveness of alcohol-rehabilitation efforts. No results have been reported to date.

Discussion of Alcohol Diagnostic Techniques

The review of current driving-related alcohol assessment literature has revealed a potential for useful techniques, but also some methodological limitations which hamper current applications.

Item Selection and Scoring. In the development of traffic safety-related alcohol diagnostic instruments, item selection has often been based on criterion-keying methods, which usually amount to simply trial and error. It may be useful, therefore, to examine diagnostic content areas within a framework of the overall alcohol consumption problem, as well as in relation to traffic safety. Cahalan's (1970) studies on identifying problem drinkers (although not primarily concerned with drinking drivers) are among the most comprehensive in the field of alcohol problem diagnosis, and provide one of the broader vantage points on assessment development. Based on an extensive review of the literature, and several sub-studies examining the relationship of psycho-social and medical factors in drinking, Cahalan developed eleven content areas as specific criteria for evaluation. These criterion measures, which Cahalan used to compute an overall index of drinking problems, include:

Index of Frequent Intoxication	Job Problems
Binge Drinking	Problems with Police or Accidents
Symptomatic Drinking	Health
Psychological Dependence	Financial Problems
Problems with Spouse or Relatives	Belligerence Associated with Drinking
Problems with Friends or Neighbors	

These categories illustrate the broad range of content areas which can be useful to assess alcohol problems. Since the applicability of these content areas to the driving-related alcohol problem is a reasonable (though unproven) assumption, it may be useful to examine the current techniques to determine the extent of their coverage of subject areas which have shown relevance to general alcohol prediction. Table 3-44 demonstrates a breakdown of the diagnostic instruments reviewed,

TABLE 3-44. ITEM CONTENT OF ALCOHOL DIAGNOSTIC ASSESSMENT TECHNIQUES

	Selzer (1970) MAST (24 items)	Selzer and Vinokur (1974) High Risk Questionnaire (205 items)	Mortimer-Filkins (1973) Questionnaire (58 items)	Mortimer-Filkins (1973) Interview (64 items)	HCASAP (1974) Interview (Unstructured)	Life Activities Inventory (24 items)
Index of frequent intoxication	6	3	-	4	3	1
Binge Drinking	1	1	-	1	1	1
Symptomatic Drinking	7	2	6	18	2	1
Psychological Dependency	-	-	6	4	1	-
Problems with Spouse or Relatives	4	25	8	1	1	6
Problems with Friends or Neighbors	1	7	3	-	1	1
Job Problems	2	18	1	4	4	3
Problems with Police	2	6	2	13	1	-
Health	1	25	1	11	3	4
Financial Problems	-	9	2	-	-	3
Belligerence	-	-	-	3	1	-
General Psychological (Depression, Restlessness	-	60	27	3	-	2
Type of Beverage	-	-	-	1	1	1
Smoking Habits	-	1	2	-	-	-
Biographical Variables	-	44	-	-	3	-
Education	-	4	-	1	1	1

Source: Adapted from: Cahalan (1970)

by each of Cahalan's content areas.[20] Further content areas included in these instruments are also shown.

Target Populations. A researcher's view of the appropriate "target population" for alcohol countermeasures has often influenced the sample selection for validation. Some consider alcohol impairment a traffic safety problem among a wide range of drivers, such as moderate or "social" drinkers, "problem" drinkers, and "alcoholics." Others define slightly different classification categories, but most concentrate their efforts upon the more excessive drinking groups.

Even considering only problem drinkers, it is apparent that problem drinking does not imply problem driving. For example, a substantial proportion of the population who are treated for alcoholism never come to the attention of driver control authorities. An ideal diagnostic system for a traffic safety-related agency must therefore be capable of isolating a problem drinking driver from the population of problem drinkers. However, the identification of alcoholism or general problem drinking is itself a major task, without attempting to identify those who are also "problem drinker drivers." Thus, many recent efforts have been directed primarily toward identifying problem drinkers. Most of the studies reviewed have employed samples of problem drinkers or alcoholics for validation. Only two of the techniques, the MAST and the Vermont Driver Profile, were reported to have also been validated on general problem drivers.

There are essentially two approaches toward further refinement of these diagnostic methods. One is the selection of problem drinkers from among groups of known problem drivers. The other is the reverse--selecting problem drivers from known problem drinkers. Each of these approaches has been attempted during recent diagnostic instrument evaluations, with varying degrees of success. Generally, identification of problem drinking has been the easier task. Efforts to select problem drivers from problem drinkers have been much less convincing.

Reliability Analysis. This is perhaps the least difficult, yet most frequenty neglected, phase of assessment technique development. Since it is a prerequisite to any conclusions regarding validity of a new technique, it must be considered essential. However, only one technique reviewed, the HSRI Protocol (Mortimer-Filkins) reported any reliability data. Reliabilities reported for that device were moderately high.

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[20] A list of all specific items was not reported by Perrine et al. (1971) or Perrine (1974).

Validation Strategies. Approaches to the validation of driver-related alcohol diagnostic techniques have included non-driving-related, or "external" validity, and driving-related concurrent and predictive validity. Because of the widely varying implications of these approaches, each should be considered separately.

1. Non-Driving-Related Validity

Although not directly applicable to accident reduction, validation using non-driving criteria has several useful applications. Individual item responses can be compared with similar data from an external source to verify whether the subject has attempted to conceal his problem. This validity function will be referred to as "response verification validity." At another level, total scores or diagnostic classifications can be compared with data from an external source to determine applicability of the device for a non-driving specific problem such as alcoholism. This approach will be referred to here as "alcohol diagnostic validity."

- Response Verification Validity

Accuracy or "truthfulness" of responses is an aspect of validity which is especially important in alcohol assessment, since excessive drinkers often have reason to conceal their problems. Most attempts at resolution of this problem have involved some form of comparison between responses and official records. A related factor to be considered is the setting in which validation efforts are conducted. Items which are answered candidly in a research environment may be less useful in an operational situation, particularly a high-stress setting (e.g., during adjudication) where problem concealment might be expected to be the greatest. To these reviewers' knowledge, no such examination of "truthfulness" in a high-stress situation has been conducted using a response verification approach.

An alternative (though not equivalent) approach was demonstrated in a recent study by the California Department of Motor Vehicles. These researchers (Epperson et al., 1975) employed a revised version of the Mortimer-Filkins instrument, which included eight faking scale questions derived from the MMPI. Although the testing was done by state driver improvement analysts, subjects were informed that the results would be used only for research purposes. To the extent that the MMPI lie scales are valid, the results of that study indicated that lack of truthfulness did not appear to be a large factor. The correlations between the lie scale and other constructs were generally low (approximately -.20). The lie scores were also not correlated with criterion performance.

Further research should address this problem in a true high-stress situation. The individual item verification approach would also appear preferable (though not necessarily feasible) to this faking scale approach, since certain test items might be answered more candidly than others. A faking scale can only assess general probability of faking.

- Alcohol Diagnostic Validity

The primary question addressed by this validation approach is "How well can diagnosis or classification be verified?" or, stated in a slightly different context, "How well does the data collection instrument quantify the extent of an alcohol problem?" These are also the questions which have been most difficult to answer. In the field of alcohol assessment, the largest obstacle has been the difficulty in defining what is meant by "alcohol problems." The development of valid criteria for defining drinking problems has been a major concern for several decades. The term "alcoholism" itself has undergone several shifts in emphasis and definition, while the conception of alcoholism based on an epidemiological (disease) model has been subject to severe criticism, based on socio-legal issues.[21]

Current alcohol research (at least the traffic safety-related research) has attempted to validate assessment systems by comparing the results with certain "external" measures are simply classifications ism. Frequently these "external" measures are simply classifications based on other related diagnostic instruments. Thus, one hypothetical classification system is used to validate another, introducing an often conspicuous circularity.

Other studies have used truly external criteria. The MAST and the HSRI Protocol were reported validated on external criteria (i.e., other agency records), but neither evaluation produced proof of an acceptably accurate diagnosis of alcohol problems.

As previously stated, however, an accurate diagnosis of an alcohol problem is not essential to driver problem assessment. At present, the relationship between driving-related alcohol problems and more general social alcohol problems is not clear. It is known that alcohol consumption occurs throughout many different classes of people, for many different reasons, with widely different consumption patterns. As a result, "alcohol problems" might more properly be defined from an "effect on society" point of view. Thus, an alcohol problem could be defined by certain social rehabilitation agencies as "alcohol consumption resulting in unemployment," or "alcohol consumption resulting in deviant behavior." A driver control agency might define an alcohol problem as "alcohol consumption resulting in impaired driving."

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[21] The disease concept assumes that the individual is not responsible for his actions. In regard to rehabilitation, the label itself negates the importance of other factors (e.g., psychological, social, cultural, etc.).

Thus, driving-related alcohol assessment should be capable of predicting a criterion measure which includes the desired target behavior--impaired driving. This topic will be discussed below.

2. Driving-Related Concurrent and Predictive Validity

The ultimate question to be answered about any driver assessment technique is "How well does it predict future driving problems?" Concurrent validation approaches provide only partial answers to this question. Most attempts at relating alcohol assessment variables to driving problems have employed this concurrent approach, using past driver record variables as criteria. Reported validity statistics were usually significant, but disappointingly low. However, this approach is useful to examine relationships among assessment variables, as well as to determine whether a more costly follow-up predictive study is warranted.

To be useful for operational assessment, a diagnostic instrument must be capable of predicting future events. Such capability can only be demonstrated by comparing the results of the instrument with events (criteria) which occur subsequent to assessment. This demonstration has seldom been successfully conducted for traffic safety-related alcohol assessment techniques. (Selzer et al., 1974 and Perrine, 1974 reported marginal significance.) Again, the major problem is lack of a suitable criterion measure. For example, prediction is very limited using alcohol-related driving measures (e.g., DWI convictions) since these are extremely rare events.

A summary of the current alcohol assessment research is presented in Table 3-45.

Recommendations and Conclusions

Current Trends in Alcohol Assessment. Diagnostic assessment of drivers with alcohol-related problems is a complex and multifaceted area of research and development. Ideally in the field of traffic safety, diagnosis is most useful in a predictive mode where potential involvement in crashes, especially fatal crashes, can be ascertained. Presently, the primary effort in diagnostic assessment has centered on the apprehended DWI. Since this group represents only a small proportion of those individuals who will ultimately evidence alcohol-related driving errors (about 12% of convicted DWI's are later convicted of a second offense), diagnosis and treatment have not yet demonstrated a marked reduction of traffic accidents. However, with expanded alcohol detection efforts through enforcement, and greater willingness on the part of the courts and licensing agencies to participate in diagnosis-treatment programs (as opposed to more traditional approaches such as plea-bargaining, jail, etc.), the potential for diagnosis is increasing. Several states are now obtaining legislative approval to expand efforts in alcohol diagnosis and treatment. The most apparent impetus for this current

Table 3-45. Summaries of Alcohol Diagnostic Instruments

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions: Type	r	P	Sample Size	Accidents: Type	r	P	Sample Size
Selzer, 1970 The Michigan Alcoholism Screening Test (MAST)	Structured interview	External Non-statistical comparison of percentage distributions of drivers diagnosed alcoholic by MAST vs percentage distributions of drivers diagnosed alcoholic by criterion score derived from record audits.	Contrasted groups: 1. hospitalized alcoholics 2. controls 3. DUIL's 4. D & D's 5. LRI license renewals with high 2-year accident and violation records).		NR		N= 1. 116 2. 103 3. 99 4. 110 5. 98		NR		
Selzer & Vinokur, 1974 Detecting the High Risk Driver: The Development of a Risk Questionnaire	Self-report questionnaire	Phase I Concurrent validity analysis for alcoholics (A) and drivers/problem drivers (G)						Item indices correlated with self-reported accidents (1 year prior)	Range G: r = .12 to r = .17 A: r = .12 to r = .24	.05 .05	G=274 A=258
								Life-change items correlated with self-reported accidents (multiple correlations) (1 year prior)	G: r = .20 A: r = .24	.01 .01	
								Best combination of predictors (stepwise regression analysis) (1 year prior)	G: r = .31 A: r = .43	.002 .001	
		Phase II Concurrent validity analysis for alcoholics (A) and drivers/problem drivers (G)						Predicted accident-risk score: Accident-free compared to accident-involved			G=774 A=285
								Item indices correlated with self-reported accidents (product moment correlations)	G: r = .10 to r = .18 A: r = .16 to r = .25	.003 .001	774 285
								Best combination of predictors (stepwise regression analysis)	G: r = .26 A: r = .32	.001 .001	774 285

Continued

NR = Not Reported
NS = Not Significant

r = Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P = Probability of significance (≤ has been dropped)

Table 3-45. Summaries of Alcohol Diagnostic Instruments *(Cont.)*

Study	Type of Instrument	Sample Description and Method	Variables	Validity: Convictions Type	r	P	Sample Size	Validity: Accidents Type	r	P	Sample Size
		Predictive validity analysis for majority of Groups A & G, Phase I		Predicted accident risk score: Accident-free compared to accident-involved				Predicted accident risk score: Accident-free compared to accident-involved (X^2 analysis)	NR	.001	G=234 A=181
				(1) Violation points	A: r = .05	NS		Accident-risk scores correlated with: (2) Number of Accidents	G: r = .21 G: r = .08 A: r = .03	.001 NS NS	
Mortimer et al. (1971)	Objective Question-naire	Development of Court Procedures for Identifying Problem Drinkers Study phase individual item & reliability anlysis. (split half reliability r = .60 - .77 Administered questionnaire	Criterion Group Validation	Concurrent Groups (criterion-alcohol/non-alcohol groups)	.30-.35	.001	148 149				
				External Criterion (BAC, DWI–CRIT)	.86-.92	.001	709				
	Interview-ing Method	Development of Court Procedures for Identifying Problem Drinkers. Administered interview including information on Physical Health, Arrest, Drinking History, Family Adjustment, Work History. Validation instructional. (split-half reliability, r = .60 - .77)	Criterion Group Validation	Concurrent Groups (criterion-alcohol/non-alcohol groups)	.41-.50	.001	148 149				
				External Criterion (BAC, DWI–CRIT)	.90-.91	.001	709				
Perrine (1974)	Question-naire Psycho-logical tests & Self-reported Driver Record	Administers a test to licensed drivers to predict self-reported accidents (concurrent) Groups Operators State Employees Learner DWI Re-examined	Criterion Group Comparison Discriminal Analysis	DWI Fleet Operator Learners	NR	.01	841	Prior Self-Reported Crashes (3 years) Regression Analysis	NR	.01	312

NR = Not Reported
NS = Not Significant

r – Correlation coefficient (product moment unless otherwise specified. Occasionally mean values reported in r column)
P – Probability of significance (% has been dropped)

trend has been the Alcohol Safety Action Projects (ASAP's), which have demonstrated the feasibility of coordinated efforts by several agencies in both the traffic enforcement/control and public health domains.[22]

In 1967, Waller stated that of the DWI's he examined, about 80% could have been diagnosed five years previously as potential DWI's by using available community agency records. He concluded that a viable area of further research would be the examination of not only driving records, but also community service, health, and welfare agency records. Closer cooperation between the licensing agencies, courts, and community agencies has made this suggestion a reality in several states.

In anticipation of the need for evaluation of diagnostic treatment efforts, numerous individual data are now being collected in some states (e.g., Wisconsin, New York, California). These data bases will provide an opportunity to "track" individuals over time to determine both recidivism and the predictive utility of diagnosis.

Future Possibilities. Continued efforts in refining alcohol diagnostic instruments for drinking problems should remain a high priority among driver control/enforcement agencies. Some specific issues to be addressed include:

- the need to predictively validate assessment instruments on large samples;
- the need to broaden assessment to drivers not necessarily identified as DWI but including groups with high risk potential; and
- the need to broaden validation efforts to include such measures as life styles, psychological variables, driving patterns, etc.

Ultimately, of course, diagnostic classification is of little utility without effective countermeasures for the remediation or control of deviant driving behaviors. The parallel effort to develop effective countermeasures should also continue, recognizing the need for separate evaluations of assessment and treatment.

Additionally, since most useful follow-up criteria (e.g., accidents) will inevitably result in low validity coefficients, the problem should be conceived on a broader societal basis which would address other destructive behaviors resulting from alcohol use. For example, court presentence investigations, basing diagnosis on extensive and coordinated use

[22] However for other reasons, the effectiveness and even the desirability of the ASAP concept have recently been questioned by some investigators (Epperson et al., 1975).

of the data files and assessment efforts in other regulatory agencies, should result in more accurate diagnosis of alcohol problems, and address alcohol problems with a broader perspective (e.g., mental health, public health, traffic safety, crime, or family dissention). Centralized treatment, with reports to appropriate agencies, should also become a reality.

Fatigue Effects

Driver fatigue has been suggested as a major cause of highway accidents. Research sponsored by the Pennsylvania Turnpike Commission in the 1950's reported that fatigue was a factor in 13 - 20% of Turnpike accidents, and was indicated in 35% of fatal accidents (Forbes et al., 1957). In 1965, the Oklahoma Turnpike Authority reported that 22% of the accidents during a ten-year period had been classified as "driver went to sleep" accidents. These accounted for 45% of all fatal accidents, and 48% of the fatalities (reported in Case et al., 1970b). These findings suggest that extreme driver fatigue ranks with alcohol as a major societal/driver problem.

However, the more recent figures resulting from Indiana University's multi-disciplinary accident investigations (Institute for Research in Public Safety, 1974), do not corroborate the two turnpike study findings. Dozing and fatigue were cited as causal factors in only 0.0 - 0.5% of the accidents investigated. There are several possible explanations for this sharply contrasting result. It is possible that the earlier studies applied a general description of "drowsiness" to accidents with no readily apparent cause. It is also possible that in the multi-disciplinary investigations, other causal factor categories to which significant percentages of accidents were assigned (inattention, 13-19%; improper lookout, 16-25%; decision errors, 36-58%) might reflect undetected fatigue effects. However, either of these interpretations is difficult to support.

The task of assigning causal mechanisms based on the situational and retrospective analyses of accident occurrences is a difficult one. In addition to the problems of obtaining reliable and valid information necessary for making even sound <u>descriptive</u> assessment, the establishment of the cause of an accident involves additional levels of inference. The fact that, say, 40% of accident-involved drivers were sleepy at the moment of their accidents would not be very remarkable if we knew that the same percentage of <u>all</u> drivers on the road at the same time and place were also sleepy. There is also a large degree of arbitrariness in making causal assessments. In multi-disciplinary studies, there are often strong motives to find a cause (as opposed to the acknowledgement of the "chance" factor), and to identify the ultimate causal responsibility for accidents as residing within the person. For this reason, any of these accident-cause field studies must be interpreted with extreme caution.

