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15. Supplementary Notes

Proceedings of an invitational symposium held in Warren, Vermont on October 13-15, 1972.

16. Abstract An invitational symposium was held October 13-15, 1972, at a remote Vermont inn and was attended by 35 research and/or administrative specialists in alcohol, drugs, and/or highway safety. The basic purpose was publication of the proceedings to incorporate these specific aims: evaluative reviews of the literature; edited transcriptions of the discussion periods; and ratings of 176 keyword topics on 3 dimensions of alcohol, drug, and driving problems, i.e., extent of present knowledge and relative priorities for both basic and applied research. The 8 reviews consist of combinations of the following topics: alcohol and/or drug influences upon driving-related behavior as studied in laboratory, simulator, and closed-course driving experiments; epidemiologic studies and countermeasure research on alcohol and/or drugs in highway crashes. A comprehensive overview of all keyword ratings was constructed to integrate research priority ratings across the 8 topical sessions. Keywords having highest priorities for both basic and applied research in both alcohol and drugs were essentially the same and were organized into 3 general categories: influences upon neurophysiological activities (central and autonomic nervous systems) and upon the psychological processes of perception (dynamic visual acuity; visual search), attention, and cognition (risk taking; decision making), and in combination with other conditions of the driver (emotion; stressors, e.g., fatigue, noise). Highest priorities for epidemiologic studies were given to the interaction between alcohol and drugs, to individual differences in alcohol consumption patterns and driving history, and to incidence and prevalence studies of drug involvement. Drug countermeasure research did not receive high priority ratings. For alcohol countermeasures, highest priority topics were research on enforcement by police surveillance and on rehabilitation by behavior modification.

17. Key Words ALCOHOL: effects(neurophysiology,vision, perception, tracking, attention, motivation, cognition,driving;epidemiology(drinking drivers);countermeasures(ASAP,legal,education,rehabilitation). DRUGS: effects(interactions);epidemiology;countermeasures. PRIORITIES: highway safety research.

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PREFACE

A survey of specialists in the area of alcohol and highway safety conducted informally during 1970-71 indicated unanimous agreement on the great need for a critical review of the literature. Many of the discussions during the course of this survey also confirmed my feelings that we needed an inventory not only of what we really know now, but especially of what we should know in the forseeable future; and that a small gathering of selected specialists would be the keystone of such an effort. Thus, it seemed that the informality and spontaneity of a good bull session could be combined with the task-orientation and structure of a small, face-to-face working conference in an isolated location to provide a relaxed but focused atmosphere in which to review the status of current knowledge, to discuss and critique research in progress, and to speculate and fantasize about planned research.

The Vermont Symposium on Alcohol, Drugs, and Driving was held at a relatively remote ski lodge in the heart of the Green Mountains on October 13-15, 1972, and was attended by 35 specialists from universities, research firms, and federal agencies. This invitational symposium represented the culmination of many hopes and ideas which were first presented formally to the National Highway Traffic Safety Administration on October 22, 1971, in an unsolicited proposal entitled, "Behavioral Aspects of Alcohol and Driving," and were subsequently resubmitted on May 16, 1972, in response to RFP No. NHTSA-2-B693 entitled, "Alcohol/Drug Research." The award was signed on June 17, 1972.

The basic purpose of the Vermont Symposium was publication of the proceedings to incorporate the following specific aims: (1) systematic, evaluative reviews of the eight major aspects of alcohol and drug problems related to highway safety, with each review written by a leading specialist in that aspect; (2) a synthesis of the edited transcriptions of the discussion periods that followed presentation of the summaries of each of the eight review papers; and (3) ratings of 176 key-word topics on three dimensions of alcohol, drug, and driving problems, i.e., the extent of present knowledge, the relative priorities for basic research in terms of informational yield, and the relative priorities for applied research in highway safety. The critical reviews consist of combinations of the following topics: alcohol and/or drug influences upon driving-related behavior as studied in laboratory, simulator, and closed-course driving experiments; epidemiologic studies of the role of alcohol and/or drugs in highway crashes and citations; and research on countermeasures for alcohol and/or drug involved problems on the highway.

This volume is actually more than a simple documentation of the Symposium proceedings since it includes complete versions of the review papers, whereas only brief summaries of the draft reviews were presented at the Symposium itself as a basis for discussion. Thus, most of the chapters in this volume represent the final versions of the review papers as modified and polished after the Symposium, thereby profiting from the discussion periods.

All the discussion periods were tape-recorded, with advance warning to the participants and with full consent to so doing. Each chairman was primarily responsible for the form the discussion from his session was to take in this volume. Accordingly, each chairman received both a typewritten transcription and a duplicate tape recording of his session. Most chairmen sent thermographic copies of a participant's transcribed comments to the individual if they were extensive, unclear, and/or dealt with sensitive material. In responding to these requests to edit their original remarks, some participants really rose to the challenge and returned expanded, highly polished texts which would be suitable for independent publication in a journal. It will also become apparent in reading through the various discussion sections of this volume that the chairmen exercised a wide range of options in preparing the final versions from the very rough transcriptions; some chairmen attempted verbatim presentation in the original sequence of speakers, whereas other chairmen opted to change the order to achieve a more meaningful flow and to edit and reduce the material to its bare essence. In fact, after reviewing the transcribed discussion from his session, one chairman even decided that it did not merit inclusion in this report since in his opinion, nothing really new or important was said.

Without doubt, the keyword ratings of present knowledge and both basic and applied research priorities comprised the most controversial (and perhaps the most unique) component of the Vermont Symposium. The participants groaned and complained as they struggled through approximately 22,000 individual decisions regarding the particular scale value for a particular keyword on a particular rating task. In a sense, the participants may have retaliated for the agony of these many decisions by rating the keyword ratings as having had the lowest value for them (see further discussion of the Evaluation Questionnaire in Appendix D). Nevertheless, the keyword ratings may ultimately prove to be the most valuable outcome of the Vermont Symposium, but a word of caution must be given concerning their use and possible abuse. As some of the participants also noted, these keyword ratings represent forced-choice judgments on a limited pool of specific words or phrases, and therefore should not be interpreted as being judgments about whole programs (whether of research or countermeasures). Furthermore, it was strongly felt that these priority ratings should never be used as a basis for drafting budgets. In fact, as one chairman aptly phrased it, "I hope that dollar signs are never attached to these mean scale values of the keyword ratings." The other chairmen and I firmly endorsed this position.

The keyword ratings do, however, provide an educated, consensual judgment on priorities for basic and applied research on specific aspects of highway safety. As the most quantified judgments currently available, they also represent relatively specific recommendations by this group of specialists for future research directions. Therefore, rather than attempting to prepare an individual chapter of recommendations which would be a redundant rework of the chapter on ratings, an extensive summary of the latter has been provided and the interested reader is referred to the relevant subsections of that chapter for research recommendations concerning a particular topic. After the Symposium, one of the participants offered a cogent recommendation concerning possible use of such ratings in the future, namely, have the review papers and the keywords to be rated mailed to the participants ahead of time and have the completed ratings returned before the beginning of the conference so that it could then get down to a discussion of a group thinking about what is known and what areas needed work, including the kind of collective think-session that was suggested concerning actual methodological approaches that might be implemented (Cliff Hahn, personal communication).

It is with a great sense of gratitude and pleasure that I acknowledge the contributions of those individuals and institutions without whose cooperation and efforts the Vermont Symposium could not have been conducted. I feel especially privileged to have been able to work with and learn from the outstanding scientists who served as chairmen-reviewers for the Symposium: Drs. Herbert Barry, III; Gerald J. Driessen; M. Stephen Huntley, Jr.; Paul M. Hurst; Herbert Moskowitz; and Reginald G. Smart. For the panel on drugs, we were fortunate to have the additional contributions of Dr. John A. Carpenter.

A special word of thanks is due the three federal officials who gave so generously of their time and ideas in organizing and in conducting the Symposium: Dr. James L. Nichols, who served as the Contract Technical Manager, as well as the moderator of the drug panel, and Dr. Robert B. Voas, both from the Office of Alcohol Countermeasures, National Highway Traffic Safety Administration, USDOT; and Dr. Albert A. Pawlowski, from the National Institute on Alcohol Abuse and Alcoholism, USHEW. In addition, Professor Robert F. Borkenstein, Director of the Center for Studies of Law and Action, Indiana University, and advisor to the Office of Alcohol Countermeasures, was very helpful in sharing his ideas and his enthusiasm. We are indebted to Dr. Gerald J. Driessen of the National Safety Council for mediating on our behalf with his organization to assist in the amenities at the Symposium, but more significantly to publish intermediate versions of the review papers in a special issue of its Journal of Safety Research, which appeared late in October.

I am deeply grateful to my friend and colleague, Dr. M. Stephen Huntley, Jr., who aided immeasurably in the Symposium organization and local arrangements. My very special personal thanks and appreciation go to that group without whom we would have been completely lost: the Project ABETS staff and spouses. If flexibility is predictive of success, then our four graduate research assistants can be expected to excel. The many contributions of Bob Lubin, Phil Zunder, Ray Kirk, and Bill Saxby ranged from attending to such logistical problems as transporting participants from the airport to the Symposium and back, tape recording all sessions and making the necessary duplicate tapes, arranging demonstrations of our instrumented research car, locating and hauling supplies, and preparing, distributing, and reducing the keyword rating materials and data, to participating as budding peers in such professionally oriented activities as vigorous involvement in the many informal discussions at the Open Houses (especially by posing many incisive and difficult questions during these discussions), by aiding in the preliminary testing and analyses of various scaling methods for the keyword ratings, by performing a variety of analyses on the 21,875 data points generated by the keyword rating tasks, and then by aiding in the preparation of portions of the text which report the results of some of these analyses. In fact, three of the graduate students were active participants in the Seminar on Alcohol and Behavior, which Steve Huntley and I offered in the fall semester of 1971, during which some of the concepts that were later incorporated in the Vermont Symposium were discussed and critiqued.

We were very fortunate to have had two successive Administrative Assistants whose particular blends of skills and talents were well-suited to the differing stages of Symposium-related activities during their respective tenures: first, Ms. Sandra Hyman who helped organize and conduct the Symposium itself, and more recently, Mrs. Marian Bickford who has helped organize and supervise the preparation of this volume, especially by providing guidance and continuity for the many tireless typists who have churned out seemingly endless drafts of the many manuscripts involved.

In addition to applying her technical skills in the programming and statistical analyses of the keyword ratings, Mrs. Mary Anne Freedman was responsible for

the installation and operation of a remote terminal at the Sugarbush Inn which enabled us to use the University of Vermont Computer Center and thereby be able to present preliminary analyses of the rating data on the third day of the Symposium. This impressive feat was accomplished by sheer diligence, working late into the night (or more accurately, early into the morning) with the aid of our loyal data processors, notably, Mrs. Leda Lubin. Mrs. Elizabeth Cowan has been very helpful in her role as technical writer and critic, both during the Symposium and during the course of preparing this volume.