There are also dangers in broadening the definition of fatigue to cover all phenomena mediated by attentiveness and vigilance. It is difficult to determine whether failure to "respond appropriately" is due to sleepiness, boredom, preoccupation, "hypnotic fixation," poor perceptual integration, inability to concentrate, or distraction. Some authorities define fatigue to encompass all performance decrements associated with length of performance, whereas others delimit fatigue to the physiological state of sleepiness and its subjective concomitants. The danger of excessively broad definition lies in treating dissimilar things as identical, thereby searching for a uniform set of determinants that do not exist.

The research to date has provided information sufficient to justify only a limited division of fatigue into two general categories--sleep-deprivation-induced and task-induced (Hulbert, 1972). It is hoped that further research will allow narrower definitions of fatigue.

Exploratory theories of task-induced fatigue range from those that link fatigue to excessive monotony to those that link fatigue to overstimulation. It has even been suggested that different personality types have different biological rythmic cycles which predispose them to be fatigued at different times of day (reported in Brown, 1967a).

There are also some exploratory theories of the relationship of sleep-deprivation-induced fatigue to driving. It has been suggested that narcolepsy (i.e., the inability to stay awake) may be present in many motorists and is possibly an extreme problem for some (Yoss, 1969). Case et al. (1970b) raise the intriguing possibility that today, when increasing lengths of time are being spent in the automobile, parents encourage their children to sleep in the car, thus conditioning this response in later life.

Sleep deprivation is invariably found to result in performance decrement. Studies of sleep deprivation effects have often been conducted in simulators (McFarland and Mosely, 1954; Hulbert, 1963). In these studies, decrements in driver efficiency were found, but the subjects had been deprived of sleep for over twenty-four hours and were performing in laboratory conditions where motivational factors were minimized. Forbes et al. (1957) observed the on-the-road performance of drivers who had been deprived of sleep for twenty-four to thirty-six hours. Using dual controlled cars, he found a significant difference between the efficiency of sleep-deprived subjects and normal subjects measured on such factors as drifting, speed changes, eye closures, calling potential hazards and so on. In the extremely sleep-deprived subjects, four out of five dozed at the wheel.

Task-induced fatigue can involve loss of sleep as well as long hours at a monotonous task. Studies have shown that drivers, after long periods of continuous driving, can no longer satisfactorily regulate both speed and tracking simultaneously or perform other precise tasks (Safford and Rockwell, 1967; Herbert and Jaynes, 1964; Platt, 1964). Other researchers (Brown et al., 1966) were not able to confirm these results. However, Hulbert (1972) points out that continuous driving over a period of twelve hours begins to include sleep-deprivation effects in addition to the task-induced effects, so that it is not possible at this time to "clearly describe the effects that may be solely induced by the driving task." (Hulbert, 1972)

Mast et al. (1966) studied the effects of fatigue using a model car moving belt simulator. Several performance measures were monitored under six experimental conditions representing length and spacing of task time. The minimum fatigue condition was two hours of performance split by a two-hour rest period. The maximum condition was six consecutive hours of task performance. Consistent fatigue-related decrements were found on tracking ability and meter vigilance. Speed maintenance and brakelight vigilance also showed fatigue-related decrements under certain conditions. Reaction time was found to improve significantly as a function of task-time, apparently indicating that learning and task accomodation are more important than fatigue and/or that reaction time is less sensitive to fatigue. One of the more important findings was the role of motivational factors. The subject's knowledge or lack of knowledge of how long he was to perform without a rest pause moderated performance decrements. From this, Mast et al. concluded, "These investigations show that performance of subjects with distant goal proximities is affected almost immediately--before one could reasonably expect fatigue effects to become apparent...it may be that a different level of performance might be expected from drivers faced with a number of hours of driving as compared with drivers on relatively short trips."

The detrimental effects of fatigue upon tracking ability and maintenance of proper lateral position have been reported by numerous investigators using simulated drive task devices (Suhr, 1959; Heimstra, 1970; Ellingstad and Heimstra, 1970; Sussman and Morris, 1970). On-the-road observation techniques have produced similar findings (Lauer and Suhr, 1959; Forbes et al., 1958 and O'Hanlon, 1971).

A significant number of investigators have reported that speed control also deteriorat s as a function of fatigue (Forbes et al., 1958; Michaut and Pattier, 1964; Safford and Rockwell, 1966). The evidence regarding the effect of driving time on judgmental factors is not as extensive. However, several investigators have concluded that judgmental errors, such as risk-taking and discourtesy, increase as a function of fatigue, i.e., driving time (Michaut and Pottier, 1964; Brown et al., 1970; and Brown, 1967b).

Using a combination of field survey, correlational and experimental methods, Harris et al. (1972) investigated the role of fatigue in commercial vehicle accidents. Vehicles were specially equipped with mechanical and electronic devices to monitor performance and physiological fatigue indices. Definite physiological fatigue correlates and performance decrements became evident in the fourth hour, increasing throughout the remainder of the ten hours, except for a recovery effect near the end of the run (goal proximity effect or more stimulating environment in areas surrounding terminal). A retrospective analysis of accident statistics indicated that accidents increased disproportionately after seven hours and remained higher for all driving times in excess of seven hours.

An analysis of the data by rest breaks indicated that the first rest break (typically after three hours of driving) produced substantial amounts of physiological fatigue recovery and fewer driving errors; the second rest break (after six hours) produced much less fatigue recovery; and the third break (after nine hours) did not even have transitory beneficial effects. There was some evidence of cumulative effect on level of physiological arousal. Drivers on duty for several consecutive days showed earlier declines, lower absolute levels of arousal, and less recovery from rest periods.

Other studies have examined driving performance among "types" of drivers who report fatigue while driving. Case et al. (1970b) compared the simulator performance of three groups of drivers. One group admitted to poor trip planning habits and drowsiness at the wheel. Another group reported good trip planning habits, and did not experience sleepiness while driving. A third group was not selected by either trip habits or drowsiness. No significant differences were found in the scores on the driving tasks between the three groups, but the "sleepy" group significantly differed from the alert group in their ability to safely respond to traffic collision situations incorporated into the filmed simulator drive. What relationship this behavior bears to real, on-the-road behavior is, of course, unknown.

These reviewers are aware of only one assessment technique specifically designed to measure propensity for driver drowsiness. Yoss (1969) developed a ten-minute test based on the correlation between eye pupil size and states of alertness. While looking at a distant target, the subject's pupil size and pupilary waves are measured. Yoss found that pupilary diameter significantly differentiated well-rested, alert subjects from those subjects who admitted to severe narcolepsy when driving. However, predictive validity has not apparently been established. It is difficult, at this point, to estimate whether such validation is warranted. The frequency of "narcolepsy" among the general driving population is probably low. Nevertheless, the test might prove extremely useful for a small sub-population of drivers.

Conclusions and Recommendations

The magnitude of the relationship between driver fatigue and highway safety remains uncertain, since there are conflicting reports on the number of accidents attributable to driver drowsiness.

Laboratory research has clearly demonstrated that a decline in performance on most driving tasks accompanies both sleep deprivation and task-induced fatigue. However, such research on driver fatigue and alertness also appears to suffer from an inherent flaw found in many other performance investigations--the phenomenon under scrutiny is altered by the attempt to measure it. Thus, performance declines attributable to fatigue may be even greater than reflected in current research.

Unfortunately, these findings have few implications for diagnostic assessment, since fatigue is a transient condition which must be predicted in advance. Presently, there is little known about the extent to which particular individuals may be inclined to drive while fatigued, or even whether the probability of driving while fatigued is related to any intrinsic personal characteristics. To answer these questions, a reliable criterion measure of "driving while fatigued" is essential.

To provide such a measure, the most desirable alternative would be a criterion based on in-depth accident investigations. However, when these techniques are used to reconstruct intangible factors such as fatigue, the results have not yet been shown sufficiently reliable.

There are certain other possibilities. Using a reliable non-driving fatigue measure (possibly a physiological measure such as pupil size), accurate estimates of fatigue among the general driving population (i.e., by roadside surveys at various hours and locations) might be obtained. This approach would allow a comparison of personal characteristics between a control and a known "fatigued-while-driving" sample, and allow concurrent prediction of a driving-related fatigue variable.[23] If accident investigations can be improved to the point that fatigue can be assigned as a definite causal factor, then the resulting "true" predictive capability would, of course, be preferable.

[23] Comparing future driving records of these groups would allow future "true" prediction, with fatigue as a predictor variable, but not as a criterion.

EXPOSURE VARIABLES

One practical solution to the problem of exposure control is simply to ask drivers to estimate their average mileage. This could be done, for example, at license renewal. Such personal mileage estimates have often been used in research studies to provide some control for quantitative exposure (total mileage). Questions such as "amount of night driving" can also provide information on the more qualitative aspects of driving exposure (i.e., the frequency of particular kinds of hazards).

The primary problem with subject-reported quantitative exposure information is the fact that drivers' mileage estimates are frequently very inaccurate. Data is particularly biased when exposure questions are asked in a driver licensing or improvement setting, where subjects may believe that high mileage estimates help excuse poor driving records. Despite this problem, many studies have shown the predictive utility of exposure estimates, without qualitative exposure data or control for estimation bias.

Levonian (1963) developed a stepwise regression equation, derived from California's point system, to predict "negligent operator" status among license renewal applicants. He found that the best single predictor was mileage estimated by the driver (simple correlation with negligent operator status = 0.13). This mileage variable was more significant than numerous other predictors, including age, sex, marital status, occupation, and all of a series of vision scores. However, Levonian did not attempt to assess any qualitative aspects of exposure, nor to control for biases within the subjects' estimates. In addition, his subjects were volunteers. Although the rate of refusal to participate was "less than 5%," this does allow for introduction of potential volunteer bias. McGuire (1969, 1972) found estimated mileage to be the best single predictor of concurrent accident frequency among young Air Force enlisted men. Similarly, Peck et al. (1971) reported that annual mileage obtained by mailed questionnaires was significantly correlated with concurrent accident frequency, and also was a significant contributor in a multiple regression equation constructed to predict accidents.

At least one study has produced a conflicting result. Asher and Dodson (1970) analyzed data of fatal accident victims who had participated in the Project TALENT (Flanagan et al., 1964) data collection effort. Asher and Dodson found that while the fatal accident victims reported learning to drive at a younger age than their peers, they also claimed, at least at that time, to drive less frequently (P = .05). However, since the fatalities in this study occurred during an interval of greater than nine years, while the Project TALENT data was collected at one time, there are wide variations in the interval between data collection and fatal accidents among the fatality victims. Exposure estimates immediately prior to fatal accidents were not available. However, it is still possible that limited traffic exposure during high school can lead to higher subsequent fatal accident probability or perhaps simply higher subsequent exposure.

There is also a possibility that exposure estimates merely reflect biographical or social factors, rather than actual mileage. When Kraus et al. (1970) compared an accident-involved sample of drivers with a non-accident sample matched on age, sex, and population of area of residence, the authors report that "the distribution of estimated miles driven in the previous year was clearly comparable in the accident and control groups." They do not report level of significance. The finding does suggest that controlling for exposure (at least exposure as estimated by the driver) may be unnecessary if there are sufficient controls for biographical variables. However, Burg found total annual mileage to be one of the better predictors of accidents even after many biographical and prior driver record variables were controlled (1967).

A study of the errors made by drivers in estimating mileage was conducted by House and Waller (1971). From a sample of students, staff, and faculty, these authors collected estimated mileage, actual odometer mileage, as well as numerous other predictors, including age, sex, marital status, occupation, number of children, model and year of car, and indices of interest in and responsibility for the vehicle. They found that actual vs. estimated mileage correlated fairly well ($r = .65$, $N = 505$), although only half of the drivers were able to estimate their mileage within 200 miles per month. The authors then developed a regression predicting actual mileage from estimated mileage. In addition to estimated mileage, the other significant predictors were age, staff status, and degree of interest in the vehicle. Although the results of this study cannot be generalized to other settings,[24] the study does suggest the possibility that similar mileage estimate correction studies could be employed in other settings.

Many researchers have attempted to improve upon the unreliability of simply asking drivers to estimate mileage by concurrently collecting qualitative exposure information. Pelz and Schuman (1971) asked subjects to specify a number of parameters of their driving exposure, such as length of time spent driving for various purposes, number of daily trips, etc. and combined these responses into one overall index of exposure, which improved prediction.[25] In another study, Harano et al. (1973) developed

[24] Due to academic setting, non-representative sample, limited number of predictor variables, and relatively small sample size.

[25] Pelz and Schuman disagree with computations of errors per mile, arguing that this figure always declines for higher mileage groups.

several qualitative and quantitative indices of exposure when comparing accident repeaters and accident free drivers. In an attempt to overcome reporting biases and inaccuracy of reporting, an exposure index was developed by using county traffic density counts for the routes the subjects most frequently travelled. In addition, maps were used to obtain mileage estimates on routes most frequently travelled (usually between residence and work). Attempts to develop total mileage indices by summing individual trips and by using the more objective data did not result in more discriminatory power between the groups than did merely asking for annual mileage. In general, the quantitative aspects of exposure (annual, weekly, hours) discriminated better than the qualitative measures (nighttime/daytime). Similarly, in a later, more in-depth analysis of his 1967 data, Burg (1973) found the qualitative exposure variables to be substantially less important than simply quantitative exposure (mileage).

Harrington (1971) in his study of young California drivers, found both annual mileage and qualitative exposure to be significant predictors (in both simple and multiple correlation) of accident frequency during the first four years of driving. Jones (1973) also analyzed the role of exposure in her study of driver training effects. Using a one-year criterion period, she found self-reported exposure to be a statistically significant predictor, but of much less magnitude than reported by Harrington. A possible reason for this difference is that Jones' subjects had accumulated very little driving experience when the exposure information was solicited and therefore may not have had an adequate reference for producing valid estimates.

DISCUSSION

Since both accidents and citations are a partial function of number of vehicle-miles driven, it is not surprising that researchers found exposure (invariably mileage) to be a significant predictor in regression equations on these two criteria. Harano et al. (1973) reported that a mileage-cluster score combination (of estimated annual mileage two years prior and miles driven per work day) was a strongly significant predictor of accident involvement. McGuire (1969) found that estimated two-year mileage was the second best predictor of accidents, after total number of moving violations. Levonian (1967), also using multiple regression methods, found driving exposure (estimated average annual mileage) to be the best single predictor of negligent operator status. Age, sex, and marital status were also significant. Numerous other variables, including 24 vision scale scores, were not significant. These collective results would indicate that projects designed to predict future driving behavior should include the best available quantitative estimate of driving exposure.

The findings on the qualitative aspects of exposure (e.g., time of day, frequency of various hazards, etc.) have been less encouraging.

However, these variables have been found significant for certain sub-populations, suggesting potential applicability to assessment, particularly whenever more specific definitions of driver problems become available.

SUMMARY OF CHAPTER 3

DRIVER PERFORMANCE AND ABILITY

Among the research studies examining driver perception, the measures of perceptual style (or the related concept of field-dependence vs. independence) have shown the most potential. The correlations of these measures with driving errors for the general driving population have usually been low. However, these measures apparently interact with biographical factors, such as age and sex, to produce decrements in driving performance. Thus, further research may demonstrate utility for predicting certain types of driving errors among certain classes of drivers.

Research on driver decision problems has been almost exclusively limited to drivers' judgements about perceived hazards. To date, few of the results have been encouraging, although further validation is currently underway.

The Level III research has also developed numerous measures of overall driving performance. These include driving simulators, instrumented vehicles, observer ratings, and self-report techniques.

Of the many studies using driving simulators, few have demonstrated any valid relationship to subsequent actual driving behavior (accidents or convictions). None have demonstrated sufficient validity for operational prediction. The multivariate studies (e.g., Harano et al., 1973) have demonstrated that simulator performance variables have relatively low usefulness when variables from other levels and conceptual areas are available. However, simulator measures may still have some utility, particularly for inexperienced driver groups, for whom lack of adequate skills may be a more frequent accident causal factor.

The remaining Level III measures of overall driving performance suffer the same lack of predictive validity as the simulator measures. Additionally, the instrumented vehicles often present operational difficulties. The observer rating techniques often have poor inter-rater reliabilities. The self-report techniques have not yet been standardized.

HUMAN CONDITIONS AND STATES

Biographical information obtained directly from the driver appears to have some useful predictive capability. Among the biographical areas reviewed, education, occupation, and socio-economic status clusters had the highest relationships with accident involvement. These measures may in part indicate exposure differences among occupational groups. Smoking cigarettes was found in a few studies to predict accident involvement for young males. Other life style variables such as school activities, social functions, and clubs showed some relationship with traffic convictions and accident involvment for younger drivers. Each of these appear to be one of many aspects of socio-economic status. When such socio-economic variables are combined into clusters (which increases reliability), their predictive utility becomes very high (Harano et al., 1973).

Biographical variables themselves offer little potential for directly describing a driver problem. However, they are useful for describing sub-populations and clarifying interactions among other conceptual areas of study (e.g., attitudes, exposure).

Many psychological, social and attitude variables have also been examined. Among these, the more transient life stress factors (e.g., marital problems, financial problems, etc.) have the highest apparent relationship to accident involvement. However, life stress has been examined almost invariably by retrospective studies, which do not provide clear indications of utility for future prediction. For these life stress factors, a future predictive study collecting recent life stress data is needed.

To examine more stable personality characteristics and traits, investigators have employed hundreds of assessment instruments and individual items. While many of these have produced significant results, correlations have been uniformly low.

Among the assessment techniques developed in the area are several "second and third generation" instruments. The most predominant approach appears to be initial item analysis of batteries of standard personality tests (e.g., MMPI), and the selection of discriminating items for subsequent efforts. Other investigators have selected items on an a priori basis, which were considered on face value to be related to driving behavior.

There are few marked differences in reliability among the personality tests, and most use similar scaling methods. Several current tests have either been derived specifically for drivers, or are general personality inventories based on items and concepts from previous inventories. The uniform application of two or three tests to a wider population base is needed, which would clarify appropriateness of certain techniques for subcultures, age groupings, etc. The current lack of standardized data on any one test limits generality of findings. A longitudinal follow-up combined with observation of driving behavior and the examination of the temporal influence of social stress should help determine the utility of personality assessment in traffic safety as well as in other social problem areas.