We are grateful to Mr. Robert Law, conference manager of the Sugarbush Inn in Warren, Vermont, who personally supervised so many of the arrangements and services which contributed to creating the informal, but gracious atmosphere that enhanced the memorable nature of the Symposium.

In conclusion, I hope that some of the more significant expectations for the Symposium are realized. More specifically, I hope that attendance at the Symposium will stimulate the research and countermeasure activities of the participants, as well as form a firm basis for continuing contacts and interchange of ideas among them. Further, I hope that this volume will provide a useful reference work and will serve as a stimulating basis for future research and countermeasure development in the areas of alcohol, drugs, and highway safety. Finally, I hope that by reporting our experiences with the Vermont Symposium, this volume will prove helpful to organizers and participants of future symposia, for which this one may well serve as a useful model.

M. W. Perrine
Symposium Director

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Chapter 1

1. INTRODUCTION

M. W. Perrine

Although highway crashes constitute an enormous social problem, the ratio of systematic research to the relative magnitude of the problem is appallingly small. In fact, there is probably no other single aspect of American behavior which is so under-studied as driving and yet which involves such a large proportion of our population and gross national product, and which has such an impact on our social behavior, on our daily lives, and on our annual death rate.

That alcohol abuse plays a leading role in highway crashes is now generally accepted as a commonplace -- perhaps unfortunately. After decades of exhaustive educational efforts by a small number of dedicated crusaders, we now find ourselves in the incongruous position of having alcohol abuse accepted uncritically as the global "explanation" for the majority of highway fatalities. The simplistic acceptance of a single descriptive factor as the causative explanation of an extremely complex problem which contains many different underlying components obscures the need for further identification of those individual components. As a major step toward such identification, the "Vermont Symposium on Alcohol, Drugs, and Driving" was conducted in October 1972. Its three specific aims were to assess the status of present knowledge and to consider relative priorities for both basic and applied research in those areas germane to its theme.

1.1 BACKGROUND

A few years ago, it was generally agreed among the relevant researchers and government officials that there was a compelling need for a critical review of the alcohol and highway safety literature. This need derived primarily from the facts that the last reviews had been published in 1968 and 1969 and that research and countermeasures in this area had burgeoned in the meantime, yet there had been no systematic review of the more recent literature. Thus, especially in view of the ever-increasing research and countermeasure activity, a systematic analysis of the state of the art seemed to be desirable and necessary in order to provide sound guidelines, both for continuing these activities and for the allocation of effort.

Regarding drugs other than alcohol, there had been an increasing cry for action and investigation, both from the private and public sectors, especially concerning the possible involvement of the various hallucinogens in highway safety problems. Since several reviews of the literature on drug use and highway safety had been published very recently (in 1970 - 1972), the rationale for a state-of-the-art review of such drug research was in part different from the rationale for the alcohol review. That is, in addition to incorporating the most recent work in a critical review of the drug literature, the most compelling need in the drug area was for a systematic evaluation of all the research to date primarily to provide a meaningful basis for establishing guidelines and priorities for future research and countermeasure activities, as well as for the allocation of effort. One reviewer had even stated that "no investigation, of any type, has demonstrated a disproportionate contribution to crashes or violations by drug abuse per se (Nichols, 1971, p. ix)." If this statement continued to be found generally true, then an over-allocation of public funds for highway-safety-oriented drug research and countermeasures simply as response to an uninformed public outcry for action could perhaps be obviated by the availability of a systematic, authoritative evaluation of the drug situation, which might in fact prove to be a "non-problem." This issue was clearly in need of further data and evaluation.

In summary, it had seemed that the relatively high degree of apparent concern about alcohol involvement in highway safety problems was warranted in terms of available data; whereas the high degree of public concern about the involvement of other drugs in highway safety problems might not actually be warranted in terms of either available or obtainable data. Thus, since the two problem areas might differ considerably in many dimensions, potentially effective countermeasures might also differ; indeed, in the case of drugs other than alcohol, countermeasures might prove to be either unnecessary or at least not cost effective. Therefore, systematic evaluation of both problem areas in conjunction with each other seemed to be especially desirable, if only to provide a rational basis for determining the relative allocation and distribution of research and countermeasure efforts to each of the two problem areas. Accordingly, the Vermont Symposium addressed itself to the role of both alcohol and other drugs in highway safety problems.

1.1 PREVIOUS RESEARCH AND REVIEWS

An attempt to assess the status of current knowledge in any discipline is necessarily constrained by the relative state of the art at the moment. If the field is new, uncomplex, and clearly delineated, then several leading experts should be capable of reviewing and reaching concensus in a relatively brief time. By contrast, if the field has a long history, is multi-faceted and multi-disciplinary, and does not have clearly defined limits, then a task force of many leading experts would be required for the review, but might be incapable of achieving consensus because of the enormous complexities of the problems, differences in orientation and subspecialities, etc. Alcohol and highway safety is a problem area which lies on the continuum somewhere between these two extreme points; it might be characterized as being relatively new as a recognized problem area, extremely complex and multi-disciplinary, and very amorphous in terms of delineation.

1.1.1 Alcohol and highway safety. As a research area, alcohol and highway safety is less than forty years old. Despite a number of conferences, articles, and reports during the first twenty-five or thirty years of its history, the first major reviews have only appeared during the last five years. Thus, as recently as 1966-1967, it was possible for a few leading specialists to review the whole body of literature in the area and publish a comprehensive, definitive assessment of the status of current knowledge at the time (Alcohol and Highway Safety, 1968). At approximately the same time, a similar but slightly more technical review was prepared by a larger group of leading specialists representing a broader spectrum of disciplines (Alcohol and the Impaired Driver, 1968). Another review, which included more of the European literature, was prepared by a very small group of specialists in the Netherlands at the same time as the two American reviews (Griep, 1969). These three reviews clearly reflect the Zeitgeist of the mid-sixties, a point in time at which the persistent efforts of a relatively small number of individuals and organizations culminated in official action being taken on the drinking-and-driving problem, e.g., the 1966 Highway Safety Act in the United States, the 1967 Road Safety Act in Great Britain, etc. All three reviews represented independent attempts by different groups of individuals to assess the status of knowledge at that particular point in time by pulling the information together from the very widely scattered sources. All three publications were doubtless written in response to the same need, namely, to fill the gap caused by the absence of any single review and assessment of the field.

Since the mid-sixties, the body of literature concerning the role of alcohol in highway safety has expanded enormously, yet no recent assessment of our current knowledge is known to have been published. The Vermont Symposium originated as a response to a similar need, namely, to fill the gap caused by the lack of any comprehensive review since the late 1960s, but in addition, the status of current knowledge would be evaluated by means of rating procedures.

Only one previous study is known in which some attempt was made to rate the adequacy of current knowledge in the area of alcohol and highway safety; however, it was only a small part of a much broader survey, such that alcohol was but one of a great many factors examined. This study was sponsored by the Automobile Manufacturers Association and was conducted in 1965-66 by Arthur D. Little, Inc. who prepared a state-of-the-art review of all factors affecting traffic safety (i.e., human, environmental, vehicular, loss-limiting, and regulatory and legal factors). Alcohol was treated as one of four medical factors (along with diseases, physiological impairments, and drugs and chemical agents), which in turn was listed as one of six human factors (biographical factors, driving as a skill, medical factors, personality factors, driver education, and pedestrians). All factors were rated on two dimensions: knowledge, and importance. No technical details concerning the rating procedure were provided in the report, and the following description is therefore based upon inferences made from the scant bit of text which accompanies the results of the ratings as presented in Figure 2 of the A. D. Little report (1966, pp. 10-11). The purpose of the ratings was stated as, "Figure 2 is intended to provide the reader with an overview of our general understanding of the state of existing knowledge on traffic safety (Little, 1966, p. 11)." Concerning the two dimensions for the ratings, it was stated that,

> "By knowledge, we mean extent to which there is factual information indicating the manner and degree to which the factor contributes to the present accident loss situation....The importance rating indicates our estimate of the degree to which changes in the factor in question contribute to the present overall accident and resulting loss situation. The validity of each such rating is naturally dependent upon the knowledge rating. Thus, where knowledge is rated as good, the importance rating can be considered to be a fairly accurate estimate. Where knowledge is rated as poor, the importance rating can only be our own subjective estimate (Little, 1966, p. 11)."

Knowledge of the factors was rated on five-point scales which were apparently labeled as: none or speculative, poor, fair, good, and excellent. Importance of the factors was rated on five-point scales, apparently labeled as: none or freak, minor, moderate, major, and critical. The number of raters was apparently somewhere between one and fourteen. In any case, the relevant results were that the A. D. Little "chart states that our knowledge on alcohol as a contributing factor is fair and that alcohol is a critical factor (1966, p. 11)."

Two previous studies are known in which an attempt was made to estimate the priority of research on the role of alcohol in highway safety (Hahn, 1968; Havelock, 1971; 1973). However, as with the A. D. Little study, the question of alcohol research priorities was but a very small part of large-scale surveys. The first attempt (Hahn, 1968) was a project sponsored by the Insurance Institute for Highway Safety and conducted by the American Institutes for Research. (The final report has apparently never been cleared for general distribution, which probably accounts for the fact that its contents are not very well known in the field.) The purpose of the project was to prepare recommendations for a research program to investigate human-factors aspects of driving and highway safety. Of the 24 "research program modules" that were developed and evaluated, only two involved alcohol ("drinking and driving in a total community setting," and "interaction effects of combined alcohol/drugs/tobacco"). Although the specific results should be considered as proprietary, it can be stated that both these modules were rated as average in urgency and above average in significance. Of greater relevance for the present study, however, is the unique and imaginative approach which the AIR investigators used to aid them during the preparation of their recommendations. As one part of the project, they surveyed "seventy-nine individuals who had demonstrated interest in highway safety research in one form or another (Hahn, 1968, p. 116)." In response to the initial letter from AIR, "replies either in the form of letters or phone calls, or personal visits were received from about one-half of those asked (Hahn, 1968, p. 116)." Regarding alcohol, "fourteen suggestions were received concerning some aspect of the alcohol problem and its relationship to traffic safety (Hahn, 1968, p. 120)." Thus, the researchers surveyed had responded more or less extensively to a fascinating, open-ended set of questions posed in the original letter from AIR; the responses were then processed by AIR staff and reduced to the 24 "research program modules," which were then rated by AIR project staff on the dimensions of significance (direct, semi-direct, and indirect), urgency, relation to other programs, and other dimensions of project relevance. The ratings produced by the AIR project staff were then submitted to a number of mini-max analyses. (For further details, the interested reader is referred to Clifford T. Hahn, American Institutes for Research, 8555 16th Street, Silver Spring, Maryland, 20910.)