Attitudes, particularly attitudes toward driving, have also been extensively studied. Among particular sub-populations of drivers (e.g., younger drivers) most results have been encouraging. Further research is needed to determine the differential applicability of these kinds of measures across all sub-populations of drivers, particularly to predict various specific driving errors.

The medical and physiological variables in Level III included only alcohol and fatigue assessment, since most other medical assessment must be conducted by a physician, and was therefore included in Level I.

Much research has been directed toward the assessment of alcohol-related driver problems. Many of the studies focus on assessment techniques which have utility for the diagnosis of drinking problems in an operational setting such as the courts, or driver improvement licensing agencies.

While most early studies related single factors to alcohol involvement, current efforts generally use a "battery" approach, using data from several sources. This latter technique has provided a steady accumulation of alcohol-related information, within both the traffic safety countermeasures area and the general predictive assessment of drinking problems. The most widely-used assessment technique appears to be the Mortimer-Filkins Questionnaire/Interview. This instrument was reported to be in use by 15 of 23 ASAP programs in 1974 for assigning drivers to countermeasure programs. Unfortunately, a review of the 1974 programs did not reveal additional validity or reliability data.

Although most efforts attempted to relate drinking diagnosis to driving performance, the validity coefficients were low (concurrent). None of the studies reported predictive validity efforts.

The primary reason for low predictive validity is the unreliability and rarity of the criteria themselves (e.g., recidivism, accidents, etc.). Attempts to overcome the criterion deficiency problem are seen in efforts to "build" multiple criteria or combinations of several drinking (non-driving) and drinking (driving) indices (e.g., Mortimer et al., 1971, "CRIT"). The use of such indices appears to be a feasible and useful direction for developing a more reliable measure of both alcohol-related driver problems and alcohol-related problems in other social areas.

The studies reviewed indicate that the questionnaire/interview approach to diagnostic assessment is operationally feasible. In the MAST, originally intended as an interview, a self-report form has been developed and tested by non-professional personnel. The reliability results from the HSRI Protocol (M-F) indicate that only a small increase in reliability is gained by administering both the interview and questionnaire, although for research purposes it may be desirable to include both. Follow-up studies using the "Life Activities Inventory" will be useful for determining the effectiveness of rehabilitative efforts in changing drinking patterns as well as providing criteria for validating initial diagnoses based on such instruments as the HSRI Protocol.

Currently there appears to be good potential for the diagnosis of general drinking problems. The utility for predicting drinking and driving problems, however, remains to be proven.

The role of fatigue in accident causation is, at best, unclear, since accident investigations cannot routinely determine whether driver fatigue was a causal factor. Many studies have shown that driver performance deteriorates with sleep deprivation or task-related fatigue. However, since fatigue is both transient and difficult to detect, the potential applications of fatigue assessment are limited to predicting "propensity of driving while fatigued." As a result, only a limited amount of research has been directed toward the assessment of driver fatigue. These efforts to date have not been very successful. In the future, when more accurate and reliable physiological measures of fatigue (i.e., which can be administered on-site, similar to current BAC testing) can be developed, this area would appear to be a fruitful one for research, since the number of accidents caused by fatigue is unknown, but possibly very great.

EXPOSURE VARIABLES

In an attempt to predict accident liability or to control accident/violation ratios by exposure, several investigations have obtained test exposure estimates directly from study subjects. Both qualitative (e.g., driving at night) and quantitative (e.g., mileage) estimates have been used. The primary problem with the exposure estimates is that they are subject to biases and errors. Despite this problem, estimated exposure information has been found to be a relatively good predictor of accident involvement, similar to biographical variables found in Chapter 1 (e.g., age, sex, marital status). Generally quantitative measures are better predictors than qualitative measures. However, for certain groups of drivers and driver-specific errors, qualitative measures could be combined with quantitative measures to further increase prediction.

CONCLUSION

A review of several different conceptual areas revealed that the study efforts have much in common. Several methodological problems appear consistently among the studies reviewed. Foremost are the numerous small studies, often using conceptually similar instruments which tend to confuse the role of person-centered factors. Few studies have analyzed the data for accident liability patterns, or clearly delineated concepts such as the interaction between person-centered variables and situational influences. Additionally, most studies employ only univariate comparisons on a series of variables. This approach does little to clarify interactions. Another difficulty has been the poor criteria (namely accidents) which are traditionally used to validate such techniques, rather than the psychometric properties of the test per se. Finally, most studies have been retrospective or concurrent, not "true" predictive. While such studies are certainly useful to explore relationships, they reflect the relatively primitive development in the research area of accident prediction.

There appears to be a general lack of theoretical framework and rigorous definition of concepts for the construction of tests. Several investigators have suggested the need to define person-centered characteristics as they relate to driving behaviors (Case and Stewart, 1958; McFarland, 1968; and Lucas, 1970), recognizing that driving behavior is but one aspect of adjustment to society. McFarland (1968) suggests that personality characteristics, for example, interact with social stress to form a cluster of social behaviors or an "adjustment complex." These social stresses paired with adjustment problems can increase the frequency of maladaptive behavior. Lucas (1970) comments further:

> "If a wide variety of traits are involved in a wide variety of accidents there is a low possibility of correlation since accidents are rare... Possibly personality factors interact with attitude to cause excessive variance." (Lucas, 1970)

There is little doubt that maladaptive personality characteristics, interacting with transient stress or social problems, can be related to crashes. Combining these factors with performance deficiencies, alcohol consumption, other human conditions, and high exposure presents a very complex picture. Rarely have studies addressed the many human factor areas simultaneously to determine the relative importance and interaction among these areas.

Improvements in research methodology should help clarify the utility of techniques. Several questions were raised by the review. How well can results be verified by cross-validation? How reliable were the scales for different populations? If results had been analyzed in a multi-variate approach, would personality "types" or patterns have been more useful than simple univariate comparisons on each of the scales? How do the techniques compare in terms of reliability and validity? Do the conclusions generalize to other populations? Would exposure control result in different findings? Answers to all of these questions can be addressed in well-designed and controlled studies.

The 1966 review of traffic safety literature by A. D. Little[26] reached much the same conclusions:

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[26] Additional review articles which were useful in compiling the present review included Adams (1970) and Schuster (1970).

"The studies reviewed here.....used small samples, geographically limited samples, occupationally limited samples, or combinations of these. This fact alone, even if strong relationships were found, considerably limits the generality of the results. In addition to the lack of generality, the rather poor reliability of most of the tests, the possibility that an individual will have an accident and that these factors may vary from day to day, and the rarity of automobile accidents due to changing probabilities of many other factors reduce the chances of establishing a strong relationship between one or more factors and accidents. And in the absence of a strong relationship between a factor and accidents, it is not justifiable to eliminate from the driving population a person who merely appears to possess the suspicious factor." (Little, 1966)

Chapter 4

SUMMARY AND RECOMMENDATIONS

SUMMARY

The state-of-the-art review demonstrated that Level I data sources have the greatest current utility for diagnostic assessment in an operational setting, based on the relatively inexpensive means of data retrieval and the consistency of significant predictors found at this level. Level II data, although presumably less difficult to obtain than Level III information (i.e., other agencies may already have stored assessment data), presents several legal and logistical problems. Privileged information requirements and a lack of coordination between agencies represent some of the obstacles. Although generally low in present utility, Level II sources appear to have good potential for diagnostic assessment, since in-depth evaluations conducted by professionals (e.g., accident investigators, physicians, psychologists, etc.) could be made available. Level III data usually requires further research before its operational utility can be determined, since, by definition, it is currently not widely used for assessment in social control agencies. For general application to the driving public, the use of Level III sources is more costly, and often requires trained personnel. Operational applications appear to be limited to selected populations exhibiting a major problem at Level I, e.g., drivers suspected of having a drinking problem.

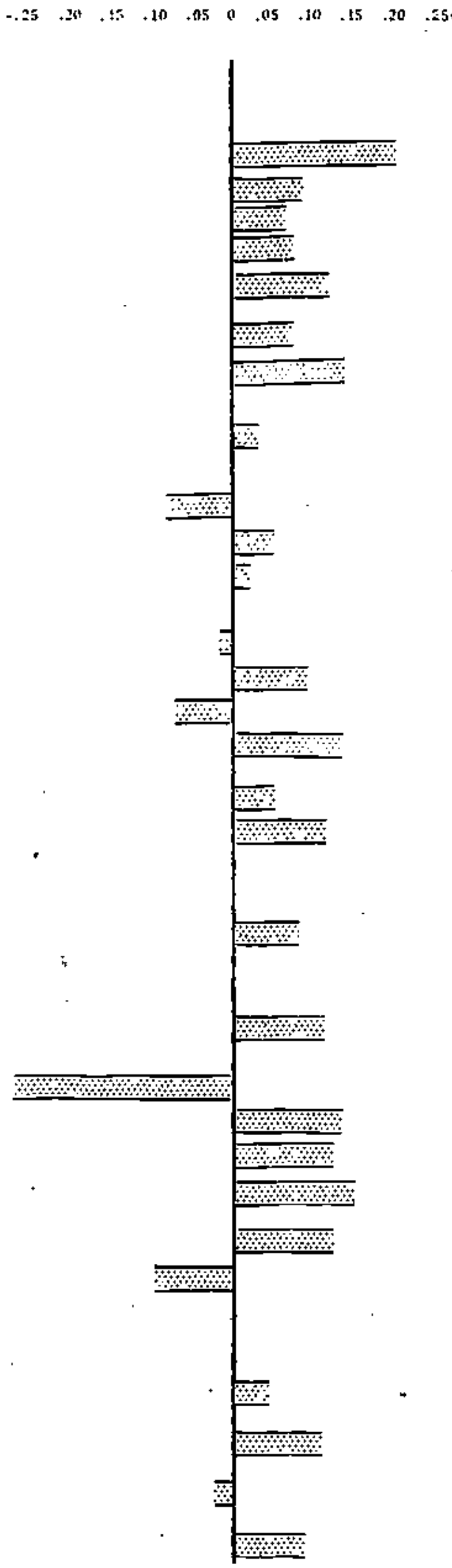
Since comparisons of the findings of different research studies are frequently complicated by differing methodologies, samples, and data collection procedures, Figure 4-1 presents some of the results from one of the more comprehensive studies, in which a broad range of assessment variables was administered to a single sample of drivers. These correlations demonstrate the magnitude of prediction which can be expected using many of the techniques discussed in the state-of-the-art review.[1] In general, prediction is highest for the driver record performance variables, and the variables at other levels measuring education, occupation, socio-economic status, and driving exposure (all of which are also interrelated).

The following section will summarize the findings on the utility of assessment techniques within conceptual areas.

[1] Expected prediction would be somewhat lower, since this study employed a contrasted sample.

*Measure From Gordon Personal Profile (GPP) or Gordon Personal Inventory (GPI)

LEVEL I:	
PERFORMANCE MEASURES:	
One Count Convictions (Moving violations except DWI, reckless, hit and run, and driving while suspended or revoked)	.204
Passing Convictions	.098
Right-of-Way Convictions	.068
Equipment Convictions	.088
Signal/Sign Convictions	.122
Turning, Stopping/Signalling Convictions	.077
Speed Convictions	.116
Major Convictions (DWI, reckless, hit and run, etc.)	.033
BIOGRAPHICAL MEASURES:	
Age	-.081
Marital Status	.051
Height	.011
MEDICAL/PHYSIOLOGICAL MEASURES:	
License Restrictions	-.005
No. Physical Symptoms	.030
Heart Palpitations	-.071
Gain/Loss of Weight	.135
Amount Alcohol Consumed on Special Occasions	.031
Vision Errors (both eyes)	.117
EXPOSURE MEASURES:	
Traffic Density (Registered vehicles per mile in county of residence)	.080
LEVEL II:	
BIOGRAPHICAL MEASURES:	
Part-time Employment	.117
Occupation:	
Professional	-.266
Service Worker	.135
Professional Driver	.128
Number of Job Changes	.143
Number of Arrests (Last three years)	.125
Gun Permit Application	-.099
LEVEL III:	
PERFORMANCE MEASURES:	
Simple Eye-Hand Task (Mean source)	.046
Simple Eye-Hand Task (Number of errors)	.105
Standard Deviation of Simulator Speed	-.024
Simulator Steering Wheel Position	.084

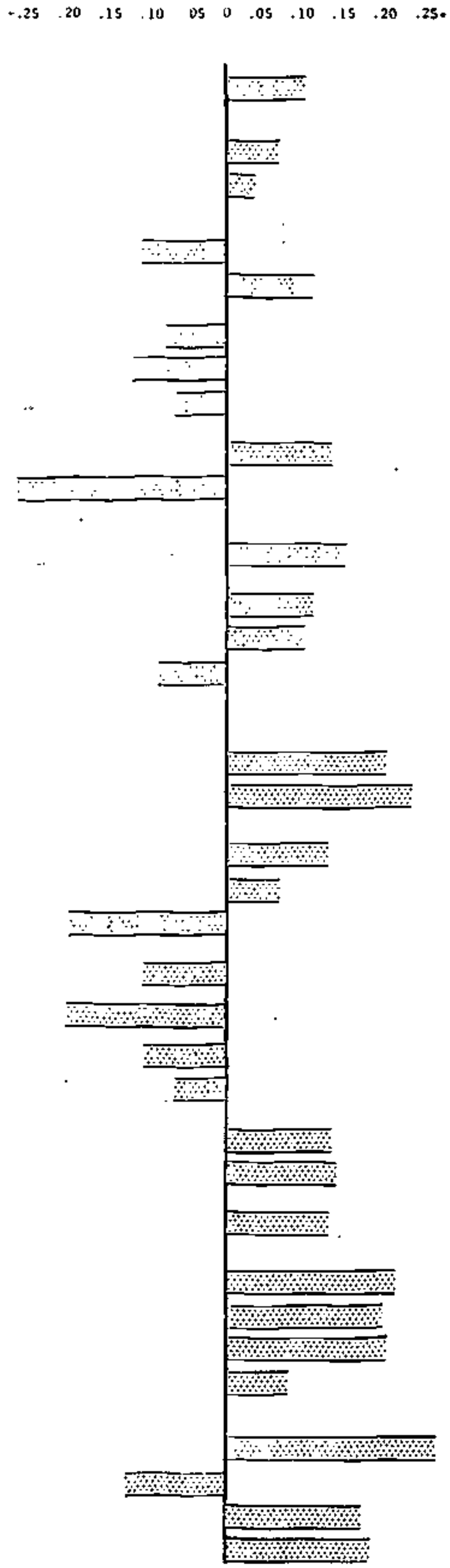


Source: All correlations from Harano, McBride, and Peck (1973). Three Year Record Predicting Concurrent, Non-Spurious Three Year Accidents

FIGURE 4-1. MAGNITUDE OF SELECTED ACCIDENT PREDICTORS BY LEVEL OF OBSERVATION

Figure 4-1 (Continued)

Simple Reaction Time Difference Score (Improvement)	.091
Complex Reaction Time Difference Score (Improvement)	.059
Embedded Figures Test	.035
BIOGRAPHICAL MEASURES:	
Number of Children	-.102
Number of brothers, sister	.098
Number of Clubs/Organizations	-.075
Clubs--Church-Related	-.116
Number of Recreations/Hobbies	-.066
Smoking Hazard Index (High non-filtered cigarettes)	.122
Socio-Economic Cluster	-.401
Difference Between Ratings of Father and Mother as Good/Valuable	.139
Severity of Parental Punishment	.104
More Family Dissention	.092
Father Permissive	-.079
PSYCHOLOGICAL MEASURES:	
Hours:	
Clean/Repair Car	.194
Driving for Fun	.228
Observer Rating:	
Driver Not Calm	.126
Driver Not	.060
Emotional Driving Cluster	-.189
Emotional Stability (Gordon Personal Profile)	-.106
Cautiousness (GPP)*	-.195
Personal Relations (GPI)*	-.101
Vigor (GPP)*	-.064
Law Enforcement Attitude (High = Too Strict)	.124
Driver Self-Rating	.127
Driver Self-Rating Compared to Elderly Driver	.122
Low Satisfaction:	
Financial	.204
Life	.185
Total	.193
Drive to Feel Powerful	.072
EXPOSURE MEASURES:	
Mileage Cluster	.276
Rush-Hour Driving	-.118
On-the-Job Mileage	.159
Midnight Driving	.167



ASSESSMENT OF FINDINGS BY CONCEPTUAL AREA

Performance

Driver record performance data (Level I) are the most useful predictors of subsequent driving performance. Total traffic convictions appear to be the best single predictor, followed by prior accidents. Specific conviction types are especially useful to identify particular driver problems. However, several deficiencies were identified which reduce the utility of driver record variables, such as selective enforcement and court procedures (e.g., plea bargaining, reduced charges, etc.). More uniform enforcement and adjudication should improve the utility of driver record information. Although on-road testing is a direct measurement technique, it was considered a Level I variable since it is a driver record variable, but current validation studies have not determined its predictive utility. Prior sanctions, or attendance at driver treatment programs were also found to be of low utility, but may become more useful when the programs are more fully evaluated.

Level II performance variables may provide slightly improved qualitative description of driver errors, since the descriptive information on culpability and driver errors (e.g., BAC, deviation from speed limit) can provide predictive capability beyond Level I information.

Level III performance variables (e.g., simulators, instrumented vehicles, etc.) are primarily utilized in a research setting and provide little operational potential at this time. Computer simulation technology may eventually provide a partial answer for diagnostic problems within a dynamic testing environment.

Biographical

Most studies have shown that biographical variables are important predictors of driving records. Age, sex, and marital status are the most important at Level I. However, these variables provide little insight as to the nature of the driver problems. They are useful as a starting point in partitioning the driving population into accident liability classes, since accident rates vary markedly across different age, sex, and marital status groupings. Occupation and socio-economic status are generally more difficult to obtain, but demonstrate predictive capability paralleling driver record data. While these variables may be available at Level II (even occasionally at Level I), the availability is not uniform, and direct inquiry of the driver is generally required (Level III). Information on life styles (Level III) provides insight into underlying problems and characteristics of the driver within the age, sex, and marital status groupings of Level I. Job, financial, and marital stresses were often found to be associated with more severe crashes (and in those involving alcohol use). However, most studies on life stresses were retrospective, so the predictive utility of such variables is not known.