A more recent attempt to estimate priority highway safety items was made as part of a large-scale survey conducted to investigate the national problem-solving system, consisting of highway safety researchers and decision makers (Havelock, 1971; 1973). The survey was conducted by the Institute for Social Research at the University of Michigan, apparently in 1969, and was sponsored by the National Highway Traffic Safety Administration. Of principal relevance for the present study was one open-ended question which asked, "What other area, if any, <u>in addition</u> to the above deserves top priority rating?" (The previous question had included a list of ten "activities which might be supported by the safety dollar"; and requested that the respondents "please rank in order <u>THREE</u> areas which you think should be of highest priority for receiving funds in 1970.") Usable responses were obtained from 15 alcohol-research opinion leaders, 105 highway safety researchers from a national sample, 48 decision makers from an alcohol conference, and 164 decision makers from a general sample (Havelock, 1971, p. 105). The verbatim responses concerning alcohol priorities were presented in Appendix D, where they have been separated according to whether they were recommended by decision makers or by researchers and then dichotomized (within each type of respondent) into responses that recommended "research and development" approaches or "action" approaches. Simple frequency distributions were determined which showed "a tendency for researchers to see priorities more in research terms. However, for the alcohol area, this paradigm does not hold. Here more researchers seem to be agreeing with decision makers that action strategies are necessary (Havelock, 1971, p. D-1)."

One recommendation which emanated from his analysis of the data was to "go all out on development of countermeasures for the alcohol problem (Havelock, 1971, p. 161)." Of particular relevance, however, were the recommendations which concerned improving the linkage between and among researchers and decision makers:

(1) "support annual conferences with published proceedings on critical topics," and (2) "consider the suggestions of the researchers and decision makers themselves on improving linkage between them," with "more meetings and conferences" being by far the most popular recommendation of the researchers and one of the most popular of the decision makers (Havelock, 1971, pp. 162-163). Thus, the Vermont Symposium was inadvertently very consistent with the results and recommendations of the Michigan survey, which was a particularly happy coincidence since the existence of the Havelock report did not come to the attention of the present writer until the spring of 1973.

1.1.1.2 Other Drugs and Highway Safety. Active concern with this area of research activity has only developed during the last decade. Indeed, the three major reviews of this area have only appeared during the past three years (Kibrick & Smart, 1970; Milner, 1972; Nichols, 1971). Furthermore, no previous attempt to rate extent of current knowledge or research priorities in the area of other drugs and highway safety is known.

1.1.2 RATIONALE AND SPECIFIC AIMS OF THE SYMPOSIUM

Although they are commonly referred to as "the alcohol problem" and "the drug problem" in highway safety, neither area consists of a single problem in the sense that it is unitary or homogeneous. Rather, there are many facets to each problem area and, consequently, many possible research approaches (e.g., laboratory approach; simulation approach; closed-course or driving-range approach; field or epidemiologic approach; etc.) and many possible countermeasure approaches (e.g., education, enforcement, legal actions, rehabilitation, etc.). Accordingly, in order to maximize accurate identification of the underlying problem components, leading specialists in alcohol, drugs, and highway safety were invited to a remote lodge to pool and evaluate their collective knowledge, as well as to interchange views on research issues and priorities.

This gathering of 35 specialists was based on four interrelated needs: (1) to provide a critical review of the extensive literature published since the 1968 Alcohol and Highway Safety Report; (2) to conduct a systematic analysis and evaluation of the burgeoning research and countermeasure activities in this area; (3) to review and evaluate the extent to which drugs other than alcohol are involved in highway safety problems; and (4) to obtain from the specialists a consensus that could serve as a basis for future research priorities and program guidance.

The specific aims of the Vermont Symposium were to provide: (1) a systematic, evaluative review of the eight major aspects of the two problem areas, with each review written by a leading specialist in that aspect; (2) a synthesis of the transcribed discussion that followed each of the eight review papers; (3) a topical matrix that would identify and catalogue current knowledge in terms of the relevant parameters; (4) based on this matrix, ratings for each topic or keyword in terms of the relative extent of present knowledge, relative priority for basic research, and relative priority for applied research; and (5) priorities for future research and program activities in these problem areas.

The fundamental purpose of the contract was the publication of the symposium proceedings as the outcome of these specific aims.

1.2 METHODS OF PROCEDURE

1.2.1 DISTRIBUTION OF REVIEW TOPICS

In recognition of the fact that the alcohol literature was far more extensive than the drug literature, proportionately more emphasis was given to the former in terms of the distribution of topics and specialists. Accordingly, the eight sessions at the Symposium consisted of various combinations and subdivisions of the following topics: (1) laboratory studies of alcohol influences upon driving-related behavior; (2) driving simulator studies of alcohol influences upon performance; (3) closed-course or driving-range studies of alcohol influences using instrumented cars; (4) epidemiologic studies of the role of alcohol in crashes and citations; (5) research on countermeasures for alcohol-involved problems on the highway; (6) laboratory, simulator, and closed-course instrumented-car studies of drug effects on driving-related performance; (7) epidemiologic studies of the role of drugs in highway crashes and citations; and (8) research on relevant countermeasures for drug-involved problems on the highway.

The draft reviews were distributed to the participants upon their arrival at the Symposium.

1.2.2 REVIEWERS

Each of the reviewers was selected in close consultation with relevant specialists in DOT and elsewhere. Each reviewer had several other responsibilities in addition to his task of preparing a critical review of the relevant literature in the sub-area which had been assigned to him. First, he served as a member of the Planning Committee which met both before and after the Symposium (discussed below). Secondly, at the Symposium itself, he served as the chairman of the topical session for his sub-area, during the course of which he presented a summary of his review and then led the subsequent discussion. Thirdly, after the Symposium, he prepared a summary of the results of the keyword ratings from his session.

1.2.3 PRE-SYMPOSIUM ORGANIZATIONAL MEETING

A small nucleus of specialists met about one month prior to the Symposium. Members of this Planning Committee included: the reviewer-chairmen of the topical sessions into which the Symposium itself was divided, the project director, and two representatives of DOT. (The list of Symposium chairmen and Planning Committee members is presented at the beginning of this report.)

The six-fold function of this preliminary meeting was to provide an opportunity for the reviewer-chairmen: (1) to discuss, formulate, and provide the basic structure for the "knowledge matrix;" (2) to specify the criteria for evaluating the adequacy of data, results, or other knowledge; (3) to determine the nature, criteria, and the mechanics of the keyword rating procedures; (4) to determine the criteria and format for the critical reviews of the literature which were to provide the input for the "knowledge matrix;" (5) to determine the criteria and format for presenting the results of the keyword ratings, especially those concerning priorities for future research; and (6) to determine the format and composition of the final report.

1.2.4 SYMPOSIUM PARTICIPANTS

Attendance at the Symposium was strictly limited to invited participants, the reviewer-chairmen, and a few special guests; accompaniment by spouses was actively discouraged. The size of the group was to be small enough to permit comfortable face-to-face discussion, even in full conference session. Approximately 60 specialists were invited, mostly from among behavioral scientists in universities, research firms, and federal agencies. The names, titles, and addresses of the 35 participants who attended the Symposium are presented in Appendix E.

1.2.5 SYMPOSIUM

The Symposium was conducted on October 13-15, 1972, at the Sugarbush Inn, a relatively remote ski lodge located in Warren, Vermont, in the heart of the Green Mountains. The Sugarbush Inn was selected not only because it has all the basic amenities for small conferences, but especially because it is isolated and far from any competing distractions. We had consciously sought out such a self-contained conference center in order to provide a congenial atmosphere that would be maximally conducive to informal interaction among the participants during their free time. To ensure that specific opportunities were available to encourage bull sessions and shop talk, an Open House was scheduled in two of the large suites after dinner each evening. This feature was enormously successful and productive, as evidenced by many written and oral comments, as well as by the formal evaluation questionnaire (see Appendix D, item 12).

The three days of the Symposium were subdivided such that the eight topical sessions were scheduled during the first two days, with each session being allocated 90 minutes, and two sessions being scheduled each morning and each afternoon. The morning of the third day was devoted to a series of brief summary reports from each session chairman, and the afternoon was devoted to a Forum Discussion. All sessions were tape recorded and the Discussions were transcribed and edited for inclusion in this report. A copy of the program is presented in Appendix A.

1.2.5.1 Topical sessions. Each of the eight topical sessions was attended by all participants and was under the direct guidance of the assigned chairman. The first 20 minutes was scheduled for the chairman to present an extensive summary of his written review (the complete review having already been received and assumedly read by each participant prior to the session). The next 50 minutes were available for focused, guided discussion of the particular review topic and its parameters, adequacy of knowledge, priorities, necessary future research, etc. At the beginning of this discussion period, preference was given to written questions and position statements submitted by the participants (see Appendix B). The final 20 minutes of the session were devoted to the mechanics of obtaining the participants' ratings on the extent of present knowledge and the research or action priority for the keyword topics (see Chapter 11, Subsection 11.0.2.2 for details on the ratings, and see Appendix C for a complete listing of all keywords according to session).

1.2.5.2 Summary session. On the third morning, each chairman presented a 20-minute summary of his session in which he integrated the major points from his own review with the major results of the keyword ratings. (The final versions of the summaries of the ratings are presented in Chapter 11, in conjunction with tables of the means and standard deviations.)

In order to reduce the keyword rating data in time for presentation during this summary session, a remote terminal was installed at Sugarbush Inn which enabled us to use the University of Vermont Computer Center for the preliminary analyses. Accordingly, the Symposium staff diligently began reducing and entering the rating data as soon as available after each session. In view of the large number of entries and the relatively slow output of the terminal, several very loyal staff members worked through the nights to meet the scheduled deadline.

1.2.5.3 Forum Discussion. The final session of the Vermont Symposium was held on the third afternoon and was designated as a forum discussion. Its two-fold purpose was to provide an opportunity: (1) for officials from the two most relevant federal agencies to offer their impressions of the Symposium material, as well as its relation to their agencies' programs, and (2) for the participants to raise questions and discuss these programs, especially in relation to the material presented at the Symposium. The two position papers were given by Dr. Robert B. Voas, representing the Office of Alcohol Countermeasures, National Highway Traffic Safety Administration, and Dr. Albert A. Pawlowski, representing the National Institute on Alcohol Abuse and Alcoholism. These two papers and the ensuing discussion are presented in Chapter 10.

During the final 20 minutes of the Forum Discussion, the participants were asked to evaluate each component of the Symposium by completing a 25-item questionnaire. The Evaluation Questionnaire and the means and standard deviations of the ratings for each component are presented in Appendix D.

1.2.6 POST-SYMPOSIUM REVIEW MEETING

The members of the Planning Committee who had attended the pre-symposium meeting (the reviewer-chairmen, project director, and representatives of DOT) convened again in early December, 1972, after the transcriptions had been distributed to them, in order to review all aspects of the Symposium and the final report: the topical reviews, summaries, and discussions; and the keyword ratings, especially those concerning priorities for future research.

1.3 WELCOME TO SYMPOSIUM

M. W. Perrine

Vermonters have a reputation for do-it-yourself independence and frugality. So instead of inviting a renowned -- and expensive -- dignitary from some foreign state to offer a few words of welcome this morning, I decided to do it myself. I am Bud Perrine.