Psychological/Social/Attitude

Although numerous studies have employed psychological measures for driver assessment, overall utility relative to driving performance is low. Level I does not contain variables which would traditionally be labelled "psychological," but one potential indicator of underlying attitudes (as well as socio-economic factors) that is available at Level I is the year, weight, and model of the driver's vehicle. Level II sources can provide the most in-depth information (e.g., mental health agency records), but assessment is often restricted to a narrow population. Additionally, for legal and ethical reasons, agencies are frequently reluctant to disclose personal information. Level III techniques appear to have the most current utility for obtaining psychological and social data. For certain sub-populations, psychological and attitude factors appear to play a major role in driving, but applications to the general public have lower utility. Costs of mass test administration are also high. Retrospective studies of fatal drivers often demonstrate highly deviant life styles and situational stress. However, for predictive purposes (which is the primary concern in diagnostic assessment), these variables have yet to demonstrate high predictive utility.

Medical/Physiological

With the exception of alcohol problem assessment and perhaps visual testing, the assessment of medical factors does not appear to have general applicability in the prediction of accident liability. This may in part be the result of current restrictive screening procedures (self-imposed and administrative policy) in licensing which limit the driving exposure of those with major medical impairments. In addition, drivers more acutely aware of their medical limitations may compensate for their deficiencies. In fact, there is some evidence to suggest that certain sub-populations (e.g., physically handicapped) may have lower accident involvement rates than the general population (due, in part, to lower driving exposure). Level II could be a major source of medical information. Its utility is highly dependent on coordinated efforts between public health agencies, physicians, and licensing agencies. Some medical information is retained by licensing agencies, but it is not often complete or comprehensive.

Recent research has demonstrated some potential for diagnostic assessment of vision problems. Since vision testing is currently conducted on a large portion of the population (license examinations), it does provide an opportunity to identify driver problems. However, the relationship of vision to driving remains unclear. For certain groups, poor vision is related to poor driving performance, but for other groups, poor vision may indicate better performance. Further refinement of vision testing (including perceptual measures) is currently underway, which may clarify these contradictory findings.

Techniques to assess alcohol-related errors have been at least partially successful. A major problem has been the fact that the available criterion measures (alcohol-related accidents, or driving-while-intoxicated (DWI) arrests) are much less frequent events than total accidents or total convictions. However, both prior DWI convictions and Blood Alcohol Content (BAC) at time of arrest are still among the best available predictors of future alcohol-related driving problems. Most current Level III assessment efforts are directed toward the small population of drivers arrested for drinking and driving. These approaches are frequently confined to identifying the magnitude of a drinking problem (and usually include treatment). While some of these diagnostic efforts have been relatively successful, their potential impact on the accident problem is limited, since many alcohol-related accidents do not involve "problem" drinkers. No Level III diagnostic approaches to date have shown the ability to predict future drinking-and-driving problems, although a few appear useful to predict drinking problems. Further validation efforts will be required to judge the overall impact of current alcohol diagnostic procedures.

Exposure Variables

Many research studies have shown the relationship between increased driving exposure and increased accident potential. Exposure variables are those variables which do not assess intrinsic characteristics of the driver, but which do reflect the quantitative (e.g., mileage) and qualitative (e.g., rush-hour driving) hazards of his driving environment. Using information from Level I sources, accident rates and types have been found to vary markedly by geographical areas (urban vs. rural), and local traffic density. These kinds of (non-individual) variables are useful when, for example, different assessment procedures might be established for different (exposure) jurisdictions. Level II exposure variables appear to have the highest potential in the area of selective enforcement, since knowledge of high accident areas may result in optimum personnel allocation and driver error identification. For individual assessment, however, useful variables are again, not often available in a coordinated manner. The Level III assessment of amount and kinds of driving exposure holds the most promise for individual prediction. In those multiple regression studies employing reported mileage, most measures (e.g., on-job mileage, annual mileage, etc.) were highly significant in predicting accident involvement at a level parallel to driver record and biographical data. In general, the quantitative measures were found more useful than the qualitative measures. Further research is needed to determine accurate means of measuring both qualitative and quantitative exposure.

UTILITY OF CONCEPTUAL AREAS BY LEVEL

To provide some empirical estimate of the relative strength and importance of the various levels of observation and conceptual areas, several multiple regression studies were examined. Although the regression method does not take into account interactions,[2] and assumes linearity of relationships, the results are useful primarily to determine the relative importance of predictors.

Studies have been selected for presentation which provide relatively stable estimates of relationships (large samples), and which employed a wide range of assessment variables (by both level and conceptual area). These studies included Harano et al. (1973), Harrington (1971), and Peck et al. (1971).

To obtain an estimate of the strength of variables in predicting accident liability across the various studies, a relative index was derived. The index is simply the variable's rank order within the regression equation divided by the total number of significant variables in the equation.[3] This calculation provides a measure, ranging from 0 to 1, of a variable's relative importance in predicting accidents. The higher the index, of course, the greater the variable's relative strength in the equation. This provides some means of comparing variable strength, or utility, across various studies.

To then summarize the relative strengths of conceptual areas and levels of observation, the average index was computed (see Table 4-1). (In those cases where two or more related variables were significant in an equation, such as total convictions and one-count convictions, the lower-ranked value was omitted in computing the mean.) These results are grouped in decreasing order in Table 4-2, which shows that Biographical data (Level 1) and Exposure data (Level III) have the highest average index, followed by Socio-Economic Status (Level II) and Performance (Level 1). Since this analysis is somewhat primitive, and in part, a function of the variables included (in addition to idiosyncrasies of the sample and criterion), there is probably little "real" distinction in the relative strength of variables receiving the highest indices. The remaining variables appear to be less useful.

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[2] Interactions and curvilinear relationships can be built into the method via transformations during coding, but this approach is somewhat inefficient and rarely used.

[3] Other factors, such as the total number of initial variables, could have been included in this index. However, because of other methodological differences among studies (e.g., sample size, length of driving record, etc.) the inclusion of this factor was felt to be an undue complication.

TABLE 4-1. SUMMARY OF REGRESSION FINDINGS

LEVEL OF OBSERVATION	PERFORMANCE	BIOGRAPHICAL	PSYCHOLOGICAL/ SOCIAL/ATTITUDE	MEDICAL/ PHYSIOLOGICAL	DEMOGRAPHIC
I	Prior convictions, prior accidents, misc. driver actions Mean Index: $\bar{x} = .51$	Age, marital status, weight, age licensed Mean Index: $\bar{x} = .69$	Make of car, vehicle year, vehicle weight Mean Index: $\bar{x} = .28$	Variables present but not significant in relation to other variables.	Variables not included in analyses presented
II	Variables not included in analyses presented.	Socio-Economic statis, occupation, education Mean Index: $\bar{x} = .59$	Variables present but not significant relative to other variables.	Variables not included in analyses presented.	Variables not included in analyses presented.
III	Simulator performance, coordination Mean Index: $\bar{x} = .24$	Clubs, activities, home status Mean Index: $\bar{x} = .34$	Attitude and Personality factors Mean Index: $\bar{x} = .37$	Variables not included in analyses presented.	Mileage (annual, weekly, on-job Mean Index: $\bar{x} = .69$

TABLE 4-2. AVERAGE INDEX FOR CONCEPTUAL AREAS BY LEVEL

Level	Conceptual Area	Mean Rank Index
Level I	Biographical	.69
Level III	Exposure	.69
Level II	Socio-Economic	.59
Level I	Performance	.51
Level III	Psychological	.37
Level III	Biographical	.34
Level I	Psychological	.28
Level III	Performance	.24

METHODOLOGICAL LIMITATIONS

For the most part, traffic safety research has addressed total accident involvement as the primary criterion for predictive purposes. This approach has suffered from several methodological limitations. The largest single problem has been the fact that accidents, at least in the United States, are extremely rare events, occuring about once every ten years for the average driver. Statistical prediction of such a rare criterion, especially using correlational methods, is necessarily limited. To overcome this problem, researchers have frequently attempted to use traffic convictions rather than accidents as a criterion measure. However, the relationship between convictions and accidents is unclear. Correlations between the two measures are low (approximately .05 - .12), suggesting that prediction of convictions may have little relevance to accident causation.

To overcome the criterion deficiency problem (rarity of accidents/violations), investigators have frequently resorted to retrospective research designs using intact groups of accident repeaters or traffic violators. While this approach may increase the probability of significant results, it suffers from a lack of generality to other populations.

In defense of the efforts to date, accident research is a very complex and difficult area of investigation. Most studies have been concurrent rather than predictive, since:

- Generally, study subjects can be easily located and tested within, for example, an operational licensing agency setting, rather than resorting to random population selection;
- Concurrent prediction can be accomplished without waiting for long time periods; and
- Retrospective studies, especially when contrasted groups (e.g., accident repeaters vs. accident-free drivers) are used for comparison, tend to circumvent the "rare-event" problem. However, since deviant individuals are highly over-represented in the sample for comparison, the relationships are also inflated and non-generalizable.

Although these retrospective studies are useful for exploratory purposes, the general paucity of predictive studies limit conclusions as to operational utility of assessment techniques, since in predictive applications, the magnitudes of relationships generally shrink to much lower levels.

The second problem that arises from the use of total accident involvement as the primary criterion for accident prediction has been the fact that the indiscriminate grouping of different types of accidents (or convictions) diminishes the utility of assessment techniques for particular driver problems. Few studies in the review attempted to differentiate between the many types of accidents or violations. Relationships between specific assessment techniques and specific drivers may be especially relevant, since different types of individuals may be involved in different types of accidents. However, further fractionating accidents into error categories does reduce criterion stability by increasing the rarity of the criterion event.

Researchers have usually recognized the need for a stable measure of driving behavior which describes the entire driving task. Intermediate criterion measures, such as observation of the driver in test situations, have been offered as one alternative, but predictive validity has not been demonstrated. Additionally, the alternatives usually present a host of other problems (such as the effect of the artificiality of the test situation), which in turn reduce validity. None of these intermediate criteria presently show useful relationships with numbers of accidents, injuries and fatalities, or dollar damage. Finally, costs and operational infeasibility also limit most alternative criterion measures.

Recent efforts, such as the multidisciplinary accident investigations, should improve our knowledge of accident causal factors and identify variations among driver sub-populations. However, the limitations of making causal inferences from after-the-fact data should be considered.

Test reliability is an issue rarely addressed in current studies. Although reliabilities are often reported elsewhere for standardized tests, questions invariably arise concerning the appropriateness of tests for various sub-populations. The extent to which background characteristics interact with test reliability raises additional questions about the relevance of tests and devices for specialized sub-populations. There is a definite need to conduct more extensive reliability studies. This is especially important in operational settings, where respondents can be expected to "fake" their responses, rather than admit to a problem. For example, Schuster et al. (1962) demonstrated that "surface" safety attitudes can be faked in a socially-desirable direction.

Retrospective designs were overwhelmingly represented in the studies reviewed. The influence of prior driving experience on responses directly dealing with driving items would also be expected to affect both reliability and validity of a measurement device.

Despite these problems, the lack of a stable criterion measure of driving behavior, rather than the psychometric properties of the tests themselves, seems to be the primary reason for the generally low utility. The low frequency of accidents, combined with multiple causal factors, environmental and vehicular factors, and other characteristics of the driver not related to person-centered variables (e.g., transient factors, hazards, etc.), all contribute to the low utility of diagnostic assessment techniques.

The lack of adequate conceptual development of assessment techniques often leaves unanswered the question of how test items or measures relate to each other or to driving behavior. The inter-relationships among areas of observation (e.g., performance, biographical, psychological) have not been adequately examined to trace the interactions of person-centered characteristics and driving errors.

For the most part, research has not comprehensively applied assessment techniques, employing only a few assessment areas at a time, such as personality, or prior driving record, as predictors. This approach has unfortunately resulted in much confusion as to the relative usefulness and importance of assessment techniques.

Additionally, the majority of studies reviewed employed significance tests on numerous single variables within a study. Such an approach (in addition to being inefficient) does not account for inter-relationships or interactions among predictor variables. Multivariate approaches (factor analysis, cluster analysis, regression, etc.) are much more powerful and appropriate techniques.[4] Another criticism of the research reviewed is the lack of intercorrelation data on tests and variables--either not reported or not computed--especially in studies reporting only univariate comparisons of several variables.

Most of the studies reviewed did not report cross-validation results; this failure has been a major reason (in addition to small samples) for conflicting findings. The use of a large number of tests (sometimes larger than samples used) increases the probability of achieving significant findings purely by chance.

Many of the methodological issues discussed here are summarized in Table 4-3.

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[4] These techniques are relatively "robust," and using large samples, violations of assumptions (e.g., non-normal distributions) are mitigated. At any rate, predictive estimates tend to be conservative.

TABLE 4-3. SUMMARY OF RESEARCH/METHODOLOGICAL PROBLEMS

APPROACH	RESULT
RESEARCH DESIGN:	
• Small samples	• Unreliable results; low statistical power
• Retrospective design/ Contrasted groups	• Possibility for criterion contamination, over-inflated results, not generalizable
• Large number of tests Small number of subjects	• Significant results occuring by chance
• No cross-validation	• Results may be inflated or due to chance
• No provision for reliability	• Lack of knowledge concerning precision of instrument
DATA ANALYSIS:	
• A series of univariate statistical analyses	• Does not take into account interactions or colinearity of variables; inefficient, similar concepts treated differently
• Tests of significance (function of sample size)	• Fail to point out magnitude of difference, or measure or association
CRITERIA:	
• Total accidents/violations	• Do not differentiate between types of behaviors
• Accidents	• Multi-causal portion attributable to human factors not delineated; rare, unstable events--need reliable measures of driving behavior
• Exposure data lacking	• Failure to test hypothesis of "exposure proneness" either as a criterion variable or as a moderator variable
THEORETICAL CONCEPTUAL:	
o Lack clear definition of personality traits/risk-taking, etc.	• Measures at different levels of meaning
• Univariate concepts	• Disregard patterns, constellations of patterns or types of problems; do not consider interaction of different levels of measurement

RECOMMENDATIONS

SHORT-TERM EVALUATION REQUIREMENTS[5]

Based on the findings of this review, a prototype model assessment system using currently available techniques was developed. (This model is described in Volume II, Assessment Techniques for Operational Users.) The model was developed in response to the question, "What can operational assessors do now to identify driver problems?" It includes those variables (and techniques) at each level of observation within all conceptual areas which appear most promising. Short-term evaluation will require application of the assessment approach in an operational setting to verify the utility of the assessment techniques and to refine the scoring procedures. Both reliability and validity (concurrent and predictive) evaluations of the assessment technique will be required. Sequentially, the evaluation would first address both internal and temporal consistency of the assessment variables, as well as concurrent validity. An empirical scoring system would then emerge from these analyses to permit more accurate diagnosis of driver problems.

Validation must then address the predictive validity of diagnostic assessment. Detailed follow-up information on subsequent driver errors (not solely total accidents) are required to validate initial problem area diagnoses. In addition to the collection of detailed driver error data, accurate severity and cost information would help to identify cost-effective applications. Because of the requirement for detailed follow-up data, very large samples and lengthy follow-up periods would be required to obtain stable criterion estimates. (Specific plans for the conduct of these evaluations are presented in Volume II.)

DIRECTIONS FOR FUTURE RESEARCH

There are several directions which must be taken in future "long-term" assessment research. There is a definite need to conduct a large-scale effort to evaluate the utility of variables and/or conceptual areas in predicting both accident liability and specific driver problems over an extended time period. It is recommended that researchers concentrate their efforts on long-term validation of selected assessment techniques. The consistent application of fewer instruments using adequate research methodologies may help to clarify many of the unresolved issues. A more comprehensive data collection effort is also recommended

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[5] Both "short-" and "long-term," as employed here, do not necessarily reflect a time dimension. The primary distinction is the level of effort and the nature of the questions to be answered.

to avoid much of the confusion resulting from past "piecemeal" approaches to the problem. The most feasible approach for driver assessment is to select promising techniques and validate them in an operational setting. Once valid techniques have been established and evaluated through a comprehensive research program, more complex applications can then be developed.

Evaluations should provide answers regarding the utility of assessment techniques for particular accident liability classes (differential assessment), effective "life span" of predictor variables, and the cost-effectiveness of assessment. The need for differential assessment is related to the previously-mentioned concept of change. It would be expected that for accident liability classes composed of young people, there would be a need for frequent assessment of status because of rapid life style changes. The operational implication is that license renewal or intervention based on driving problems for these groups might occur at shorter intervals than for middle-aged groups. In addition, for the population over 65 years old, some states have proposed shorter renewal periods. The above factors have important implications for the research design employed. After selection and refinement of all variables from short-term evaluation, the long-range efforts can proceed.

We will tentatively suggest that these efforts include mandatory assessment of a very large population (perhaps new license applicants and re-licensees), a long-term longitudinal follow-up, and an evaluation on a wide range of predictive criteria (possible including on-site, in-depth accident investigations).

The possibility exists that variables may be useful predictors for different time periods. Long-term research designs should allow for evaluation of the possibility that variables initially collected will have a different effect over time. For example, an attitude or personality measure may be less useful for long-term prediction than more stable characteristics, such as perceptual style or chronic illness. Long-term assessment evaluations should be designed to examine the "effective life-span" of all predictor variables.

Of particular importance to the administrator would be the prediction of some sort of severity scale. Data for creating such a scale can be found in accident records in most states. Prediction of a severity scale would give the administrator a rough idea of the amount of damage or "societal cost" which will be produced by different accident liability classes, rather than simply the probability of their having an accident. This will allow better estimates of countermeasure cost-effectiveness.

The ultimate value in assessment, of course, lies in the referral of the driver to the program best suited to modify his particular problem, or alternatively, in the imposition of administrative sanctions which limit his risk exposure. Therefore, diagnostic assessment of driver problems must become an integral part of the treatment process.

Long-term evaluation should be concerned with the evaluations of assessment methods and treatment programs (neither of which can currently be considered adequately refined). Subsequent efforts could then include the evaluation of combined assessment and treatment, commonly referred to as "tailored treatment programs."

The lack of continuity in research applications was a primary reason for the relatively few refined instruments found in the literature. Although basic research should parallel an evaluation of an operational assessment approach, very rigid criteria should be imposed on operational evaluations to ensure continuity.