It is a special pleasure to welcome all of you to the Vermont Symposium on Alcohol, Drugs, and Driving. Some of you are old friends and some are more recent acquaintances. But some of you have previously been known only as names on articles and books; and now I have the opportunity to meet you individually as the real person behind the author's name. It is gratifying that others also share this experience.

Last night, for example, I was talking with Rudy Mortimer and we were joined by Bob Borkenstein, whom I assumed knew everyone here and was also known by everyone here. Therefore, I didn't bother interrupting the conversation with needless introductions since I assumed that they obviously knew each other. But then it occurred to me that I must be wrong when they began introducing themselves. Bob responded to Rudy's name with some associations to Mortimer and Snerd and Bergen and McCarthy, comments Rudy has doubtless heard many times over the years. But having set the stage beautifully, Bob was then ready for his bon mot: "Oh, of course, you must really be the Mortimer of the Mortimer Test!" (which, of course, Rudy is).

So names become people, and that is really the main purpose of the informal atmosphere we have tried to create here so that you, who know of each other only through research efforts, publications, and various program activities, will have an opportunity to know each other personally, as human beings. Hopefully during the course of this informal, but guided Symposium, you will have the opportunity to exchange, not only ideas, but values. Knowing each other more as human beings should also increase the fecundity of future interactions and research and program activities.

We are running a bit late and I will therefore postpone talking about the historical background of the Symposium and the mechanics of the program until after our first speaker. I have asked Dr. Robert Voas to say a few words of introduction by way of structuring the general context within which we are meeting. Most of you know Bob as a very, very active member of the alcohol programs at the National Highway Traffic Safety Administration of the Department of Transportation. Bob has been with the alcohol programs there since about 1969, and his activity level increases and increases and increases. In fact, I am pleasantly surprised to find him actually here with us this morning, since he spoke at a dinner in New York last evening. Now, a few words of introduction from Bob Voas.

1.4 OPENING REMARKS AT SYMPOSIUM

Robert B. Voas

There are three cardinal principles of running good research programs on the part of university people who wish to have continued support from the government. The first principle is to minimize the demands on the time of a government contract monitor. Secondly, never embarrass the government monitor by asking him what the goals and objectives of the research program are. And third, never, but never, require anything of him before 9:00 a.m. in the morning. I think Bud has violated all of these. I will try to overlook this and see what I can do.

Some of my colleagues in our office who are operational program managers allege that no matter how well you fund a research project, and how much time you allow the research investigator, his report's conclusion will be the same -- more research is required! This symposium is designed to legitimize this conclusion. However, we hoped to add to this result more precise information on specifically what kind of research is required, particularly in relationship to a set of practical requirements for government programs working in alcohol and drugs in relation to highway safety.

Perhaps it would be helpful if I distinguish between the two principal ways in which the federal government supports research. One approach, perhaps best exemplified by the National Science Foundation and the NIMH, is to allow the research professionals themselves to propose programs by submitting detailed proposals. The most effective of these are then selected by a review committee made up of outstanding scientists outside of the government. In this way, the government attempts to promote science by allowing the scientists themselves to submit ideas and select those ideas which appear to have the most merit. Another approach is exemplified by the NASA and our own National Highway Traffic Safety Administration. This procedure requires that the government develop a research program. This program must then be broken down into units of work and the scientific professionals solicited to take on these individual projects. In concept, this procedure insures that the government receives research results that are directed very specifically at the problems that the government sees itself facing.

Since it is this latter method which is used by the NHTSA, the purpose of this symposium is to get your input into the development of a long-range program of research in alcohol and drugs. This must be done, of course, in terms of the practical realities we face in our program operations. Those of us in government should be aware of any of those realities as a result of our day-to-day work. However, we recognize that we are not fully aware of the status of the research in alcohol and drugs in relation to highway safety and how that research might relate to our operational programs. Thus, the purpose of this symposium is to bring together those of you who have been most actively working in research and in evaluation of countermeasure programs to assist us in developing a program of research for the future.

The report that will come out of this symposium will not only be a guide to those of us who are involved in day-to-day operations, but will also be used as a basis for estimating future budget requirements. Therefore, it must be a document, which while sound and complete in terms of its scientific background, speaks not just to researchers, but to program administrators and ultimately to the members of Congress, or at least to their staffs. It must describe what the research needs are, why these needs exist, and develop a detailed program of research.

We are in a unique position at this time because alcohol and drugs are currently two of the major areas of interest to the public, the Congress, and the Administration. They are prepared to support sound programs in these areas. They also, however, are taking a very hard look at results. Unfortunately, there have been many highway safety programs whose results have been not very tangible. At all levels of Government, including the Congress, there is a very great concern that future activities be evaluated. And so, while there is a readiness to support as never before, there is also a strong need at all levels to take a very hard look at the scientific justification for the program proposed.

We hope you will prepare us a report which comes as close as possible to satisfying the requirements as you see them for research in the field of alcohol and drugs in relation to highway safety. We hope you will be able to defend your recommendations effectively through your knowledge and background in the research field. We hope your report will be forcefully and effectively presented to an audience, not just of scientists, but also of administrators.

Chapter 2

ALCOHOL INFLUENCES UPON DRIVING-RELATED BEHAVIOR:

A Critical Review of Laboratory Studies of Neurophysiological, Neuromuscular, and Sensory Activity

M. W. Perrine

ABSTRACT

Do alcohol influences upon performance in laboratory tasks have any valid transfer to real-world driving behavior? Laboratory studies of basic psychophysiological functions assumedly relevant for on-the-road driving performance were reviewed critically in terms of susceptibility to alcohol influences and individual differences.

Understanding alcohol influences upon more complex behaviors (e.g., perception, attention, or even driving performance) can be facilitated by developing a relevant neurophysiological model; two important interrelated issues for such a model were reviewed: (a) the actual site of alcohol effects in the nervous system, and (b) the apparent biphasic effects of alcohol.

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) from .08% to .15%.

Sensory activity: six reviewed aspects of vision are arranged in order of decreasing susceptibility to low and medium BACs: (a) dynamic visual acuity, (b) adaptation and brightness sensitivity, (c) critical flicker fusion, (d) static visual acuity, (e) glare resistance and recovery, and (f) visual field. Only the first three aspects showed significant impairment at medium BACs.

Methodological issues: interrelations of variability and validity were discussed. Alcohol increases variability in many physiological and psychological response measures, even when the means are not significantly changed. Thus, are there unequivocally valid indicators of alcohol impairment which can be used to specify the criteria for "impairment"?

1. INTRODUCTION

The present paper is deliberately addressed to a thorny question which is neither original nor specifically limited to the particular topic under considera tion: "Do alcohol influences upon the performance of some task observed in a scientific laboratory have any meaningful transfer or implications for real-world behavior, such as driving?" Even if this question can be answered in the affirmative, it is quickly followed by a second and perhaps more demanding question: "To what extent is extrapolation from laboratory to highway warranted and valid?"

It would be presumptuous to suggest that the present review of laboratory studies of alcohol effects will provide definitive answers to these questions, but it is expected that this selective review will at least provide a heuristic focus for future research efforts which will hopefully be more productive, more systematic, and more concerted than has typically been the case in the past. Perhaps more so than with any other specialty in behavioral science, the alcohol literature seems to be cluttered with the bones of isolated, poorly controlled, one-shot studies by investigators who were probably just curious about what happens when alcohol is simply added as a treatment condition in an area of research which they had already been pursuing. Thus, the greatest single need appears to be a willingness on the part of investigators to develop and then to pursue a line of research in sufficient depth to permit definitive statements to be made about the particular topic or subtopic which they are examining.

2. INVESTIGATED INFLUENCES OF ALCOHOL UPON BEHAVIOR

Those aspects of behavior which have been examined experimentally in laboratory studies in terms of alcohol influences are presented in Table 1. Although these behavioral aspects differ greatly in degree of assumed relevance for driving performance, they are nevertheless listed more or less exhaustively in an attempt to provide an overview of the scope of previous laboratory research on alcohol effects, as well as to provide a keyword description of the topical population of laboratory experiments from which the driving-relevant behaviors and studies can be selected. The behavioral aspects listed in Table 1 are arranged in general order of increasing susceptibility to individual differences and to alcohol influences; thus, in one sense, these behavioral aspects seem to fall along a crude scale which could be defined as ranging from the relatively "simple" to the relatively "complex" processes.

A number of reviews of the alcohol and behavior literature have been published over the years, ranging from the very comprehensive review by Jellinek and McFarland (1940) and other earlier but less extensive reviews (Darrow, 1929; Marshall, 1941), to the series of four articles appearing in French in the 1946 edition of Schweizerische Medizinische Wochenschrift (cited in Wallgren & Barry, 1970, p. 276), to the more specialized and recent reviews by Begleiter and Platz (1972); Carpenter (1962, 1968); Carpenter and Armenti (1972); Kalant (1970); Martin (1970); Naitoh (1972); the Secretary of Health, Education, and Welfare (1971); and Williams and Salamy (1972); but by far the single most comprehensive review yet published is that of Wallgren and Barry (1970), to whom the writer is greatly indebted for selected aspects of the present paper.

3. INFLUENCES OF ALCOHOL UPON DRIVING-RELEVANT BEHAVIOR

Behavioral aspects assumedly relevant for on-the-road driving performance have been selected from the list in Table 1 and divided more or less equally and sequentially among the writers of this and the next two reviews (H. Moskowitz, and H. Barry, respectively). Accordingly, the present paper is primarily concerned

TABLE 2-1

Aspects of Behavior which have been Examined

in Laboratory Studies in Terms of Alcohol Influences

1. NEUROPHYSIOLOGICAL ASPECTS
   - Autonomic nervous system function
   - Central nervous system function

2. NEUROMUSCULAR ASPECTS
   - Muscle strength
   - Manual motor control
   - Walking steadiness
   - Standing steadiness

3. SENSORY ASPECTS
   - Color vision
   - Static visual acuity
   - Visual field
   - Glare tolerance and recovery
   - Adaptation
   - Brightness sensitivity
   - Critical flicker fusion
   - Dynamic visual acuity

4. SENSORY MOTOR ASPECTS
   - Ocular motor
   - Sensory motor coordination and speed
   - Tracking (pursuit and compensatory)
   - Simple reaction time
   - Choice reaction time

5. VISUAL PERCEPTION
   - Visual search
   - Detection
   - Discrimination
   - Recognition
   - Identification
   - Suggestion

6. ATTENTION
   - Intensive or concentrated attention
   - Selective attention
   - Divided attention

7. MEMORY
   - Short term
   - Long term

8. LEARNING

9. COGNITION
   - Verbal performance
   - Problem solving
   - Decision making
   - Risk taking

10. MOTIVATION

11. EMOTION AND MOOD

with the first three categories in Table 1, namely: (1) neurophysiological aspects of behavior; (2) neuromuscular aspects of behavior; and (3) sensory aspects of behavior. The following paper by Moskowitz is concerned with the next three categories: (4) sensory motor aspects of behavior; (5) visual perception; and (6) attention. The third companion paper by Barry is concerned with the remaining five categories: (7) memory; (8) learning; (9) cognition; (10) motivation; and (11) emotion and mood.