Assessment must be optimized through an iterative process, i.e., the technique development-refinement cycle. Optimization is a process of tracing the interactions of techniques (concepts) with driving problems, and determining their relevance to particular accident liability groups. Improvement in criterion description (e.g., causal factors, accident types) for research and operational programs should result in improved prediction of driver problems. Technique development can then move toward more refined procedures for evaluating performance in a testing environment.

REFERENCES

Introduction

Adams, J.R. "Personality Variables Associated with Traffic Accidents," Chapter 1, Behavioral Research in Highway Safety. Reprint with no ed. identified, no pub. identified. Vol. 1, No. 1, January 1970.

California Department of Motor Vehicles (1964-1967). The 1964 California Driver Record Study, Parts 1-9. Report 20. Sacramento, California.

Haight, F. "Recent Publications", Accident Analysis and Prevention. Vol. 4, 1972, pp. 353-355.

Lucas, R.L. "Attitudes, Personal Characteristics, and Driver Behavior", Chapter Six, Injury Control in Traffic Safety, N.C. Heimstra, ed. Springfield, Illinois: Charles C. Thomas, Publisher, 1970.

McGuire, F.L., "The Understanding and Prediction of Accident-Producing Behavior," Highway Safety: Anatomy of a Problem, North Carolina Symposium on Highway Safety, Vol. I, Chapel Hill, Fall, 1969, pp. 101-124.

National Safety Council, Accident Facts 1974 Edition, Chicago, Illionis, 1974.

Shaw, L. and Sichel, H.S. Accident Proneness: Research in the Occurrence, Causation, and Prevention of Road Accidents. Pergamon Press, 1971.

Tillman, W.A. and Hobbs, G.E. "Accident-Prone Automobile Driver: A Study of Psychiatric and Social Background." American Journal of Psychiatry, 1949, pp. 321-331.

AAMVA Bulletin, "New Approach to Driver Testing Introduced by Iowa Department", January 1971.

Asher, W., and Dodson, B. Social, Psychological, and Educational Characteristics of Adolescents and Young Adults Killed in Indiana Automobile Accidents, Purdue University, October, 1970.

Bailey, N.D., and Hall, J.E., Analysis of Motor Vehicle Accidents Involving Air Force Personnel, Caywood Schiller Associates, July, 1969.

Baker, S. P. Characteristics of Fatally Injured Drivers, The Johns Hopkins University, School of Hygiene and Public Health, February, 1970.

Baker, S. P., and Spitz, W. U. "Age Effects and Autopsy Evidence of Disease in Fatally Injured Drivers", Journal of American Medical Association, Vol. 214, No. 6, pp. 1079-1088, November, 1970.

Bishop, R. W. Comparing the Effectiveness of Various Combinations of On-Street and Multiple-Car Driving Range Instructional Hours. Tallahassee: Florida State University, 1965.

Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., and Zylman, R. The Role of the Drinking Driver in Traffic Accidents. Indiana University, Department of Police Administration, February, 1964.

Brazell, R.E. A Follow-Up Study of Public School Driver Trainees Relating Driving Performance Records to Selected Academic and Training Factors. Unpublished doctoral dissertation, University of Michigan, 1961.

Buikhuisen, W., and Steenhuis, D.W. The Effectiveness of Penal Sanctions as an Instrument to Combat Recidivism Among Subjects Convicted for Drunken Driving, Criminological Institute - Groningen University, The Netherlands, 1972.

Burg, A. An Investigation of Some Relationships Between Dynamic Visual Acuity, Static Visual Acuity, and Driving Record, Report No. 64-18, Los Angeles: University of California, Department of Engineering, April, 1964.

Burg, A. The Relationship Between Vision Test Scores and Driving Record: General Findings. Final Report No. 67-24. Los Angeles California: Department of Engineering, Reports Group, University of California, June 1967.

Burg, A. "The Stability of Driving Record Over Time," Accident Analysis and Prevention, Vol. 2, 1970, pp. 57-65.

Cahalan, D. Problem Drinkers: A National Survey, Jossey-Bass, San Francisco, California, 1970.

California Department of Motor Vehicles (1964-1967). The 1964 California Driver Record Study, Parts 1-9, Report 20, Sacramento, California.

California Highway Patrol (1967). 1967 California Annual Traffic Accident Summary, Sacramento, California, 2 pp.

Campbell, B. J. "A Comparison of the Driving Records of 1,100 Operators Selected at Random." Traffic Safety Research Review, September, 1958.

Carlson, W. L., Identifying the Problem Driver from State Driver Records, Highway Safety Research Institute, May 1968.

Carlson, W. L. and Klein, D. "Familial vs. Institutional Socialization of the Young Traffic Offender", Journal of Safety Research, Vol. 2, No. 1, March, 1970.

Carroll, P. S., The Meaning of Driving Exposure, University of Michigan, HIT Lab Reports, April, 1971.

Cerrelli, E. C. Driver Exposure - Indirect Approach for Obtaining Relative Measures, DOT Document HS-820 179, Washington, D.C., 1972.

Clark, C. D., A Comparison of the Driving Records and Other Characteristics of Three Alcohol-Involved Populations and A Random Sample of Drivers, HIT Lab Reports, Vol. 2, No. 10, pp. 1-5, June, 1972.

Committee on Public Works, Department of Transportation, 1968 Alcohol and Highway Safety Report: A Study Transmitted by the Secretary of the Department of Transportation to the Congress, in Accordance with the Requirements of Section 204 of the Highway Safety Act of 1966, Public Law 89-564, U.S. Government Printing Office, Washington, D.C., August 1968.

Coppin, R. S. and Peck, R. C. The Totally Deaf Driver in California, Part II, Report No. 16, Sacramento, California Department of Motor Vehicles, 1964.

Crancer, A. and McMurray, L. Accident and Violation Rates of Washington Drivers with Medical Licensing and Driving Restrictions, Washington State Department of Motor Vehicles Administrative Services, Report No. 007, Olympia, Washington, December 1967.

Crancer, A. and O'Neall, A. A Record Analysis of Washington Drivers with License Restrictions for Heart Disease, Washington State Department of Motor Vehicles, Research and Technology, Report No. 025, Olympia, Washington, December, 1969.

Crancer, A. and Quiring, D. L. Driving Records of Persons Hospitalized for Suicide Gestures, Washington Department of Motor Vehicles, Division of Research, Olympia, Report 014, July 1968a.

Crancer, A. and Quiring, D. L. Driving Records of Persons With Selected Chronic Diseases, Washington State Department of Motor Vehicles, Administrative Services, Report No. 015, July 1968b.

Davis, T. G., Wehling, E. H., and Carpenter, R. L. "Oklahoma's Medically Restricted Drivers: A Study of Selected Medical Conditions", Journal of the Oklahoma State Medical Association, Vol. 66, pp. 322-327, July, 1973.

Didenko, O., McEachern, Berger, and Pollack. Drinking Driver and Traffic Safety Project: Final Report Vol. 1. Los Angeles, California: University of Southern California, 1972.

Dreyer, D. R. Physically Handicapped Drivers: A Comparative Study of Driver Records, Research and Statistics Section, State of California Department of Motor Vehicles, May 1973.

Epstein, J. D., and O'Day, J. Crashes Between Large and Small Cars: The Real World Perspective, Part I. Different Cars, Different Worlds, University of Michigan HIT Lab Reports, 1972.

Erickson, H. M. and Waller, J. A. "Medical Deficiencies, Detection Reporting". Proceedings, National Conference on Medical Aspects of Driver Safety and Driver Licensing, 1964.

Ferreira, J. Quantitative Models for Automobile Accidents and Insurance. United States Department of Transportation, September, 1970.

Filkins, Compton, Douglass, and Flora. Analysis of High Risk Groups for Alcohol Countermeasures, Highway Safety Research Institute, The University of Michigan, December 1974.

Finch, J. R. and Smith, J. P. Psychiatric and Legal Aspects of Automobile Fatalities, Charles C. Thomas: Springfield, Illinois, 1970.

Finkelstein, R., McGuire, J. P. An Optimum System for Traffic Enforcement/Driver Control, G. E. Sylvania, Inc., October, 1971.

Flanagan, J. C., Davis, F. B., Dailey, J. T., Shaycoft, M. F., Orr, D. B., Goldberg, I., and Neyman, C. A. The American High School Student, Technical Report to the U.S. Office of Education, Cooperative Research Project No. 635, Pittsburgh: Project TALENT Office, University of Pittsburgh, 1964.

Freeberg, N. E. and Creech, F. R. Development of Measures for a Driver Licensing Program in the State of North Carolina, Educational Testing Service, July, 1971.

Freund, R. J., "Some Observations on Regressions with Grouped Data." American Statistician, June 1971, pp. 29-30.

Goodson, J. E. Changing Characteristics of High Accident Driver Over a Five Year Period, No. 29, Engineering Experiment Station, Purdue University, West Lafayette, September 1, 1972.

Goldstein, L. G. "Human Variables in Traffic Accidents: A Digest of Research", Traffic Safety, March 1964, pp. 26-31.

Goldstein, L. G., Driver Improvement: A Review of Research Literature. California Traffic Safety Education Task Force, Department of Education, 1974.

Harano, R. M. Psychometric Prediction of Negligent Driver Recidivism. Sacramento, California: California Department of Motor Vehicles, July 1974.

Harano, R. M., McBride, R. S., and Peck, R. C. The Prediction of Accident Liability Through Biographical Data and Psychometric Tests, California Department of Motor Vehicles, Research and Statistics Section, Research Report 44, 1973.

Harano, R. M. and Peck, R. C. The California Motorcycle Study -- Driver and Accident Characteristics, California Department of Motor Vehicles, July, 1968.

Harano, R. M. and Peck, R. C. The Effectiveness of a Uniform Traffic School Curriculum for Negligent Drivers, Highway Research Final Report, California Department of Motor Vehicles, June 1971.

Harrington, D. M. "Factor Analysis of Driver Record", Research Review, September, 1968, pp. 81-87.

Harrington, D. M. The Young Driver Follow-Up Study, California Departement of Motor Vehicles, 1971.

Harrington, D. M. An Evaluation of the Driving Test as an Examination Requirement for Drivers Previously Licensed in Another State, California Department of Motor Vehicles, Research and Statistics Section, Research Report 44, 1973.

Harrington, D. M. and McBride, R. S. "Traffic Violations by Type, Age, Sex, and Marital Status", Accident Analysis and Prevention, Vol. 2, pp. 67-79, 1970.

Henderson, R. L. and Burg, A. "Visual Tests for Driver Licensing", unpublished paper, 1972.

Henderson, R. L. and Burg, A. The Role of Vision and Audition in Truck and Bus Driving, TM(L)-5260/000/00, Santa Monica: System Development Corporation, December, 1973.

Henderson, R. L. and Burg, A. Vision and Audition in Driving, Final Report, Santa Monica: System Development Corporation, (DOT-HS-009-1-009), April, 1974.

Hoffman, H. "The Risks for Healthy and Somatically Disabled Persons to Take Part in Road Traffic and Vice Versa, the Risks to the Traffic by the Participation of Diseased Persons. Prophylactic Measures." Proceedings of the Second Congress of the International Association for Accident and Traffic Medicine, August 1966, Stockholm, Sweden, Malmo: Shanetryck AB., 1966, pp. 125-138.

Homburger, W. S., On the Analysis of Accident Trends, Institute of Transportation and Traffic Engineering, University of California, Berkeley, California, December, 1968.

Human Factors Laboratory, Department of Psychology, University of South Dakota, Alcohol Safety Action Projects Interim Analyses of Drinker Diagnosis, Referral and Rehabilitation Countermeasures: Analytic Study Numbers 5 and 6, Contract No. DOT-HS-191-3-759, 1974.

Ingersoll, R. L., Trow, J. E., and Clarke, D. W. The High Risk Driver: A Descriptive Study, Program on Alcohol and Drug Abuse, New Hampshire Division of Public Health, Concord, September, 1970.

Institute for Research in Public Safety. Tri-Level Study of the Causes of Traffic Accidents: Interim Report I, 2 Vols., Bloomington, Ind. August, 1973.

Jackson, N. "R.D.L.", American Association of Motor Vehicle Administrators Newsletter. Vol. VIII, No. 5, September-October 1971, pp. 1-3.

Jordan, A., and Wilson, J. E. "Traffic Records - A Conceptual View", Traffic Engineering, July, 1971.

Klein, D. "A Reappraisal of the Violation and Accident Data on Teen-Aged Drivers", Traffic Quarterly, October, 1966.

Klein, D. and Waller, J. Causation, Culpability, and Deterrence in Highway Crashes, U.S. Government Printing Office, 1970.

Kraus, A. A., Steele, R., Ghent, W. R., and Thompson, M. G., "Pre-Driving Identification of Young Drivers with a High Risk of Accidents", Journal of Safety Research, Vol. 2, No. 2, June 1970.

Lauer, A. R., "Methods of Measuring the Ability to Drive an Automobile", Bulletin 115, Engineering Extension Service, Iowa State College, Ames, Iowa, June 1936.

Levonian, E. Prediction of Negligent Operators, Institute of Transportation and Traffic Engineering, University of California, Los Angeles, December 1963.

Levonian E. "Prediction of Accidents and Convictions," Traffic Safety Research Review, Vol. II, No.3, September 1967.

Levonian, E., Case, H. W. Behavioral and Demographic Correlates of Responses to a Driving Questionnaire, Highway Research Board Proceedings, Vol. 40, 1961.

Little, A. D., The State of the Art of Traffic Safety: A Critical Review and Analysis of Technical Information on Factors Affecting Traffic Safety, Cambridge, Mass., Arthur D. Little, Inc., 624 pp. June 1966.

MacDonald, J.M. "Suicide and Homicide by Automobile", American Journal of Psychiatry, Vol. 121, No. 4, October 1964, pp. 366-370.

Malfetti, J. L. "The Impaired Driver", New York State Journal of Medicine, Vol. 63, No. 7, June 1963, pp. 1778-1785.

Mann, W. A., Driver Education and the Teen-age Driver, Michigan State University Highway Traffic Center, East Lansing, MI, October 1958.

Marsh, W. C., and Hubert, D. M. The Prediction of Driving Record Following Driver Improvement Contacts. Sacramento, Calif: Department of Motor Vehicles Research and Statistics Section, January 1974.

McFarland, R. A. "The Older Driver and Accidents", Police, July-August 1966.

McFarland, R. A., Domey, R. G., Duggar, B. C., Crowley, T. J. and Stoudt, H. W. An Evaluation of the Ability of Amputees to Operate Highway Transport Equipment, Harvard School of Public Health, Boston, Mass., December 1968.

McGuire, F. L. Analysis of Data on Air Force Personnel Collected at Lackland Air Force Base, San Diego Computing Center, October 1969.

McGuire, F. L. "Smoking, Driver Education, and Other Correlations of Accidents Among Young Males", Journal of Safety Research, Vol. 4, No. 1:5-11, March 1972.

McGuire, F. L. and Kersh, R. C. An Evaluation of Driver Education, Berkeley: University of California Press, 1969.

McKnight, A. J. and Adams, B. B. Driver Education Task Analysis, Volume I, Task Descriptions, Human Resources Research Organization, Alexandria, Virginia, 1970.

McRae, D. J. "The Relation of Licensing Test Scores to Subsequent Driver Performance", No. 67, University of North Carolina, August 1968.

National Safety Council, Accident Facts, Chicago, Illinois, 1969 Edition.

National Safety Council, Accident Facts, Chicago, Illinois, 1974 Edition.

Neyhart, A. E. Road Test Check List for Passenger Car Drivers, American Automobile Association, Washington, D.C. 1955.

Ohio Department of Education, The Development and Validation of Attitude, Knowledge, and Performance Test for Evaluating Driver Education Curricula, National Highway Traffic Safety Administration, 1974.

O'Neall, P. A. "Relationship of Accident Involvement and Number of Citations: 1966 Data", Report 006, Department of Motor Vehicles, Olympia, Washington, November, 1967.

Peck, R.C. and Harano, R.M. State Driver Improvement Analysis Driver Improvement Literature Review. Sunnyvale, California: Public Systems Incorporated, February, 1975.

Peck, R. C., McBride, R. S., and Coppin, R. S. "The Distribution and Prediction of Driver Accident Frequencies", Accident Analysis and Prevention, Vol. 2, 1971, pp. 243-299.

Pelz, D. C., and Schuman, S. H. "Are Young Drivers Really More Dangerous After Controlling for Exposure and Experience?", Journal of Safety Research, Vol. 3, No. 2, June, 1971a.

Pelz, D. C. and Schuman, S. H. Motivational Factors in Crashes and Violations of Young Drivers, University of Michigan, October, 1971b.

Perchonok, K. Accident Cause Analysis, Cornell Aeronautical Laboratory, Inc., July, 1972.

Perrine, M. V. The Vermont Driver Profile: A Psychometric Approach to Early Identification of Potential High-Risk Drinking Drivers, University of Vermont: Burlington, Vermont, September 1974.

Perrine, M. W., Waller, J. A., and Harris, L. S. "Alcohol and Highway Safety: Behavioral and Medical Aspects", Project ABETS, Department of Psychology, University of Vermont, September 1971.

Quenault, S. W., Golby, C. W., and Pryer, C. M. Age Group and Accident Rate - Driving Behavior and Attitudes, Road Research Laboratory, Crowthorne, England, 1968, R.R.L. Report No. LR 167, 1968. (Distributed in the U.S. by NTIS as PB 180 112)

Reese, J. H. "Power, Policy, People", Highway Research Board Special Report 123, 1971.

Riley, M. C. and McBride, R. S. Safe Performance Curriculum for Secondary School Driver Education: Program Development, Implementations, and Technical Findings, Human Resources Research Organization, Alexandria, Virginia, September, 1974.

Schuman, S. H., Pelz, D. C., Ehrlich, N. J., and Selzer, M. L. "Young Male Drivers Impulse Expression, Accidents, and Violations", Journal of the American Medical Association, Vol. 200, July 1967, pp. 1026-1030.

Schuster, D. H. "Prediction of Current Accident Record for Youthful Drivers," Traffic Safety Research Review, Vol. 10, No. 1, March, 1966.

Schuster, D. H. "Prediction of Follow-Up Driving Accidents and Violations", Traffic Safety Research Review, March, 1968.

Schuster, D. H. A Two Year Follow-Up of Official Action Taken Against Problem Drivers, Presented at the American Psychological Association Convention, Washington, D. C. , September 1971.

Selzer, M. L. "Alcoholism, Mental Illness, and Stress in Drivers Causing Fatal Accidents", Behavioral Science, Vol. 14, 1969, pp. 1-10.

Selzer, M. L. and Payne, C. E. "Automobile Accidents, Suicide, and Unconscious Motivation", American Journal of Psychiatry, Vol. 119, 1962, pp. 237-240.

Selzer, M. L. and Vinokur, A. "Detecting the High Risk Driver: The Development of a Risk Questionnaire", Highway Safety Research Institute, January 1974.

Shupe, L. and Pfau, R. "Who are These Drinking Drivers"? Alcohol and Traffic Safety Proceedings, International Conference on Alcohol and Traffic Safety, Department of Police Administration, Indiana University, Bloomington, 1966, pp. 62-81.

Smith, W. and Associates. Motor Vehicle Accident Costs, New Haven, 1966.

State of Washington, Project METER - An Evaluation, State of Washington Department of Motor Vehicles, January 1971.

Tillman, W. A., and Hobbs, G. E. "Accident-Prone Automobile Driver: A Study of Psychiatric and Social Background", American Journal of Psychiatry, 1949, pp. 321-331.

Traffic Laws Commentary, "Requiring Physicians to Report", National Highway Traffic Safety Administration, Department of Transporation: Washington, D.C., Vol. 1, No. 2, April 1972a.

Traffic Laws Commentary, "Medical Advisory Boards", Washington, D.C.: Department of Transportation, National Highway Traffic Safety Administration, Vol. 1, No. 1, March 1972b.

Wallace, J. E. Problem Drivers: An Evaluation of Four Treatment Programs and the Use of Questionnaire Material for Predicting Success, Research and Technology, Office of the Director, Report 026, December 1969.

Wallace, J. E. and Crancer, A. Licensing Examinations and Their Relation to Subsequent Driving Records, State of Washington, Department of Motor Vehicles, January 1969.

Waller, J. A. "Chronic Medical Conditions and Traffic Safety: A Review of the California Experience", New England Journal of Medicine, Vol. 273, No. 26, December 1965, pp. 1413-1420.

Waller, J. A. Medical Impairment to Driving. Springfield, Illinois: Charles C. Thomas, 1973.

Waller, J. A. and Goo, J. T. "Accident and Violation Experience and Driving Test Score", Highway Research Record, No. 225, 1968.

Waller, J. A. and Goo, J. T. "Highway Crash and Citation Patterns and Medical Conditions", Journal of Safety Research, Vol. 1, No. 1, March, 1969, pp. 13-27.

West, I., Nielson, G. L., Gilmore, A. E., and Ryan, J. R. "Natural Death at the Wheel", Journal of the American Medical Association, Vol. 205, No. 5, July, 1968, pp. 266-271.

Whittenburg, J. A., Pain, R. F., McBride, R. S., and Amidei, J. Driver Improvement Training and Evaluation: Initial Development, Final Report for Contract FH-11-7618, The American University, Washington, D.C., 1972.

Whittenburg, J. A., McBride, R. S., Pain, R. F. and Baker, G. L. Driver Improvement Training and Evaluation: Final Report. The American University Development Education and Training Research Institute, Washington, D.C., July, 1973.

Wiener, E. L. Elderly Pedestrians and Drivers: The Problem That Refuses to Go Away, Department of Management Science, University of Miami, Coral Gables, Florida, 1972.

Williams, G. M. Subsidized Highway Mayhem: Empirical Definition of Injury Accident Experience and Suggested Policy Research for Traffic Safety and Transportation Planning, Doctoral dissertation, the University of Michigan, 1974.

Zylman, R. "Driver's Records: Are they a Valid Measure of Driving Behavior?" Accident Analysis and Prevention, Vol. 4, 1972, pp. 333-349.

Zylman, R. "Semantics Gymnastics in Alcohol-Highway Crash Research and Public Information Programs", Proceedings of the 16th Conference of the American Association for Automotive Medicine, American Association of Automotive Medicine, Society of Automotive Engineers, Inc., New York, 1973, pp. 250-268.

Chapter 2

Barry, H., III. "Motivational and Cognitive Effects of Alcohol," Alcohol, Drugs, and Driving, Perrine, M.W. (ed.), Psychological Research Foundation of Vermont, Inc., Burlington, Vt., pp. 71-95, March 1974. (Proceedings of an invitational symposium held in Warren, Vt., October 13-15, 1972).

Blotzer, P., Krumm, R. L., Krus, D. M., Stark, D. E., Accident Causation, Pennsylvania Turnpike Joint Safety Research Group, September, 1954.

Borkenstein, R. F., Crowther, R. F., Shumate, R. P., Ziel, W. B., and Zylman, R. The Role of the Drinking Driver in Traffic Accidents, Department of Police Administration, Indiana University, Bloomington, March, 1964.

Carlson, W. L. and Klein, D. "Familial vs. Institutional Socialization of the Young Traffic Offender", Journal of Safety Research, Vol. 2, No. 1, March, 1970.

Cerrelli, E. C. Driver Exposure - Indirect Approach for Obtaining Relative Measures, DOT Document HS-820 179, Washington, D.C., 1972.

Clay, M. L. Chronic Alcoholics and Highway Safety -- Findings and Their Implications. A report to the Michigan Office of Highway Safety Planning, Ann Arbor, Michigan: Mental Health Research Institute, University of Michigan, December 31, 1970.

Clay, M. L. Final Report on an Evaluative Study of the Macomb County Alcohol-Highway Safety Program to June 30, 1972. Ann Arbor, Michigan: Mental Health Research Institute, University of Michigan.

Committee on Public Works, Department of Transportation, 1968 Alcohol and Highway Safety Report: A Study Transmitted by the Secretary of the Department of Transportation to the Congress, in Accordance with the Requirements of Section 204 of the Highway Safety Act of 1966, Public Law 89-564, U.S. Government Printing Office, Washington, D.C., August 1968.

Cornell Aeronautical Laboratory, Inc. "Preliminary Tabulation on Traveling Speed and Injury Producing Rural Automobile Accidents ACIR Data", July, 1968.

Crancer, A. and McMurray, L. Credit Ratings as a Predictor of Driving Behavior and Improvement, State of Washington, Department of Motor Vehicles, May 1968a.

Crancer, A., and Quiring, D. L. The Chronic Alcoholic as a Motor Vehicle Operator, State of Washington: Division of Research, Department of Motor Vehicles, May 1968b.

Crancer, A. J. and Quiring, D. L. Driving Records of Persons Arrested for Illegal Drug Use. Washington State Department of Motor Vehicles, Administrative Services, Report No. 011, Olympia, Washington, 1968c.

Filkins, L. D., Mortimer, R. G., Post, D. V., and Chapman, M. M. Field Evaluation of Court Procedures for Identifying Problem Drinkers, Highway Safety Research Institute, Ann Arbor, Michigan, December 1973.

Harano, R. M. Psychometric Prediction of Negligent Driver Recidivism. Sacramento, Ca: California Department of Motor Vehicles, July 1974.

Harano, R. M., McBride, R. S., and Peck, R. C. The Prediction of Accident Liability Through Biographical Data and Psychometric Tests, California Department of Motor Vehicles, Research and Statistics, Section, Research Report 44, 1973.

Harrington, D. M. The Young Driver Follow-Up Study, California Department of Motor Vehicles, 1971.

Holcomb, R. L. "Alcohol in Relation to Traffic Accidents", Journal of the American Medical Association, Vol. 111, September 1938, pp. 1076-1085.

Huntley, M. S., "Alcohol Influences Upon Closed-Course Driving Performance", Alcohol, Drugs, and Driving, Perrine, M.W. (ed.), Psychological Research Foundation of Vermont, Inc., Burlington, Vt., March 1974, pp. 107-127, (Proceedings of an invitational symposium held in Warren, Vt., October 13-15, 1972).

Hurst, P. M. "Epidemiological Aspects of Alcohol in Driver Crashes and Citations", Alcohol, Drugs, and Driving, Perrine, M.W. (ed). Psychological Research Foundation of Vermont, Inc., Burlington, Vt., March 1974, pp. 131-173. (Proceedings of an invitational symposium held in Warren, Vt., October 13-15, 1972.)

Institute for Research in Public Safety. Tri-Level Study of the Causes of Traffic Accidents: Interim Report I, 2 Vols., Bloomington, Indiana, August, 1973.

Jones, T. O., and Tennant, J. A. "A Critical Evaluation of the Phystester: A Test for Driver Impairment", Proceedings of 16th Conference of the American Association for Automotive Medicine, American Association of Automotive Medicine, Society of Automotive Engineers, Inc., New York, 1974, pp. 274-306.

Klein, A. W., Davis, J. H., and Blackbourne, B. D. "Marihuana and Automobile Crashes", Journal of Drug Issues, Vol. 1, No. 1, January 1971, pp. 18-26.

Kraus, A. S., Steele, R., Ghent, W. R., and Thompson, M. G. "Pre-Driving Identification of Young Drivers with a High Risk of Accidents", Journal of Safety Research, Vol. 2, No. 2, June, 1970.

Little, A. D. The State of the Art of Traffic Safety: A Critical Review and Analysis of Technical Information on Factors Affecting Traffic Safety, Cambridge, Mass., Arthur D. Little, Inc., June, 1966.

Little, J. W., Young, G., and Selk, S., Constitutional Protections of Convicted DWI Offenders Selected to Receive Special Sanctions - Alcohol Countermeasures, Literature Review, U.S. Department of Transportation, June 1973 - June 1974.

Loomis, T. A. and West, T. C. "The Influence of Alcohol on Automobile Driving Ability," Quarterly Journal of Studies on Alcohol, Vol. 19, March 1958, pp. 30-46.

Lucas, G. H., Kalow, W., McColl, J.D., Griffith, B. A. and Smith, H. "Quantitative Studies of the Relationship Between Alcohol Levels and Motor Vehicles Accidents," Proceedings of the Second International Conference on Alcohol and Road Traffice, 1953, Garden City Press Co-operative, Toronto, Canada, 1955, pp. 139-142.

Mason, M. F., and Dubowski, K. M. "Alcohol, Traffic, and Chemical Testing in the United States: A Resume and Some Remaining Problems", Clinical Chemistry, Vol. 20, No. 2, 1974.

McCarroll, J. R., and Haddon, W. "A Controlled Study of Fatal Automobile Accidents in New York City", Journal of Chronic Diseases, Vol. 15, 1962, pp. 811-826.

Moser, B. A., Bressler, L. D., and Williams, R. B. Collection, Analysis and Interpretation of Data on Relationship Between Drugs and Driving. U.S. Department of Transportation, Washington, D.C., 1972.

Moskowitz, H. "Alcohol Influences Upon Sensory Motor Function, Visual Perception, and Attention", Alcohol, Drugs, and Driving, Perrine, M. W. (ed.), Psychological Research Foundation of Vermont, Inc., Burlington, Vt., March 1974, pp. 49-69. (Proceedings of an invitational Symposium held in Warren, Vt., October 13-15, 1972).

Nichols, J. L. Drug Use and Highway Safety: A Review of the Literature, Final Report. Stevens Point, Wisconsin: Wisconsin State University, (DOT-HS-012-1-019), July, 1971.

Nielson, R. A., Alcohol Involvement in Fatal Motor Vehicle Accidents, California Traffic Safety Foundation, San Francisco, September, 1965.

Nielson, R. A. A Survey of Post-Mortem Blood Alcohols from 41 California Counties in 1966, California Traffic Safety Foundation, San Francisco, April 1967.

O'Day, J. Drinking Involvement and Age of Young Drivers in Fatal Accidents, HIT Lab Reports. Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, October 1970.

Perrine, M. W. (Ed.). Alcohol, Drugs, and Driving, Psychological Research Foundation of Vermont, Inc., Burlington, Vt., March 1974, 404 pp. (Proceedings of an invitational symposium held in Warren, Vt., October 13-15, 1972).

Perrine, M.W., Waller, J.A., and Harris, L.S. Alcohol and Highway Safety: Behavioral and Medical Aspects, (Final Report on Contracts No. FH-11-6609 and FH-11-6809), U.S. Department of Transportation, 1971.

Research Triangle Institute, Speed and Accidents, Volumes I and II, June 26, 1970.

Schmidt, W., Smart, R.G., and Popham, R.E., "The Role of Alcoholism in Motor Vehicle Accidents" Traffic Safety Research Review, Vol. 6, December 1962, pp. 21-27.

Smart, R.G., "Use of Psychoactive and Hallucinogenic Drugs in Relation to Driving Risk", in M. W. Perrine (ed.), Alcohol, Drugs, and Driving, (DOT-HS-265-2-489), March 1974, pp. 173-197.

Solomon, D. Accidents on Main Rural Highways Related to Speed, Driver and Vehicle, July 1964.

State of California, "Report of Fatal and Injury Motor Vehicle Traffic Accidents for 1966".

Stroh, C. M. Alcohol and Highway Safety Roadside Surveys of Drinking-Driving Behavior: A Review of the Literature and a Recommended Methodology, Road and Motor Vehicle Traffic Safety Ministry of Transport, Canada, 1972.

Turn, R. Privacy and Security in Personal Information Databank Systems, Santa Monica, California: The Rand Corporation, March, 1974.

U.S. Department of Transportation/Federal Highway Administration, Maximum Safe Speed for Motor Vehicles, January 31, 1969.

U.S. Department of Transportation, National Highway Traffic Safety Administration, Design Manual for State Traffic Records Systems, Standard Data Elements and Coding, Accident Data Subsystem, Volume II, Section 4, July 1973.

Wallace, J. E. Problem Drivers: An Evaluation of Four Treatment Programs and the Use of Questionnaire Material for Predicting Success, Research and Technology, Office of the Director, Report 025, December 1969.

Waller, J. A. "Chronic Medical Conditions and Traffic Safety: Review of the California Experience", New England Journal of Medicine, Vol. 273, No. 26, December 1965, pp. 1413-1420.

Waller, J. A. "Identification of Problem Drinking Among Drunken Drivers," Journal of the American Medical Association, Vol. 200, No. 2, April 10, 1967, pp. 124-130.

Waller, J. A. Medical Impairment to Driving. Springfield, Illinois: Charles C. Thomas, 1973.

Waller, P. Young Driver' Passengers -- A Factor in Safe Driving, According to Study, 1971.

Wiener, E. L. Elderly Pedestrians and Drivers: The Problem that Refuses to Go Away, Department of Management Science, University of Miami, Coral Gables, Florida, 1972.

Zylman, R. "Semantic Gymnastics in Alcohol-Highway Crash Research and Public Information Programs", Proceedings of the 16th Conference of the American Association for Automotive Medicine, American Association of Automotive Medicine, Society of Automotive Engineers, Inc., New York, 1973, pp. 250-268.

Aaron, J.E. Annotated Bibliography, Highway Systems Research Car Studies and Related Literature. Southern Illinois University: Carbondale, 1972.

Adams, J.R. Measurement of a Hazard Judgement by a Stimulus Accretion Technique. Columbia University, Safety Research and Education Project, Teachers College: New York, 1968.

Adams, J.R. "Personality Variables Associated with Traffic Accidents," Chapter 1, Behavioral Research in Highway Safety. Reprint with no ed. identified, no pub. identified. Vol. 1, No. 1, January 1970.

Adams, J.R. Behind-the-Wheel Self Analysis in Driver Rehabilitation. Continental Research Institute: New York, 1971.

Adams, J.R. and Cuneo, J.A. Diagnosis of Attention Mechanisms in Drivers with Rutten's ADM Device. Continental Research Institute: New York, 1969.

Adams, J.R. and Williams, E.B. "The Association Between Smoking and Accidents: Overdependency as an Influencing Variable," Traffic Quarterly, October 1966, pp. 583-588.

Allen, J.A., Jr., Schroeder, S.R. and Ball, P.G. "Effects of Head Restriction on Drivers' Eye Movements and Errors in Simulated Dangerous Situations," Journal of Applied Psychology, 59:5, 1974.

Allen, T.M., Lunenfeld, H. and Alexander, G.J. "Driver Information Needs," Highway Research Record, No. 366, 1971.

Anderson, A.L., Nilsson, A. and Henriksson, N.G. "Personality Differences Between Accident-Loaded and Accident-Free Young Car Drivers," British J. Psychol., 61:3, 1970, pp. 409-421.

Asher, W. and Dodson, B. Social, Psychological, and Educational Characteristics of Adolescents and Young Adults Killed in Indiana Automobile Accidents. Purdue University: Lafayette, Indiana, October 28, 1970.

Babarik, P. Automobile Accidents and Driver Reaction Pattern. American Institutes for Research in the Behavioral Sciences: Silver Spring, Maryland, 1966.

Baker, S.P. Characteristics of Fatally Injured Drivers. The Johns Hopkins University, School of Hygiene and Public Health, February 1970.

Barley, M.D., Haberman, P.W. and Aekshe, H. "The Epidemiology of Alcoholism in an Urban Residential Area." Quart. J. Stud. Alcohol, 26, 1965, pp. 19-40.

Barrett, G.V., Alexander, R.A. and Forbes, B.J. Analysis of Performance Measurement and Training Requirements for Driving Decision Making in Emergency Situations. University of Rochester, Management Research Center: Rochester, New York, Technical Report #55, June 1973.

Barrett, G.V. and Thornton, C.L. "Relationship Between Perceptual Style and Driver Reaction to an Emergency Situation," Journal of Applied Psychology, 52:2, 1968, pp. 169-176.

Barrett, G.V. and Thornton, C.L. "Perceptual Style and Speed Judgments." Perceptual and Motor Skills, 29:1, August 1969a, pp. 75-78.

Barrett, G.V., Thornton, C.L. and Cabe, P.A. "Relation Between Embedded Figures Test Performance and Simulator Behavior." Journal of Applied Psychology, 53:3, June 1969b, pp. 253-254.

Beamish, J.J. and Malfetti, J.L. "A Psychological Comparison of Violator and Non-Violator Automobile Drivers in the 16 to 19 Year Age Group." Traffic Safety, March 1962, pp. 12-15.

Berkhout, J., O'Donnell, R.D., Hahn, P.M. and Bieber, R. Recording and Analysis of Physiological Responses and Vehicle Data During High Speed Driving. Proceedings of the Sixteenth Conference of the American Association for Automotive Medicine, Lake Bluff, Illinois, 1972.

Bhise, V.D. and Rockwell, T.H. Role of Peripheral Vision and Time Sharing in Driving. Proceedings of Fifteenth Conference of the American Association for Automotive Medicine, Colorado, 1971.