Regarding the organization of the present review, the selected behavioral aspects are presented in the same order of generally increasing susceptibility to individual differences and alcohol influences as in Table 1. However, specific functions or subcategories within each of these major categories of behavior are not necessarily ordered within the particular subsection of the review on the basis of assumed increase in susceptibility. Furthermore, within each category of behavior presented in the following discussions, empirical results which are based upon measures of central tendency (and which therefore are assumedly normative or "typical") are presented first, and then individual differences are considered to the extent that relevant experiments have been found in the literature. In an effort to focus upon factual knowledge in this review, studies which were especially lacking in experimental rigor have been excluded, even though they would otherwise have been very relevant.

3.1 Neurophysiological Aspects

Investigations of alcohol effects upon neurophysiological activity may seem at first glance to bear no direct relation to real-world driving performance and thus to be clearly beyond the scope of the present paper. However, an understanding of the influences of alcohol upon more complex behaviors such as perception or attention can be facilitated: (1) by developing a relevant neurophysiological model; (2) on that basis, by tracing back from the observed complex behavior to alcohol effects at the neurophysiological level; and (3) by then being able to specify the exact alcohol effects upon the particular neurophysiological correlates of the observed complex behavior. Therefore, a brief sketch of key issues for a neurophysiological model, as well as a review of the more salient, recent findings from electrophysiological studies of alcohol influences should provide both a challenge and a stimulating basis for the subsequent examination of alcohol effects upon driving-related performance. The challenge derives from the sharp controversies surrounding some of these recent findings and the fact that there is currently no general consensus among the limited number of researchers in this area. Nevertheless, the neurophysiological literature has been reviewed and the key issues summarized here in an effort, not only to provide a stimulating (and perhaps controversial) basis for the present papers, but especially to stimulate and focus future research, discussions, and attempts at building more useful, more valid models.

Two neurophysiological issues seem to be particularly relevant for understanding alcohol influences upon driving performance, especially in terms of individual differences. The first issue concerns the actual site of alcohol effects in the nervous system, whereas the second concerns the basis for the apparent biphasic responses to alcohol.

3.1.1 Site of Alcohol Effects

Regarding the first neurophysiological issue, an appreciable amount of evidence has been reported suggesting that the reticular activating system (RAS) is the single most important component of the central nervous system in terms of susceptibility to alcohol influences upon its functions, as well as in terms of the mediation (and perhaps magnification) of those influences to the other components of the central nervous system which the RAS regulates and integrates.

Of greatest importance for the present discussion is the crucial role which the RAS plays in the control of arousal and attention, as well as in the regulation of excitation and inhibition at lower levels of the central nervous system. If the current conceptualization of RAS function is correct (namely, that its activation is a necessary intermediate condition for cognitive responses at the cortical level to sensory stimulation at the peripheral level), then the relative susceptibility of RAS function to influences of increasing concentrations of alcohol becomes a crucial issue in attempting to understand the effects of alcohol upon such complex behaviors as driving which necessarily involve the integrative functions of the RAS to a great extent. Accordingly, the decrement in the complex behavior manifested under alcohol must be in part a function of the relative alcohol effects upon the RAS, at least to the extent that this component of the nervous system is involved in the complex behavior (in this case, driving). However, this postulated relation can doubtless be enhanced or reduced by the influences of alcohol upon other components of the nervous systems. For example, it is assumed that the influences of alcohol upon hypothalamic function will be reflected as changes in motivation, mood, and emotion which could in turn either facilitate or inhibit the influences of alcohol upon the integrative and arousal functions of the RAS. Furthermore, it is possible that the RAS functions are affected at lower blood alcohol concentrations than are the hypothalamic functions, but as yet there are very few empirical data to support this view.

Basic agreement that RAS function is influenced even by low concentrations of alcohol is found in five recent reviews (Himwich & Callison, 1972; Kalant, 1970; Maling, 1970; Wallgren & Barry, 1970; Williams & Salamy, 1972). In fact, Maling (1970) goes so far as to state that "like the barbiturates and other general anesthetics, alcohol depresses first the reticular activating system. Release of the cortex from the integrating action of the reticular activating system disrupts the smooth operation of motor and thought processes (p. 278)." On the basis of his review of the few relevant animal studies, Kalant (1970) states that:

> Caspers (1958) noted a considerably earlier and greater depression of excitability by ethanol in this system... (the RAS)...than in the cortex..., and Ohga (1962) demonstrated a much greater increase in threshold for local electrical stimulation in the midbrain reticular formation than in any other site explored. Further, the cortical arousal response to stimulation of peripheral nerves, or of the midbrain reticular formation, is inhibited at alcohol levels which do not depress direct cortical excitability or the recruiting response to stimulation of the diffuse thalamic projection system. . .(Caspers, 1958; Story et al., 1961; Ohga, 1962; Himwich et al., 1956) (Kalant, 1970, pp. 210-211).

The importance of the above conclusions for the subsequent section concerning attention should be briefly noted at this point. It is commonly assumed that alcohol reduces, limits, or impairs attention. If attention is mediated primarily by the RAS, then one would hypothesize that the primary effect of alcohol upon attention occurs at that level and that this effect would be manifested as an impairment of attention. However, evidence for a uniformly depressant action of alcohol upon the various categories of attention is equivocal (an issue which is also discussed by Moskowitz in the section on attention). Nevertheless, the results of these studies -- however equivocal -- have important implications for relating the effects of alcohol to the possible neurophysiological correlates of attention. For example, one might speculate as follows: (1) that the reticular formation is affected at a lower blood alcohol concentration than the visual cortex; (2) that therefore the visual sensory functions measured with intensive-attention tasks require relatively little neural integration, are relatively less influenced by changes in RAS levels of functioning, and thus are controlled primarily at the cortical level; and (3) that the perceptual/cognitive functions measured with divided-attention tasks require relatively much more neural integration, are relatively much more influenced by changes in RAS activity and level of functioning, and thus may be said to be controlled primarily at the lower subcortical level of the reticular formation. Thus, it may well be that divided attention, but not intensive attention is largely mediated by the reticular formation. It should be emphasized that the validity of these inferences is in great need of empirical research. (No data are currently available concerning individual differences in alcohol effects upon RAS function.)

Regarding cortical function, the few human experiments concerning the effects of alcohol upon evoked visual or auditory responses have produced a fascinating basis for further speculation (Begleiter & Platz, 1972). Alcohol has been reported to decrease the intensity of the alpha suppression caused by either visual or auditory stimulation (Khristozov & Atsev, 1960) and to reduce the amplitude of the auditory evoked response without affecting either its latency or duration (Gross, Begleiter, Tobin, & Kissin, 1966). Unfortunately, it was impossible in these studies to determine whether the effects of alcohol were upon the direct sensory pathways or upon the reticular formation itself. Even more far-reaching implications could be drawn from results reported by Beck, Dustman, and Sakai (1969) in their discussion of electrophysiological correlates of selective attention:

> The effects of alcohol ingestion on the amplitude of the visual and somato-sensory evoked response . . . (Lewis, 1968) . . . shows trends peculiarly similar to what is encountered in the retarded and mongoloid subjects . . . .(namely, no hemispheric differences in evoked responses). . . .. With alcohol ingestion of moderate amounts, 1-3 ounces, there is a general attenuation of the amplitude of late components of the evoked response in parietal areas. However, the attenuation is most marked in the right parietal area. The assymetry of left and right parietal responses, seen in most normal subjects, disappears with mild intoxication; both hemispheres become equal in amplitude.
>
> We feel a common denominator of these later studies may be the level of attentiveness, namely, normal and bright children are by definition more attentive than dull or mongoloid youngsters; alcohol is a depressant and level of attention is probably reduced after ingestion; during counting or conditioning the level of attention is most probably increased. In all these instances there is a marked change in amplitude and stability of the evoked response recorded from the right parietal scalp in the

> same direction as the level of attention. The findings are clear and reliable but the explanation is obscure. (Beck et al., 1969, p. 412).

It would seem appropriate to conclude the discussion of this first issue regarding the locus of alcohol effects with a summary statement ventured by Kalant (1970) at the end of his review of the literature on acute intoxication from small, medium, and large doses of alcohol:

> The picture of acute intoxication produced by increasing concentrations of alcohol in the blood is one of simultaneous impairment of functions attributed to cortical and various subcortical levels of the central nervous system. Instead of a progression of effect from the cerebral cortex downward, there appears to be a progression of effect at all levels concurrently, with the preponderence of effects being subcortical. (Kalant, 1970, p. 192).

3.1.2 Biphasic Effects of Alcohol

The second neurophysiological issue concerns the apparently paradoxical effects of alcohol at different concentrations in the body, such that opposite effects are manifested at low concentrations in contrast to the effects on the same aspect of activity at medium or high concentrations. Numerous physiological investigations have provided evidence for these so-called "biphasic" effects of alcohol on many levels of neural activity, including excitability of nerve cells, peripheral nerves, nerve-muscle junctions, muscle fibers, neuronal and synaptic membranes (Grenell, 1972), and neurons in the central nervous system, as well as certain aspects of the sensory-motor systems. "Low concentrations decrease the excitation threshold but rising concentrations change the effect to depression and finally complete blockage (Wallgren & Barry, 1970, p. 254)."

The relevant issue for the present paper concerns the basis for, and the validity of these reported biphasic effects of alcohol at the neurophysiological level because of their influence upon, and implications for more complex behavior, especially that of driving after drinking. The most parsimonious explanation for the observed excitatory or facilitative effects of alcohol upon neurological activity is that alcohol is consistently a neural depressant and therefore that the apparent stimulating or facilitating effects are probably due to the depressant action of alcohol upon some inhibitory mechanism. In other words, alcohol can be assumed to depress and thus to disinhibit some inhibitory mechanism. This view of alcohol as a disinhibitor of inhibitors finds empirical support in the literature at the neurophysiological as well as at the complex behavioral level, but this view is nevertheless not universally accepted by all alcohol investigators. In his subsequent companion paper, Barry espouses the opposing depressant and disinhibitory actions of alcohol to account for its influences upon the more complex motivational and cognitive aspects of behavior.

Although alcohol is generally considered psychopharmacologically to be a central nervous system depressant, this view may represent too great an oversimplification of the available data. On the basis of their review of the electrophysiological literature, especially considering the differential alcohol effects upon excitatory and inhibitory pathways, Wallgren and Barry (1970) offer the following summary:

> In electroencephalogram (EEG) recordings from the scalp in humans and various species of animals, alcohol decreases frequency and increases amplitude of alpha activity, indicating preponderantly depressant effects, but a few observations suggest slight stimulant effects at low doses. High doses induce delta activity. In studies of direct stimulation and recording with acutely and chronically implanted electrodes in animals, alcohol enhances response to direct stimulation in some localized structures according to several reports, but the preponderant findings are depressant effects, even at low doses. Moderate doses of alcohol increase cortical excitability, due to direct action and to weakening of the inhibitory activity of the reticular formation. Ethanol in moderate doses has a weak tendency for selective depression of inhibitory systems in the brain. Alcohol depresses the activation level, but after low and moderate doses, temporary arousal can be induced both by sensory stimulation and direct stimulation of the reticular formation. Although the reticular formation and certain cortical structures have been shown to be particularly sensitive to the effects of alcohol, the depressant effects of high doses are generally diffuse and widespread without sharp differences among areas of the central nervous system. There has been no adequate study of effects of alcohol on the cerebellum, in spite of the important role of that brain structure in the control of motor behavior (Wallgren & Barry, 1970, pp. 314-315).