Bloomer, R.H. "Perceptual Defense and Vigilance and Driving Safety." Traffic Quarterly, 1962.

Boersma, F.J., Muir, W., Wilson, K. and Barnham, R. "Eye Movements During Embedded Figure Tasks." Perceptual Motor Skills, 28, 1969.

Bracy, L.F. An Exploration of the Relationship Between Personality and Automobile Accident Proneness. University of Mississippi: Biloxi, 1970.

Broadbent, D.E. Perception and Communication. Pergamon Press: Oxford, 1958.

Brown, I.D. "Car Driving and Fatigue." Triangle: The Sandoz Journal of Medical Science, 8:131, 1967, pp. 131-137.

Brown, I.D. "Decrement in Skill Observed After Seven Hours of Car Driving." Psychonomic Science, Vol. 7, 1967b, pp. 131-132.

Brown, I.D. "Some Alternative Methods of Predicting Performance Among Professional Drivers in Training." Ergonomics, 11:1, 1968, pp. 13-21.

Brown, I.D. Psychophysiological Measures of Drivers Under Actual Driving Conditions. Unpublished Doctoral Dissertation, University of Illinois, 1969.

Brown, I.D., Tickner, A.H. and Simmonds, D.C.V. "Effects of Prolonged Driving Upon Driving Skill and Performance of a Subsidiary Task." Industrial Medicine and Surgery, 35:9, 1966.

Brown, I.D., Tickner, A.H. and Simmonds, D.C.V. "Effect of Prolonged Driving on Overtaking Criteria." Ergonomics, Vol. 13, 1970, pp. 239-242.

Brown, P.L. and Berdie, R.F. "Driver Behavior and Scores on the MMPI." Journal of Applied Psychology, Vol. 44, 1960, pp. 18-21.

Burg, A. The Relationship Between Vision Test Scores and Driving Record: General Findings. Final Report No. 67-24, Department of Engineering, Reports Group, University of California: Los Angeles, June 1967.

Burg, A. The Effects of Exposure to Risk on Driving Record. Institute of Transportation and Traffic Engineering, University of California: Los Angeles, June 1973.

Burg, A. Traffic Violations in Relation to Driver Characteristics and Accident Frequencies. School of Engineering and Applied Science, University of California: Los Angeles, June 1974.

Cahalan, D. Problem Drinkers: A National Survey. Jossey-Bass: San Francisco, 1970.

Case, H.W. and Hulbert, S.F. Judgment of Vehicle Speed and Traffic Patterns. Institute of Transportation and Traffic Engineering, University of California: Los Angeles, Phase I, February 1970; Phase II, May 1970a.

Case, H.W., Hulbert, S.F. and Mellinger, L. Effects of Fatigue on Skills Related to Driving. Institute of Transportation and Traffic Engineering, University of California: Los Angeles, January 1970b.

Case, H.W. and Stewart, R. "Development of a Driving Attitude Scale, Driver Characteristics, and Behavior Studies." Highway Research Board Bulletin No. 172, 1958.

Cohen, J., Dearnaley, E.J. and Hansel, E.M. "Influence of Training on the Performance of Bus Drivers." British Operations Research Quarterly, 7, 1956.

Cohen, J. and Preston, B. Causes and Prevention of Road Accidents. Faber and Faber: London, 1968.

Conger, J.J., Gaskill, H.S., Glad, D.D., Hassel, L., et al. "Psychological and Psychophysiological Factors in Motor Vehicle Accidents." Journal of the American Medical Association, 169:14, 1959, pp. 1581-7.

Currie, L. "The Perception of Danger in a Simulated Driving Task." Ergonomics, 12:6, November 1969, pp. 841-849.

DeRidder, J.C. The Personality of the Urban African in South Africa. Humanities Press: New York and London, 1961.

Dumas, J. "Decision Making in Dynamic Circumstances." International Automotive Engineering Congress, Paper #730022, 1973.

Edwards, D.S. and Hahn, C.P. Filmed Behaviors as a Criterion for Safe Driving, Final Report R70-2. American Institutes for Research in the Behavioral Sciences: Silver Spring, Maryland, 1970.

Edwards, D.S., Hahn, C.P. and Fleishman, E. Evaluation of Laboratory Methods for the Study of Driver Behavior: The Relation Between Simulator and Street Performance. American Institutes for Research in the Behavioral Sciences: Silver Spring, Maryland, May 1969.

Edwards, W. Information Processing, Decision Making, and Highway Safety. In Driver Behavior: Cause and Effect: The Proceedings of the Second Annual Traffic Safety Research Symposium of the Automobile Insurance Industry. James O'Day, (Ed.), Insurance Institute for Highway Safety: Washington, D.C., 1968.

Ellingstad, V.S. and Heimstra, N.W. "Performance Changes During Sustained Operation of a Complex Psychomotor Task." Ergonomics, Vol. 13, 1970.

Elliott, R. and McMichael, R. "Effects of Specific Training on Frame Dependence." Perceptual and Motor Skills, 17, 1963, pp. 363-367.

Ellis, N.C. and McGlamery, D. Psychophysiological Measurements as Related to the Operation of a Motor Vehicle, Report No. 606-3. Texas Transportation Institute: College Station, Texas, 1970.

Epperson, W., Peck, R. and Harano, R. 1972 Resolution, Chapter 152 (SCR-44-Harmer). California Department of Motor Vehicles: Sacramento, May 1975.

Fergenson, P.E. A Study of the Relationship Between Driver Decision Time and Driving Accident and Violation Record, Report SIT-DL-69-1329. Stevens Institute of Technology: Hoboken, NJ, 1968.

Fergenson, P.E. "The Relationship Between Information Processing and Driving Accident and Violation Record." Human Factors, 13:2, 1971, pp. 173-176.

Filkins, L.D., Mortimer, R.G., Post, D.V. and Chapman, M.M. Field Evaluation of Court Procedures for Identifying Problem Drinkers. Highway Safety Research Institute: Ann Arbor, Michigan, December 1973.

Finch, J.R. and Smith, J.P. Psychiatric and Legal Aspects of Automobile Fatalities. Charles C. Thomas: Springfield, Illinois, 1970.

Fine, B.J. "Introversion-Extroversion and Motor Vehicle Driver Behavior." Perceptual and Motor Skills, 12, 1963, pp. 95-100.

Fine, J.L., Malfetti, J.L. and Shoben, E.J. Jr. Manual for the Administration of the Columbia Driver Judgment Test. Teachers College Press, Columbia University: New York, 1965.

Finkelstein, R. and McGuire, J.P. An Optimum System for Traffic Enforcement/Driver Control, Final Report, Vol. I. GTE Sylvania, Inc.: Mountain View, California, October 1971.

Flanagan, J.C., David, F.B., Dailey, J.T., Shaycoft, M.F., Orr, D.D., Goldberg, I. and Neyman, C.A. The American High School Student. Technical Report to the U.S. Office of Education. Project TALENT Office, University of Pittsburgh, 1964.

Forbes, T.W. Human Factors in Highway Traffic Safety Research. Wiley-Interscience, Wiley Series in Human Factors: New York, 1972.

Forbes, T.W., Katz, M.S., Cullen, J.W. and Deterline, W.A. Sleep Deprivation and Effects on Components of Driving Behavior. Paper presented at the Annual Meeting of the American Psychological Association, New York City, September 1957.

Forbes, T.W., Katz, M.S., Cullen, J.W. and Deterline, W.A. "Sleep Deprivation Effects on Components of Driving Behavior." Highway Research Abstracts, 28, 1958, pp. 21-26.

Forbes, T.W., Nolan, R.O., Vanosdall, F.E., et al. Driver Performance Measurement Research: Volume I. Technical Report. Department of Psychology and Highway Traffic Safety Center, Michigan State University: East Lansing, Michigan, Report No. DOT-HS-800 881, February 1973.

Fox, P. and Lehman, F.G. Safety in Car Following--A Computer Simulation. Newark College of Engineering: Newark, NJ, 1967.

The Franklin Institute Research Laboratories. Overtaking and Passing Under Adverse Visibility Conditions, Volumes I and III. Bureau of Public Roads, U.S. Department of Transportation: Washington, D.C., January 1970.

Gallagher, V.P. Applicability of Embedded Figures Test as a Predictor of Desynchronizing Reaction Action. Unpublished masters thesis, Bernard Baruch College of City University: New York, 1969.

Gibbs, C.B. "The Effect of Psychological Stress on Decision Processes in a Tracking Task." Quarterly Bulletin, 4, 1967.

Gibson, H.B. The Spiral Maze: A Psychomotor Test with Implications for the Study of Delinquency. British Journal of Psychology, 55, 1964, pp. 219-225.

Gibson, J.J. and Crooks, L.E. "A Theoretical Field-Analysis of Automobile Driving." Journal of Psychology, 11:3, 1938.

Gibson, R.S. Influence of Physical Threat Stress on Perceptual Psychomotor Performance. In Proceedings of the 79th Annual Convention of the American Psychological Association, 1971.

Goldstein, L.G. Research on Human Variables in Safe Motor Vehicle Operation. The Driver Behavior Research Project, George Washington University: Washington, D.C., 1961.

Goldstein, L.G. "Human Variables in Traffic Accidents: A Digest of Research." Traffic Safety Research Review, 1964.

Greenshields, B.D. "Driving Behavior and Related Problems." Highway Research Record, 25, 1963.

Greenshields, B.D. "Discovery of an Objective Driving Test." Journal of Traffic Safety Education, 22:1, 1974.

Greenshields, B.D. and Platt, E.N. "The Development of a Method of Predicting High Accident and High Violation Drivers." Journal of Applied Psychology, 51:3, 1967.

Gumpper, D.C. and Smith, K.R. "The Prediction of Individual Accident Liability with an Inventory Measuring Risk-Taking Tendency." Research Review, 12:2, 1968.

Gustafson, E.R. A Study to Compare the Effectiveness of Instruction in the Allstate Good Driver Training and on the Multiple-Car Off-Street Driving Range with the Multiple-Car Off-Street Driving Range. Unpublished Doctoral Dissertation, Michigan State University: East Lansing, Michigan, 1965.

Guyer, R.M. Driver Propensities and Driving Record. Unpublished Masters Thesis, Illinois State University: Normal, Illinois, 1970.

Guze, S.B., Tuason, V., Gatfield, P., Stewart, M. and Picken, B. "Psychiatric Illness and Crime with Particular Reference to Alcoholism: Study of 223 Criminals." J. Nerv. Ment. Dis., 134, 1962, pp. 512-521.

Haight, F.A. "A Mathematical Model of Driver Alertness." Ergonomics, 15:4, 1972, pp. 367-378.

Hakkinen, S. Traffic Accidents and Driver Characteristics: A Statistical and Psychological Study, Scientific Researches No. 13. Finland's Institute of Technology: Helsinki, 1958.

Haner, C.F. "Use of Psychological Inventory in Writing for Youthful Male Drivers." Traffic Safety Research, March 1963.

Harano, R.M. "Relationship of Field Dependence and Motor Vehicle Accident Involvement." Perceptual and Motor Skills, 31, 1970.

Harano, R.M. Psychometric Prediction of Negligent Driver Recidivism. California Department of Motor Vehicles: Sacramento, July 1974.

Harano, R.M., McBride, R.S. and Peck, R.C. The Prediction of Accident Liability Through Biographical Data and Psychometric Tests, Final Report. California Department of Motor Vehicles: Sacramento, March 1973.

Harrington, D.M. The Young Driver Follow-Up Study. California Department of Motor Vehicles: Sacramento, 1971.

Harris, W., Mackie, R., et al. A Study of the Relationships Among Fatigue, Hours of Service, and Safety of Operations of Truck and Bus Drivers. Human Factors Research, Incorporated: Goleta, California, November 1972.

Heath, E.D., "The Relationships Between Driving Records, Selected Personality Characteristics and Biographical Data of Traffic Offenders and Non-Offenders." University Microfilms, Doctoral Dissertation Series, Publication No. 21, 705, 1957.

Hebb, D.O. "Drivers and the CNS (Conceptual Nervous System)." Psychological Review, 62, 1955.

Heimstra, N.W. "The Effects of 'Stress Fatigue' on Performance in a Simulated Driving Situation." Ergonomics, 13, 1970, pp. 209-218.

Heimstra, N.W., Ellingstad, V.S. and DeKock, A.R. "Effects of Operator Mood on Performance in a Simulated Driving Task." Perceptual Motor Skills, 25, 1967, pp. 729-735.

Hennepin County Alcohol Safety Action Project. Field Evaluation of Hennepin County and Mortimer-Filkins Procedures for Identifying Problem Drinkers. Hennepin County: Minnesota, December 1974.

Herbert, M.J. and Jaynes, W.E. Performance Decrement in Vehicle Driving, Report No. 597. U.S. Army Medical Research Laboratory: Fort Knox, Kentucky, November 1963.

Herbert, M.J. and Jaynes, W.E. "Performance Decrement in Vehicle Driving." Journal of Engineering Psychology, 3, 1964, pp. 1-8.

Hoinville, G., Berthoud, R. and Mackie, A.M. A Study of Accident Rates Amongst Motorists Who Passed or Failed an Advanced Driving Test, Report No. LR 499. Transport and Road Research Laboratory, 1972.

Holmes, T.H. and Rahe, R.H. "The Social Readjustment Rating Scale." Journal of Psychosomatic Research, 11, 1967, pp. 213-218.

House, E.G. and Waller, P.F. Accuracy of Drivers' Estimates of Vehicle Mileage Driven. Highway Safety Research Center, University of North Carolina: Chapel Hill, November 1971.

Hulbert, S.F. Blood Sugar Level and Fatigue Effects on a Simulated Driving Task, Engineering Report No. 63-53. University of California: Los Angeles, October 1963.

Hulbert, S.F. "Effects of Driver Fatigue." In T.W. Forbes (Ed.), Human Factors in Highway Traffic Safety Research. Wiley Interscience: New York, 1972, pp. 288-301.

Hulbert, S.F. and Wojcik, C. "Driving Task Simulation." In T. W. Forbes (Ed.), Human Factors in Highway Traffic Safety Research. Wiley Interscience: New York, 1972, pp. 44-73.

Human Factors Laboratory. Life Activities Inventory. Department of Psychology, University of South Dakota: Vermillion, SD, March 1974.

International Driver Behavior Research Association. Proceedings of the First Conference of the International Driver Behavior Research Association. Zurich, Switzerland, 1973.

Institute for Research in Public Safety. Tri-Level Study of the Causes of Traffic Accidents: Interim Report I, 2 volumes. Institute for Research in Public Safety: Bloomington, Indiana, August 1973.

Jackson, D.N., Hourany, L. and Vidmar, N.J. "A Four-Dimensional Interpretation of Risk Taking." Journal of Personality, 40:3, September 1972, pp. 483-501.

Jones, M.H. California Driver Training Evaluation, Final Report to the California Legislature. School of Engineering and Applied Science, University of California: Los Angeles, December 1973.

Katz, M.M. and Lyerly, S.B. "Methods for Measuring Adjustment and Social Behavior in the Community: I. Rationale, Description, Discriminative Validity and Scale Development." Psychological Rep. Monograph, 13, 1963, pp. 503-535.

Kenel, F.C. The Effectiveness of the Mann Inventory in Classifying Young Drivers into Behavioral Categories. University Microfilms: Ann Arbor, Michigan, 1967.

Kerlan, M.W., Mortimer, R.G., Mudge, B. and Filkins, L.D. Court Procedures for Identifying Problem Drinkers: Volume 1. Manual. Highway Safety Research Institute: Ann Arbor, Michigan, June 1971.

Kole, T. and Henderson, H.L. "Cartoon Reaction Scale with Special Reference to Driving Behavior." Journal of Applied Psychology, 50:4, 1966, pp. 311-316.

Kraus, A.A., Steele, R., Ghent, W.R. and Thompson, M.G. "Pre-Driving Identification of Young Drivers with a High Risk of Accidents." Journal of Safety Research, 2:2, June 1970.

Kroll, C.V. A Preview--Predictor Model of Driver Behavior in Emergency Situations. Cornell Aeronautical Laboratory, Inc.: Buffalo, New York, January 1971.

Levonian, E. Prediction of Negligent Operators. Institute of Transportation and Traffic Engineering, University of California: Los Angeles, December 1963.

Levonian, E. "Prediction of Accidents and Convictions." Traffic Safety Research Review, II:3, September 1967.

Lauer, A.R. and Suhr, V.W. "The Effect of a Rest Pause on Driving Efficiency." Perceptual and Motor Skills, 9, 1959, pp. 363-371.

Little, A.D. The State of the Art of Traffic Safety: A Critical Review and Analysis of the Technical Information on Factors Affecting Traffic Safety. Arthur D. Little, Inc.: Cambridge, Massachusetts, June 1966.

Lower, J.S., Mortimer, R.G. and Filkins, L.D. Court Procedures for Identifying Problem Drinkers. Volume 1. Scoring Keys. Highway Safety Research Institute: Ann Arbor, Michigan, June 1971.

Lucas, R.L. "Attitudes, Personal Characteristics, and Driver Behavior." In N.C. Heimstra (Ed.), Injury Control in Traffic Safety, Chapter Six. Charles C. Thomas, Publisher: Springfield, Illinois, 1970.

Lucas, R.L., Heimstra, N.W. and Spiegel, D. "Part-Task Simulation Training of Drivers' Passing Judgments." Human Factors, 15:3, June 1973, pp. 269-274.

Magoun, H.W. "Recent Contributions to the Electrophysiology of Learning." Annals of the New York Academy of Science, 92, 1961.

Marsh, W.C. and Hubert, D.M. The Prediction of Driving Record Following Driver Improvement Contacts. Department of Motor Vehicles, Research and Statistics Section: Sacramento, California, January 1974.

Mast, T.M., Jones, H.V. and Heimstra, N.W. "Effects of Fatigue on Performance in a Driving Device." Highway Research Record, 122, 1966, pp. 93.

McBride, R.S. "The Prediction of Driving Behavior Following a Group Driver Improvement Session." Journal of Applied Psychology, 1970.

McFarland, R.A. and Mosley, A.L. Human Factors in Highway Transportation Safety. Harvard School of Public Health: Boston, Mass., 1954.

McFarland, R.A., Domey, R.G., Duggar, B.C., Crowley, T.J. and Stoudt, H.W. An Evaluation of the Ability of Amputees to Operate Highway Transport Equipment. Harvard School of Public Health: Boston, Mass., December 1968.