It has also been suggested that the apparent excitatory influences of alcohol at lower doses may be due to attempted compensatory activity on the part of the organism to off-set the sedating depressant actions of the drug, similar to the initial responses to anesthesia (John Sterns, personal communication, 1972).

Regarding the influences of alcohol upon motor behavior and upon the functions of the various sensory-motor systems, Wallgren and Barry (1970) conclude that:

> ...alcohol selectively suppresses the inhibitory more than the excitatory function, but this selectivity is not very marked. Measures of simple motor reflexes and chronaxie of muscular responses generally indicate a greater depressant action of alcohol on flexor than on extensor muscles, but findings have been inconsistent. Since the effects of alcohol on peripheral nerves and on the muscles are rather slight, the disturbances in motor performance observed with intoxicating doses of alcohol are probably due mainly to central effects (Wallgren & Barry, 1970, p. 314).

Finally, the results of these neurophysiological investigations concerning the biphasic effects of alcohol and its site of action in the body have important implications for the more complex behaviors which are discussed in the following papers by Moskowitz and by Barry. Of greatest importance for the present paper, however, are the influences of medium (.05% to .08%) blood alcohol concentrations upon the arousal and the integrating functions of the reticular formation, on the one hand, and upon the emotional and motivational functions of the limbic system (especially the hypothalamus), on the other.

3.2 Neuromuscular Aspects

Ataxia and increased body sway are generally taken to be symptomatic of acute alcohol intoxication. In fact, the Romberg standing steadiness test is doubtless the most frequently used neuromuscular measure of alcohol effects, both in police stations and in research laboratories. Wallgren and Barry (1970) state that:

> One of the most sensitive measures of detrimental effects of alcohol is the Romberg test, in which the subject is instructed to stand as steadily as possible with the eyes closed, so that the kinesthetic and vestibular senses provide the only sensory information. The amount of swaying is usually recorded, either photographically from above or mechanically with the aid of attachments to the shoulders (Wallgren & Barry, 1970, p. 309).

Despite the availability and use of other neuromuscular measures (e.g., finger-to-finger test, finger-to-nose test, hand or finger steadiness tests, picking up objects from the floor, walking steadiness test), the reviewing for this subsection was primarily limited to an examination of alcohol influences upon body sway for three reasons: (1) standing steadiness is relatively susceptible to the influences of alcohol; (2) it lends itself relatively well to the precision of quantification necessary for scientific investigation; and (3) the utility of the other major possibility -- walking steadiness tests -- is apparently greatly limited by the relatively small decrement in performance observed at low and medium blood alcohol concentrations (under .10%), as well as by the difficulty in obtaining objective measures of the degree of the detrimental effects of alcohol (Wallgren & Barry, 1970, pp. 312-313).

The few more recent studies (Kelly, Myrsten, Neri, & Rydberg, 1970; Schneider, 1972) which have appeared since the last review (Wallgren & Barry, 1970) also substantiate the fact that swaying is very sensitive to alcohol effects. Therefore, the major questions remaining for present purposes concern: (1) the threshold BAC at which swaying begins to manifest appreciable increase, and (2) the BAC at which all subjects show a significant increase. Regarding the latter question, most investigators who use the standard Romberg test in laboratory experiments report significant increases in sway at BACs ranging from .075% (Fregly, Bergstedt, & Graybiel, 1967), .08% (Ideström & Cadenius, 1968), .10% (Goldberg, 1943), to .12% (Kelly et al., 1970). It should be noted that in the one study (Fregly et al., 1967) in which variability data were presented, the standard deviations for some subjects were very large even at the lower BAC (.075%), but especially at the higher BAC (.095%). Nevertheless, it would seem safe to conclude that all subjects would manifest appreciable sway under laboratory conditions at BACs of .10% or higher. However, in real-world conditions when the person is in jeopardy of being convicted for driving while intoxicated, it appears that many individuals are capable of mustering sufficient self-control to override the influences of alcohol upon body sway. For example, Wallgren and Barry (1970) summarized the results of two very relevant studies as follows:

> Laves (1955), in tests of 100 people accused of drunken driving, found that among those with blood alcohol levels of 0.10 - 0.15% more than half swayed perceptibly in the Romberg test, whereas less than 25% showed changes in any of his other measures of motor performance. Contrary to these reports, Prag (1953), in a study of 100 automobile drivers charged with intoxication, reported no observations of swaying in the Romberg test at blood alcohol levels below 0.2% (p. 311).

The first question regarding the threshold value of BAC at which swaying first manifests appreciable decrease is much more difficult to answer on the basis of available experiments. Using the standard Romberg test, Goldberg (1943) reported a threshold BAC of .065%, but Idestrðm and Cadenius (1968) found essentially no increase in sway at BACs of .04%. Using a modified version of the Romberg test (one foot placed in front of the other) which is even more sensitive to the effects of alcohol, Goldberg (1943) reported a threshold BAC of .041%, whereas Idestrðm and Cadenius (1968) reported no appreciable increase in sway at .04%. Thus, one can conclude that for the standard Romberg test under laboratory conditions, the threshold BAC lies in the vicinity of .06%, whereas with the modified Romberg test, it may lie between .04% and .05%. Clearly, the issue can only be decided by a more systematic parametric investigation than has been published to date.

The validity and utility of the standing steadiness tests for enforcment purposes are discussed below in Section 5.

3.3 Sensory Aspects of Vision

Of all the modalities, vision is generally assumed to be the most important for driving behavior. This consensual importance probably derives from at least two major considerations: (1) the vast majority of relevant information for successful driving performance is obtained by means of the visual modality; and (2) impairment of driving performance is felt to be more directly related to impairment of vision than of any other single modality, a point which becomes completely obvious in the extreme case of total impairment, or blindness; that is, the absence of no other single modality would place a greater limitation on driving ability than would the absence of vision. Accordingly, the remainder of the present paper is primarily concerned with the visual modality.

Fortunately, some of the relations between vision and driving have already been systematically examined by Burg (1970) in an on-going, longitudinal comparison of visual performance with three-year driving records of an enormous sample of California drivers (N = 14,215). Seven aspects of visual function were tested: dynamic visual acuity, static visual acuity, horizontal visual field, horizontal phoria, low-illumination vision, glare recovery, and eyedness or sighting dominance. The criterion measures for driving performance were crashes and convictions for traffic citations incurred over a 36-month period. On the basis of correlational and multiple regression analyses, Burg concluded that:

> Among the vision variables studies, DVA... (dynamic visual acuity)...shows the strongest and most consistent relationships with driving record. These relationships are in the 'expected' direction, i.e., poor vision is associated with poor driving.

> There is substantial but not conclusive evidence that static visual acuity, visual field, and possibly glare recovery also are related to driving records, again in the expected direction (Burg, 1970, p. 65).

Regarding alcohol effects upon the visual modality, two recent reviews indicate that the more simplex visual functions are relatively insensitive to the influences of alcohol (Honegger, Kampschulte, & Klein, 1970; Wallgren & Barry, 1970). In fact, Honegger et al. (1970), who have conducted the only known investigation of alcohol effects upon dynamic visual acuity, even go so far as to offer the following summary statement:[1]

> The retinal functions are either not at all impaired by alcohol or are not substantially impaired by alcohol. This is true especially for visual acuity, color vision, visual field, dark adaptation, twilight vision, and pupillary sensitivity. These retinal functions are tested during the examination for driving ability. In contrast, alcohol produces a sustained disturbance in visual motility, not only in that the binocular interaction is broken off, but also that the monocular course of movement is affected (Honegger et al., 1970, p. 31).

Accordingly, the following review of alcohol studies emphasizes static and dynamic acuity, visual field, dark adaptation, brightness sensitivity, glare resistance and recovery, and flicker fusion.

3.3.1 Static Visual Acuity

Static visual acuity refers to the human ability to distinguish relatively small spatial separations; and this ability to discriminate relatively small spatial intervals in non-moving objects is typically tested by means of the Snellen chart (using letters of the alphabet), the Landolt ring (detecting the orientation of a small break in an otherwise solid ring), the Bausch and Lomb Ortho-Rater, etc. Acuity is usually determined for each eye separately and for both near and far objects. No impairment of static visual acuity has been obtained at low blood alcohol concentrations (Brecher, Hartman, & Leonard, 1955; Colson, 1940; Marquis, Kelly, Miller, Gerard, & Rapoport, 1957; Mortimer, 1963). Some impairment in some subjects is obtained with medium blood alcohol concentrations ranging from .05% to .08% (Brecher et al., 1955; Colson, 1940; Mortimer, 1963; Newman & Fletcher, 1941; Seehafer, Huffman & Kinzie, 1968; Verriest & Laplasse, 1965). However, impaired visual acuity was reported for an increasing proportion of subjects at higher blood alcohol concentrations; for example, Newman and Fletcher (1941) report impairment in 85% of subjects whose blood alcohol concentrations ranged between 101 and 125 mg%.

In summary, it would not seem that a very large proportion of adults suffer impairment of static visual acuity until blood alcohol concentrations well in excess of .08% have been reached.

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[1] Responsibility for inaccurate translation of substance or nuance from the original German text rests with the present writer.

3.3.2 Dynamic Visual Acuity

Despite both the obvious and the demonstrated significance of dynamic visual acuity for successful driving performance, only one experiment is known in which the influences of alcohol upon this important visual function were investigated. Honegger et al. (1970) used a visual tracking situation in which a single letter was projected on a screen and then rotated in a circle about the screen at selected speeds. The independent variables were stimulus size and rotation speed. With a target blood alcohol concentration of .10%, a dose of 1 g. of alcohol per kg. of body weight was mixed with fruit juice and was consumed within 30 minutes. Dynamic visual acuity measurements and blood samples were obtained five times, the first measurement being taken immediately upon cessation of drinking, the subsequent two measurements being taken at 30-minute intervals, and the last two measurements being taken at 1-hour intervals.

A two-way analysis of variance indicated that visual acuity for moving objects is time-dependent, that is, the acuity is significantly reduced during the alcohol diffusion stage and yet begins to improve during the alcohol equilibrium stage. In fact, the point of greatest decrement in visual acuity for moving objects was obtained 30 minutes after cessation of drinking and at blood alcohol concentrations as low as .02% in some subjects. It is interesting to note that the authors report that dynamic visual acuity was already impaired before the subjects reported subjective feelings of alcohol effects. Thus, motoric coordination of binocular motility or visual tracking accuracy was significantly impaired in all subjects at blood alcohol concentrations up to .10% and in some subjects at blood alcohol concentrations as low as .03%.