McGlade, F.S. A New Road Test. New York University Center for Safety Education and Shell Oil Co.: New York, 1961.

McGlade, F.S. "Testing Driving Performance--Developmental and Validation Techniques." Highway Research News, 5, May 1963.

McGuire, F.L. "Psychological Comparison of Automobile Drivers." U.S. Armed Forces Medical Journal, 7:1, 1956a, pp. 1741-1748.

McGuire, F.L. "The Safe-Driver Inventory: A Test for Selecting the Safe Automobile Driver." U.S. Armed Forces Medical Journal, VII:9, September 1956b.

McGuire, F.L. "The Understanding and Prediction of Accident-Producing Behavior." In Highway Safety: Anatomy of a Problem, North Carolina Symposium on Highway Safety, Vol. I, Chapel Hill, North Carolina, Fall, 1969, pp. 101-124.

McGuire, F.L. "Smoking, Driver Education, and Other Correlations of Accidents Among Young Males." J. of Safety Research, 4:1, March 1972, pp. 5-11.

McGuire, F.L. and Kersh, R.C. "The Relationship Between the Driver Attitude Scale and the McGuire Safe Driver Scale." Traffic Safety Research Review, June 1964.

McMurray, L. Emotional Stress and Driving Performance: The Effect of Divorce, Report 016. Division of Research, Administrative Services, Department of Motor Vehicles: State of Washington, August 1968.

McPherson, K. and Kenel, F.C. "Perception of Traffic Hazards: A Comparative Study." Research Review, 12:2, 1968.

McRuer, D.T., Peters, R.A., Ringland, R.F., Allen, R.W., Blauvelt, A.A., and Weir, D.H. Driver Performance Measurement and Analysis System (DPMAS), Task I: Requirements and Plans for Prototype Equipment. Systems Technology, Inc.: Hawthorne, California, December 1973.

Michaut, G. and Pottier, M. "Conduite en Situation Monotone." Organisme National de Securite Routiere, Bulletin No. 8, 1964.

Moffie, D.J., Symmes, A. and Milton, C.R. "Relation Between Psychological Tests and Driver Performance." Highway Research Board Bulletin 60, Road-User Characteristics, Publication 244, NAS-NRC: Washington, D.C., 1952.

Mortimer, R.G., Filkins, L.D. and Lower, J.S. Development of Court Procedures for Identifying Problem Drinkers: Final Report. Highway Safety Research Institute: Ann Arbor, Mich., November 30, 1971.

Mortimer, R.G. and Lower, J.S. "Development of a Questionnaire to Identify the Problem-Drinking Driver." Proceedings of the 14th Annual Conference of the American Association for Automotive Medicine, Towsley Center for Continuing Medical Education, University of Michigan, Ann Arbor, November 19 and 20, 1970, pp. 195-206.

Mostofsky, D.I. Attention: Contemporary Theory and Analysis. Meredith Corporation: New York, 1970.

Mourant, R.R. and Rockwell, T.H. Visual Scan Patterns of Novice and Experienced Drivers. Symposium on Psychological Aspects of Driver Behavior, Netherlands, 1971.

Mulford, H.A. and Wilson, R.W. "Identifying Problem Drinkers in a Household Health Survey." Public Health Service Pub. No. 1000, Series 2, No. 16, May 1966.

Mudge, B., Kerlan, M.W., Post, D.V., Mortimer, R.G., and Filkins, L.D. Court Procedures for Identifying Problem Drinkers. Volume 2: Supplementary Readings. Highway Safety Research Institute: Ann Arbor, Mich., June 1971.

National Conference on Driving Simulation. New Horizons for Highway Safety Through Driving Simulation. A report on the National Conference on Driving Simulation, Santa Monica, California, February 27 through March 1, 1961.

Neyhart, A.E. Road Test Check List for Passenger Car Drivers. American Automobile Association: Washington, D.C., 1955.

Nolan, R. A Comparative Study of the Teaching of the Multiple-Car Off-Street Driving Range and the Aetna Drivotrainer. Unpublished Doctoral Dissertation, Michigan State University, East Lansing, Mich.,1964.

Nunnally, J.C. Psychometric Theory. McGraw-Hill: New York, 1967.

O'Hanlon, J.F. Fatigue as Estimated from Concurrent Performance and Psychophysiological Measures in Prolonged Driving. Human Factors Research, Inc., Tech. Rep. 1712-1, 1971

O'Hanlon, J.F. "Heart Rate Variability: A New Index of Driver Alertness/Fatigue." Automotive Engineering Congress, Paper 720141, 1972.

Ohio Department of Education, The Development and Validation of Attitude, Knowledge and Performance Test for Evaluating Driver Education Curricula. National Highway Traffic Safety Administration, Washington, D.C., May 1973.

Olson, P.L. "Aspects of Driving Performance as a Function of Field Dependence." Journal of Applied Psychology, 59:2, 1974.

Osgood, C.E., Suci, G.J. and Tannenbaum, P.H. The Measurement of Meaning. University of Illinois: Urbana, 1957.

Pease, J.J. and Damron, C.F. "The Effectiveness of Video Tape Feedback on Driving Performance and Self-Evaluation. Journal of Safety Research, 6:1, 1974.

Peck, R.C., McBride, R.S. and Coppin, R.S. "The Distribution and Prediction of Driver Accident Frequencies." Accident Analysis and Prevention, 2, 1971, pp. 243-299.

Pelz, D.C.and Schuman, S.H. Motivational Factors in Crashes and Violations of Young Drivers. Text of spoken presentation, American Public Health Association meetings, Minneapolis, Minnesota, October 13, 1971. Highway Safety Research Institute: Ann Arbor, Michigan, 1971.

Perrine, M.W. The Vermont Driver Profile: A Psychometric Approach to Early Identification of Potential High-Risk Drinking Drivers. Paper presented at the Sixth International Conference on Alcohol, Drugs and Traffic Safety, Toronto, Canada, September 1974.

Perrine, M.W., Waller, J.A. and Harris, L.S. Alcohol and Highway Safety: Behavioral and Medical Aspects, Final Report on Contracts No. FH-11-6609 and FH-11-6899. U.S. Department of Transportation: Washington, D.C., 1971.

Platt, F.N. "A New Method of Evaluating the Effects of Fatigue on Driver Performance." Human Factors, 6:4, August 1964, pp. 351-358.

Platt, F.N. "Heart Rate Measurements of Drivers with the Highway System Research Car." Journal of the Medical Association of Georgia, 59, 1970.

Plummer, L.S. and Das, S.S. "A Study of Dichotomous Thought Processes in Accident-Prone Drivers." British Journal of Psychiatry, 122, 1973, pp. 289-294.

Posner, M.I. "Components of Skilled Performance." Science, 152, 1966.

Quenault, S.W. Driver Behavior--Safe and Unsafe Drivers, Road Research Laboratory Report LR-70. Ministry of Transport: Crowthorne, Berkshire, England, 1967.

Quenault, S.W. "Research on Driver Behavior Leads to a Driver Classification Plan." Traffic Digest and Review, 17:11, November 1969, pp. 1-6.

Quenault, S.W. Overtaking Behaviour Under Normal Traffic Conditions. (Interim Report). Transport and Road Research Laboratory: Berkshire, England, 1974.

Quenault, S.W. and Fairhead, R.D. Driver Behaviour and Results of Some Psychological Tests. Transport and Road Research Laboratory: Berkshire, England, 1971.

Quenault, S.W. and Parker, P.M. Driver Behaviour--Newly Qualified Drivers. Proceedings of the International Driver Behaviour Research Association, Zurich, 1973.

Robinson, G.H. et al. "Visual Search by Automobile Drivers." Human Factors, 14:4, 1972.

Robinson, J.P., Athanasiou, R., and Head, K.B. Measure of Occupational Attitude and Occupational Characteristics. Survey Research Center, The University of Michigan: Ann Arbor, 1969.

Rockwell, T.H. "Skills, Judgement and Information Acquisition in Driving." In T. W. Forbes (Ed.), Human Factors in Highway Traffic Safety Research. Wiley-Interscience: New York, 1972.

Rockwell, T.H. and Burner, L.R. "Information Seeking in Risk Acceptance." American Society of Safety Engineers Journal, XII:11, November 1967.

Rommel, R.C.S. "Personality Characteristics and Attitudes of Youthful Accident-Repeating Drivers." Traffic Safety, March 1959, pp. 13-14.

Ross, H. "Schematic Analysis of the Driving Situation." Traffic Safety, 1960.

Safford, R. and Rockwell, T.H. "Performance Decrement in 24-Hour Driving." Highway Research Record, 163, 1967, pp. 68-79.

Safren, M., Cohen, S. and Schlesinger, L. "The Drivometer as a Measure of Driving Skill." Journal of Safety Research, 2:1, 1970.

Salvatore, S. "Effect of Removing Acceleration Cues on Sensing Vehicular Velocity." Perceptual and Motor Skills, 28, 1969, pp. 615-622.

Schlesinger, L.E. and Safren, M.A. Perceptual Analysis of the Driving Task. Driver Behavior Research Project, George Washington University: Washington, D.C., 1962.

Schori, T.R. "Experimental Approaches and Hardware for Driving Research." In N.W. Heimstra (Ed.), Injury Control in Traffic Safety. Charles C. Thomas: Springfield, Illinois, 1970.

Schmidt, C.W., Jr., et al. "Characteristics of Drivers Involved in Single-Car Accidents." Archives of General Psychiatry, 27, December 1972, pp. 800-803.

Schuster, D.H. "Prediction of Current Accident Record for Youthful Drivers." Traffic Safety Res. Rev., 10:1, March 1966.

Schuster, D.H. "Attitudes Toward Driving Safety and Their Modification." Human Factors, 12:1, February 1970, pp. 89-94.

Schuster, D.H. Driving Hazards Perceptual Test Based on the All-State Film Hazardous Situations. Mimeo, 1971.

Schuster, D.H. and Guilford, J.P. The Driver Attitude Survey. Sheridan Psychological Supply: Beverly Hills, California, 1962.

Selzer, M.L. The Michigan Alcoholism Screening Test (MAST): The Quest for a New Diagnostic Instrument. Paper delivered at the 126th Annual Meeting of the American Psychiatric Association, San Francisco, California, May 11-15, 1970.

Selzer, M.L. The Michigan Alcoholism Screening Test (MAST): The Quest for a New Diagnostic Instrument." American Journal of Psychiatry, 127, 1971, pp. 1653-1658.

Selzer, M.L. and Chapman, M. "Differential Risk Among Alcoholic Drivers." Proceedings of the 14th Annual Conference of the American Association of Automotive Medicine, Towsley Center for Continuing Medical Education, University of Michigan, Ann Arbor, November 19 and 20, 1970, pp. 207-214.

Selzer, M.L., Vanosdall, F.E. and Chapman, M. "Alcohol in a Problem Driver Group: A Field Trial of the Michigan Alcoholism Screening Test (MAST)." Journal of Safety Research, 3:4, December 1971, pp. 176-181.

Selzer, M.L. and Vinokur, A. Detecting the High Risk Driver: The Development of a Risk Questionnaire. Highway Safety Research Institute: Ann Arbor, Michigan, 1974.

Senders, J.W. "Visual Scanning Behavior." In NAS Visual Search, National Academy of Sciences, 1973.

Senders, J.W., Kristofferson, A.B., Levison, W., Dietrich, C.W. and Ward, J.L. An Investigation of Automobile Driver Information Processing, Final Report. U.S. Department of Commerce, Bureau of Public Roads; Washington, D.C., 1966.

Senders, J.W., et al. Additional Studies on Driver Information Processing. Bolt Beranek and Newman, Inc.: Cambridge, Mass., 1969.

Sewell, R. and Perratt, C. A Data Acquisition System for Research Studies of Driver Performance in Real Traffic Situations. Paper accepted for presentation at the 54th Annual Meeting of the Transportation Research Board, January 1975.

Shaffer, J., Towns, W., Schmidt, C., Fisher, R. and Zlotowitz, H. "Social Adjustment Profiles of Fatally Injured Drivers." Arch. Gen. Psychiatry, Vol. 30, April 1974.

Shaw, L. "The Practical Use of Projective Personality Tests as Accident Predictors." Traffic Safety Research Review, June 1965, pp. 34-72.

Shaw, L. and Sichel, H.S. Accident Proneness: Research in the Occurrence, Causation, and Prevention of Road Accidents. Pergamon Press: Oxford, 1971.

Siebrecht, E. Measuring Driver Attitudes. Center for Safety Education, New York University, 1941.

Smith, G.L., Jr. "The Effect of Stress on Driver Information Seeking." Automotive Engineering Congress Paper No. 720143, 1972.

Smith, G.J.W. and Nyman, G.E. The Serial Colour-Word Test: A Summary of Results. Skandinaviska Testforlaget: Stockholm, 1964.

Soliday, S.M. and Allen, J.A., Jr. Hazard Perception in Automobile Drivers: Age Differences. Highway Safety Research Center, University of North Carolina: Chapel Hill, 1972.

Solvic, P. "Assessment of Risk Taking Behavior." Psychological Bulletin, 61:3, 1964, pp. 220-233.

Spicer, R.A. Human Factors in Traffic Accidents, Final Report. U. S. Public Health Service, 1964.

Stephens, B.W. and Michaels, R.M. "Timesharing Between Two Driving Tasks Simulated Steering and Recognition of Road Signs." Public Roads, 33:5, 1964.

Suhr, V.W. Driving Effiency Over a Six-Hour Period by Simulated Driving Performance. Unpublished Doctoral Dissertation, Iowa State College, 1956. In A. R. Lauer and V.W. Suhr, "The Effect of a Rest Pause on Driving Efficiency." Perceptual and Motor Skills, 1959, 9, pp. 363-371.

Sugarman, R.C. and Cozad, P.C. Road Tests of Alertness Variables. Final Report for Contract No. DOT-HS-053-1-145, 1972.

Sussman, E.D. and Morris, D.F. An Investigation of Factors Affecting Driver Alertness. Cornell Aeronautical Laboratory Tech. Report VJ-2849-B-1, 1970.

Teichner, W.H. "Response Blocking: A Necessary Performance Criterion." In Pre-Crash Factors in Traffic Safety. The American Association for Automotive Medicine, 1968.

Tillman, W.A. and Hobbs, G.E. "The Accident Prone Automobile Driver: A Study of Psychiatric and Social Background." Amer. Journal of Psychiatry, 106, 1949, pp. 321-331.

Treat, J.R. and Drakes, R. An Analysis of Emergency Situations, Maneuvers, and Driver Behavior in Accident Avoidance, Final Report. Institute for Research in Public Safety, Indiana University: Bloomington, March 1975.

Uhlaner, J.E., Van Steenberg, N.J. and Goldstein, L.G. "The Construction of Experimental Group Tests for the Prediction of Safe Driving." BESRL Research Memorandum 51-40, 1951.

Versace, S.V. Perception of Driving Stimulus Test. Unpublished thesis for Master's of Science. Central Missouri State University: Warrensburg, 1972.

Wallace, J.E. Problem Drivers: An Evaluation of Four Treatment Programs and the Use of Questionnaire Material for Predicting Success, Report No. 026. Washington Department of Motor Vehicles, December 1969.

Weinstein, S.A. Recognition of Photographed Traffic Hazards as an Indicator of Automobile Accident Involvement. PhD dissertation, Teachers College, Columbia University, 1970.

Weir, D.H. and Allen, R.W. Physiological and Response Measurements in Driving Tasks, SAE Congress, Paper No. 720139, Detroit, 1972.

Whinery, L.H., Hilbert, R.E. and Nicewander, W.A. Second Interim Report for Project on the Predictive Sentencing of 16-18 Year-Old Male Habitual Traffic Offenders. The University of Oklahoma Research Institute: Norman, September 1, 1972.

Whinery, L.H., Hilbert, R.E., and Nicewander, W.A. Third Interim Report on Project on the Predictive Sentencing of 16-18 Year Old Male Habitual Traffic Offenders. Office of Research Administration, University of Oklahoma: Norman, December 31, 1973.

Wiener, E.L. Elderly Pedestrians and Drivers: The Problem that Refuses to Go Away. Department of Management Science, University of Miami: Coral Gables, Florida, 1972.

Whittenburg, J.A., McBride, R.S., Pain, R.F. and Baker, G.L. Driver Improvement Training and Evaluation: Final Report. The American University Development Education and Training Research Institute: Washington, D.C., July 1973.

Whittenburg, J.A., McBride, R.S., Pain, R.F. and Baker, G.L. Driver Improvement Training and Evaluation. The American University: Washington, D.C., June 1974.

Whittenburg, J.A., Pain, R.F., McBride, R.S. and Amidei, J. Driver Improvement Training and Evaluation: Initial Development, Volume 1, Final Report FH-11-7618. American University Development Education and Training Research Institute: Washington, D.C., May 1972.

Williams, E.B. and Malfetti, J.L. Driving and Connotative Meanings. Teachers College, Columbia University: Teachers College Press, 1970.

Williams, J.R. A Study of the Relationship Between Three Dimensional Spatial Relations Ability and Driving Performance. Unpublished Doctoral Dissertation, New York University, 1971.

Witkin, H.A. "Psychological Differentiation and Forms of Pathology." Journal of Abnormal Psychology, 70, 1965.

Wright, K.A. Dynamic Visual Perception in Vehicle Guidance: A Review of the Literature. Department of Industrial Engineering and Operations Research, University of California: Berkeley, 1966.

Yoss, R.E. "The Sleepy Driver: A Test to Measure Ability to Maintain Alertness." Mayo Clinic Proceedings, 44, November, 1969, pp. 769-783.

Zwahlen, H.T. "Driver Risk-Taking: The Development of a Driver Safety Index." Highway Research Record, No. 464, 1973.

Chapter 4

Harano, R.M., McBride, R.S., and Peck, R.C. The Prediction of Accident Liability Through Biographical Data and Psychometric Tests, California Department of Motor Vehicles, Research and Statistics Section: Sacramento, 1973.

Harrington, D.M. The Young Driver Follow-Up Study. California Department of Motor Vehicles: Sacramento, 1971.

Peck, R.C., McBride, R.S., and Coppin, R.S. "The Distribution and Prediction of Driver Accident Frequencies." Accident Analysis and Prevention, Vol. 2, 1971, pp. 243-299.

Schuster, D. and Guilford, J. "The Psychometric Prediction of Problem Drivers." Traffic Safety Research Review, 6, 1962, pp. 16-20.

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