Honegger et al. (1970) suggest that a disturbance of visual acuity for moving objects is not only important in that rapidly moving objects are less well recognized, but also, at a more general level, that accurate ocular motoric coordination is inadequate. They conclude that in such a case the general orientation in space is also impaired, which has serious implications for driving performance in that both fixation and tracking movements are more inaccurate and poorly coordinated and that therefore the alcohol effects place such a driver in greater danger (Honegger et al., 1970, p. 43).

Compelling as these data and interpretations may be, the exact relation between dynamic visual acuity as tested in the laboratory and actual driving performance must be investigated systematically, both with and without alcohol. Fortunately, the strong relation between dynamic visual acuity and driving record reported by Burg (1970) provides a very promising basis upon which to pursue these suggested investigations.

3.3.3 Visual Field

The results of the four known studies of alcohol influences upon the extent of sensory responsiveness of the horizontal visual field can be summarized quite simply: even relatively high doses of alcohol do not appear to cause any appreciable reduction in the extent of the lateral visual field in terms of sensory sensitivity. The fact that these four studies appeared within a few years of each other some 30 years ago provides silent testimony to the brief interest in the topic and to its early dismissal as being unworthy of further investigation at the sensory level (Colson, 1940; King, 1943; Newman & Fletcher, 1941; Peters, 1942). These studies are briefly reviewed by King (1943) and by Wallgren and Barry (1970).

Even though the sensory basis for an alcohol-induced reduction in the extent of the visual field was effectively laid to rest by those four earlier studies, interest in the phenomena of "tunnel vision" or "funnel vision" has enjoyed a relatively recent renaissance in which the emphasis is more appropriately placed upon alcohol-induced changes in the functional visual field during performance of much more complex tasks which typically involve divided attention, that is, visual time-sharing on a foveal and on an extra-foveal task more or less simultaneously. These phenomena are much more relevant for driving performance, but since they involve the more complex processes of attention, they are reviewed under that topic in the following paper by Moskowitz.

3.3.4 Adaptation and Brightness Sensitivity

Brightness sensitivity refers to the ability to detect low intensity targets, and therefore is highly related to the adaptation of the eyes at the time. Adaptation refers to the ability of the visual system to adjust to variation in light intensities across a very wide range.

The majority of fatal highway crashes occurs at night or under conditions of low illumination (Travelers Insurance Company, 1971). Since alcohol is known to be over-represented in drivers and pedestrians involved in crashes during these times, it is particularly important to examine those aspects of visual functioning which are necessary for nocturnal driving and walking, i.e., dark adaptation, sensitivity in low illumination, and glare resistance and recovery.

Regarding dark adaptation and brightness sensitivity, previous reviews generally state that at lower doses (up to .065%), either no alcohol effect or even a slight improvement has been reported. For example, on the basis of Jellinek and McFarland's (1940) praise for an ancient study by Lange and Specht (1915) who used only four subjects and reported a 30% increase in sensitivity to a dim light, it is commonly believed that lower doses of alcohol actually facilitate the ability to detect low intensity targets. In citing that study as well as a few more recent studies which reached the same conclusion, Wallgren and Barry (1970) state: "This evidence that alcohol may improve perception of dim light, while reducing the ability to differentiate among brighter lights, suggests a resemblance of the alcohol effect to dark adaptation (p. 289)." However, irregularities should be noted in at least one of those cited studies in which improvement in dark adaptation at lower alcohol doses was reported, namely, some of the subjects in Yudkin's (1941) experiment apparently suffered from deficient night vision and were selected for that purpose.

A further search of the literature indicates that more recent studies report neither a beneficial effect of small doses of alcohol upon dark adaptation nor upon increased sensitivity to low intensity targets. In fact, several of these recent studies report significant detrimental effects of medium doses of alcohol (.08%) on measures of dark adaptation. More specifically, Lewis (Lewis, 1972; Lewis & Sarlanis, 1970) conducted a pair of experiments to investigate age differences in the effects of alcohol upon the ability to detect low contrast targets under lower (mesopic) levels of illumination. Significant impairment was reported for BACs of .08%, whereas little or no deterioration was found at BACs of 0%, .04%, or .06%. Congruent and analagous results were obtained among the older subjects (50 to 60 years old) and among the younger subjects (21 to 30 years old). Lewis (1972) concluded that:

> Young and old appear to be equally affected by alcohol, but for the older person this effect is being added to a limitation that increases with age (p. 15).
>
> Age ... brought in another variable which strongly suggested that a baseline shift was developing ... (such that) ... As people get older, there is a reduction in pupillary diameter and a loss in retinal sensitivity, which slows their ability to adapt to light changes. Thus, abrupt transitions in lighting may predispose an individual to an accident situation that might have been avoided had he been aware of the phenomenon of dark adaptation and the problems related to it (p. 14).
>
> (These results suggest that an older) individual should demonstrate extra caution in undertaking any task that demands utilization of low contrast visual signals under conditions of reduced illumination after ingesting even moderate levels of alcohol, especially if these activities carry any risk for himself or others (p. 15). (Material in parenthesis added by present writer.)

For the purposes of the present paper, it is concluded that dark adaptation (at least in terms of the detection of low contrast targets) is impaired by BACs of .08% or higher. The alcohol impairment of this visual function is doubtless a contributing factor in nighttime crashes, especially when older persons are involved since they are already operating at a lower level of efficiency in these terms.

3.3.5 Glare Resistance and Recovery

Glare refers to any intense light source which reduces one's ability to make visual distinctions in the surrounding field. Individuals differ in their ability to resist or tolerate glare in terms of being able to continue to obtain useful information in the presence of the bright light source; and they also differ in their ability to recover from the effects of glare.

As in the case of adaptation, it would seem especially important to determine the extent to which alcohol affects glare resistance and recovery, since a disproportionate number of alcohol-involved crashes occur after dark. Despite the possible importance of this question, only a few studies are known in which it has been specifically addressed (Mortimer, 1963; Newman & Fletcher, 1941; Verriest & Laplasse, 1965). The fact that the results of these three studies are not consistent with each other may be attributed in part to the great differences in the tasks and procedures involved.

Using an ascending and descending judgmental procedure, Mortimer (1963) found no significant reduction in glare tolerance at either very low blood alcohol concentrations (.01%) or at medium concentrations (.06%). Using a dose of 0.7 g. of alcohol per kg. body weight, Verriest and Laplasse (1965) report that "alcohol perhaps lowers the resistance to glare in some subjects (p. 99)." Newman and Fletcher (1941) investigated both glare resistance and glare recovery in two separate tasks. At blood alcohol concentrations under .10% (.058% to .099%), only 23% of the 13 subjects in this category were reported to show any major change in glare resistance; and approximately the same proportion of subjects showed major change in the other two categories of higher blood alcohol concentrations. In fact, only 24% of the 50 subjects were reported to show major change at any point across the full range of blood alcohol concentrations obtained (.058% to .218%). Thus, there is no compelling evidence that glare resistance is appreciably decreased by blood alcohol concentrations up to .08%. In fact, even at higher concentrations, the majority of subjects do not show a major decrease in glare resistance.

Perhaps even more surprising results were reported by Newman and Fletcher (1941) for their glare recovery test, on which approximately as many subjects showed an alcohol-induced increase as those who showed an appreciable decrease in the time required to perceive the direction of a dimly lighted arrow after being exposed to a very bright light. Newman and Fletcher reported that the improvement in the recovery from glare was especially prevalent among those subjects with an initially good performance (i.e., without alcohol), and that therefore the apparent facilitating effects of alcohol may be based upon its liberation of Vitamin A from the liver which may actually accelerate dark adaptation.

In any case, none of the data from these three studies provides strong support for a consistent degrading influence of alcohol upon glare tolerance, resistance, or recovery. However, it should be noted in conclusion that these studies involved relatively simple tasks and sensory-level responsiveness; therefore, it is still possible that alcohol actually does contribute to a deterioration in performance on more complex tasks and at higher levels of responding through some combination of its effects at these higher levels plus a concomitant reduction in glare resistance and recovery at the sensory level.

3.3.6 Critical Flicker Fusion

The critical flicker fusion threshold (CFF) refers to the transition point at which an intermittent, rapidly flickering light source is first perceived as being continuous or fused. Accordingly, CFF is used as an index of the temporal resolution or acuity of the visual system, as well as an indicator of central nervous system function and condition. Previous reviewers have offered differing conclusions concerning the effects of medium doses of alcohol on CFF. For example, Carpenter (1962) suggested that these effects are still controversial and largely unresolved, whereas Wallgren and Barry (1970) summarized their review by stating that "alcohol decreases speed of response to a flickering light (lower threshold of critical flicker fusion) (p. 315)."

The experiments in the literature are found to be in general agreement that CFF is impaired at BACs from .07% to .10%. Most of the disagreement between studies is found at the lower BACs, since some investigators report decreases in CFF with BACs as low as .02%, whereas other investigators report no change whatsoever at the lower BACs (.02% to .04%). However, in one very careful experiment (Lewis, Dustman, & Beck, 1969), CFF discrimination was found to be significantly enhanced by a BAC of .03%. It should also be noted that no deficit in CFF was observed in the latter study even at BACs of .06% and .09%. The authors of a more recent study (Tarter, Jones, Simpson, & Vega, 1971) suggest that the rather dissonant results reported by Lewis et al. (1969) can be attributed to having used practiced subjects, the assumption being that practice can mitigate the effects of alcohol. In fact, the variations in results obtained in these studies can be attributed to some combination of differences in practice, experimental design, criteria for judging CFF (both within subject and between subjects), and shifting one's criteria for judgment as a function of alcohol.

In conclusion, the results of the available studies generally indicate that the temporal acuity of the visual system is impaired by BACs of approximately .08%.

4. METHODOLOGICAL ISSUES CONCERNING BEHAVIORAL VARIABILITY IN ALCOHOL RESEARCH

Although behavior is the most important single concept in considering alcohol impairment of driving performance, it is nevertheless extremely difficult to define it precisely and satisfactorily. For that matter, similar difficulties exist in any attempt to define "driving" or even "impairment." The basic problem in all three cases derives not from some idle exercise in semantics, but rather from the facts that: (1) none of these three concepts is unitary and homogeneous in its meaning; (2) each of the three concepts can be subdivided along a vast variety of variables, both situational and structural; and (3) measurement of the components or subcomponents of these three concepts typically shows considerable variability, both within and between individuals. This variability is clearly the greatest single problem for both scientist and administrator and for both theory and practice.

As a minimum, the scientist is concerned with accounting for the causes of variability, whereas the administrator and legislator are concerned with obtaining and implementing procedures (rules, regulations, and laws) which can be enforced without incorporating the potentially debilitating consideration of variability. That is, in the area of drinking-and-driving, the administrator or legislator seeks a yardstick for impairment which will enable him to establish and enforce a single unequivocal norm or cutting point which is valid for all individuals. Unfortunately, such a goal is probably just as unrealistic as it is desirable.

A special responsibility is therefore placed upon the laboratory scientist who conducts alcohol research which has potential implications for drinking-and-driving regulations. He must be concerned not only with the traditional measures of central tendency (such as the mean) for the particular subjects in his experiment (the basis of the normative approach), but he must be especially concerned with the conceptualization, measurement, and reporting of variability. More specifically, the range of his concerns with variability should include: (1) variability associated with increasing concentrations of blood alcohol; (2) variability within a given individual at different points in time, as well as variability between different individuals at a given time; and (3) variability in the investigated behavior itself, without alcohol. Underlying these concerns is the one almost lawful bit of knowledge we do have about alcohol: across a wide variety of investigated behaviors, alcohol increases variability in many physiological and psychological response measures.

Although most investigations of alcohol effects report the mean (or some other measure of central tendency), this approach assumes -- at least implicitly -- that the responses in question are normally distributed, which is not necessarily warranted in the case of alcohol influences on behavior. Such attempts to approximate the true value of the mean for that behavior in order to describe the norm for the particular group or population is certainly acceptable as a beginning of scientific understanding, but in the case of a drug such as alcohol which is known to increase variability in responses, we must now concentrate on being able to specify the parameters and influences of individual differences in these responses as a function of alcohol. In other words, we should now be addressing ourselves to such questions as: (1) How do we account for the variability in alcohol effects in terms of differences within and between individuals; and (2) what are the most important primary and moderator variables that should be considered in trying to account for the observed variability and individual differences in alcohol effects? On the basis of our current knowledge, the following variables would seem to be leading candidates for initial consideration: sex, age (which may be primarily an indication of differential learning or experience), specific experience (such as driving record, drinking patterns, etc.), intelligence, personality, stress, fatigue, and perhaps even such highly specific considerations as differences in time of day or differences in metabolic rate. Further discussions of the importance of individual differences in alcohol effects are presented in some of the subsequent papers, especially those by Barry and by Huntley.

The question of variability in alcohol effects has significant implications for such real-world problems as those involved in drinking-and-driving regulations. For example, legislation involving a "presumptive level of impairment" or "per se impairment" are based upon both an assumed norm as well as certain deviations from the norm. The issue then focuses upon determining the blood alcohol concentration at which all drivers are "impaired." Two very important sets of questions follow from this issue: (1) What are the specific criteria for determining and setting such a cutting score for blood alcohol concentration; and (2) what are the specific criteria for "impairment"? In addressing the first set of questions, we must necessarily consider the problems involved with the proportion of false positives and false negatives obtained from different settings of the cutting score, as well as the problems resulting from various sources of error in method and in measurement, to name just a few of the more important considerations.

The major problems with the second set of questions concerning the criteria for "impairment" arise from the attempt to establish the degrading influences of alcohol under observation in the laboratory and then to treat them as "impairment" for extrapolation to real-world driving. Closer approximations of "impairment" in real-world driving can be obtained by using instrumented cars on closed driving courses (discussed in the subsequent paper by Huntley). Ideally however, we should seek valid indicators of "impairment" of real-world driving (especially in crisis situations) to be obtained by means of unobtrusive measures. This task is obviously exceedingly difficult, but not impossible, and should receive very high priority for future research.

5. DISCUSSION AND CONCLUSIONS

This section serves the combined function of providing: (1) an evaluative discussion of the major issues, and (2) a summary of the main conclusions. For the sake of convenience, this section generally follows the same organization as the material in the preceding sections.

5.1 Neurophysiological Aspects

It was suggested that an understanding of alcohol influences upon more complex behaviors -- such as perception, attention, or even driving performance -- can be facilitated by developing a relevant neurophysiological model on the basis of which we can trace back from the observed complex behavior to alcohol effects at the neurophysiological level and then be able to specify the exact alcohol effects upon the particular neurophysiological correlates of the observed complex behavior. Two key issues for such a neurophysiological model were specified and reviewed in an effort to provide a stimulating (if somewhat controversial) basis for the behavioral papers in this symposium, as well as to stimulate future research and attempts at model building. The first issue concerns the actual site of alcohol effects in the nervous system, whereas the second concerns the basis for the apparent biphasic responses to alcohol. Although treated separately by necessity, both issues are clearly interrelated and should be considered together in the future research.

5.1.1 Site of alcohol effects. The reticular activating system (RAS) was taken to be the single, most important component of the central nervous system in terms of the susceptibility to alcohol influences, upon both its immediate functions as well as its mediated functions. That is, a decrement in complex behavior manifested under alcohol must be -- at least in part -- a function of the relative alcohol effects upon the RAS. Furthermore, it is plausible to assume that RAS functions are probably affected at lower BACs than other important aspects of central nervous system function, such as hypothalamic functions. Accordingly, it was suggested that divided attention (or time sharing), but not intensive (or concentrated) attention is largely mediated by the RAS, which could account for performance on tasks involving divided attention being impaired at lower BACs than performance on tasks involving intensive attention.

Regarding cortical function, alcohol reduces certain cortical responsiveness to incoming visual and auditory stimuli, and therefore may reduce our cortical ability to attend to and to process information, including incoming stimuli. Accordingly, alcohol reduction in cortical responsiveness would manifest itself in observed behavior as impairment of perception, attention, reaction time, etc. Nevertheless, this reduction in cortical responsiveness may be a concomitant or even a result of limitations already imposed by reduced RAS function which, as already suggested, may occur at relatively low BACs.

It is tempting to speculate further and to suggest that some individual differences in the influences of alcohol may be attributable to differences in initial (or baseline) levels of cortical function, such that individuals with a higher initial level of functioning are relatively less impaired by the same BAC as an individual with a lesser baseline capability. The more traditional correlates of such differences in cortical functioning might be differences in intelligence, attentiveness, and even such personality characteristics as sensitizers vs. repressors, or extraverts vs. introverts. It should be noted that these speculations are in great need of further research.

5.1.2 Biphasic effects of alcohol. Alcohol is frequently found to have paradoxically opposite effects at low BACs than it does at medium or high BACs, such that low concentrations seem to be excitatory or stimulating, whereas the higher concentrations yield inhibitory or depressant effects. It was suggested that a more parsimonious explanation for the apparent excitatory effects of lower BACs is that they could be the result of alcohol depression of some inhibitory mechanism, such that alcohol at low concentrations functions as a disinhibitor of inhibitors. It has also been suggested that the apparent excitatory effects of lower BACs may be due to attempted compensatory activity by the organism to off-set the depressant actions of the drug, similar to the initial responses to anesthesia. In this regard, it is important to note that the alcohol effect can apparently be overridden only at the lower BACs. The possible relation between these apparent disinhibitory effects of low BACs and the suggested differential sensitivity of RAS function to the lower BACs must remain a matter of challenging conjecture for the moment.

In any case, if the observed excitatory effect of lower BACs does reflect such compensatory activity by the organism, it would seem analogous to the frequently observed ability of intoxicated individuals to muster reserve resources, pull themselves together, and rise to an important challenge, such as trying to appear very sober to the police officer who has just stopped them for some driving violation.

Finally, it could be said that in one sense, these paradoxically opposite effects of different BACs seem to range from the very simple level of nerve cells to the very complex level of human drinking behavior, at which level the norms in Western culture sanction and even encourage alcohol usage at low doses ("social drinking"), but strongly reject alcohol usage at high doses (problem drinking or alcoholism). Even in that sensitive and highly stigmatized area of driving-after-drinking, we now find ourselves in the position of having to sanction -- or at least implicity to accept -- driving at relatively low concentrations of blood alcohol (which is now labeled "responsible," meaning at least "not irresponsible") in order to provide the necessary aura of credibility to muster sufficient public support for the strong and often personally inconvenient sanctions against driving at medium and high blood alcohol concentrations (which is labeled irresponsible, dangerous, deadly, murder, etc., etc.). Additional implications of the biphasic effects of alcohol for the problem of driving-after-drinking are discussed in the final portion of this section.

5.2 Neuromuscular Aspects

Standing steadiness is generally conceded to be one of the most sensitive behavioral indicators of alcohol intoxication. Furthermore, it seems warranted to conclude that most individuals will manifest appreciable increases in sway using the standard Romberg tests under laboratory conditions at BACs in the vicinity of .10%. Nevertheless, in relation to driving performance, standing steadiness is open to several crucial criticisms which apply equally well to the other neuromuscular measures of alcohol influences (e.g., finger-to-finger test, finger-to-nose test, etc.). In particular, the validity of these various neuromuscular measures for the <u>actual</u> impairment of driving performance has yet to be conclusively established, especially in the relatively controversial (from a judicio-legal point of view) range of blood alcohol concentrations from .08% to .15%. The fact that there may be an established high positive correlation between decrement in performance of the neuromuscular task and the increase in blood alcohol concentration does not in and of itself establish the neuromuscular tasks as unequivocal evidence for impairment in driving performance. It is difficult enough to establish the validity of blood (or breath) alcohol concentration as an unequivocal indicator of driving impairment without attempting to use neuromuscular measures which -- although associated with blood alcohol concentration -- do not lend themselves to the same degree of precision of measurement and which are subject to much greater individual differences, both in baseline performance and in alcohol-influenced performance. Thus, the utility of any of these neuromuscular tasks for the enforcement of drunken driving legislation is extremely limited, especially since it is impossible at the time of testing the allegedly impaired driver to obtain a no-alcohol baseline measure for that particular individual on that particular neuromuscular task.

An additional limitation should be mentioned since it may obviate the use of any neuromuscular task for systematic enforcement purposes. We must differentiate very clearly between data obtained in the scientific laboratory with paid volunteer subjects and measures obtained in the field from individuals who are in jeopardy of a DWI conviction. The investigations by Laves (1955) and by Prag (1953) cited above provide a strong basis for questioning the validity of attempting to use neuromuscular measures of alcohol impairment for anything other than an opportunity for a police officer to interact further with a suspected drunken driver after he has completed the preliminary steps of inspecting vehicle registration and driver's license.

Despite the above limitations and criticisms, further investigation of standing steadiness as a possibly valid indicator of driving impairment would seem to be warranted under certain conditions, the most important of which is the necessity to conduct a systematic series of experiments (with special attention to individual differences) to determine multi-level dose-response functions for the more promising variations of the standing steadiness task (feet together, one foot in front of the other, standing on one foot only, and each of these tasks with eyes open and with eyes closed). Even more important, however, is the absolute necessity to cross-validate such a study with measures of actual driving performance and their specific decrement under alcohol. In this regard, the standard Romberg test (feet together and eyes closed) is apparently not adequate, but further discussion is beyond the scope of the present paper and the interested reader is referred to the extensive review of this topic by Wallgren and Barry (1970, pp. 309-313).

5.3 Sensory Aspects of Vision

Since vision is the most important modality for driving, any visual impairment can potentially be reflected in driving impairment. The six sensory aspects of vision assumed to be the most relevant for driving performance were reviewed and the following conclusions reached:

5.3.1 Static visual acuity: Not a very large proportion of adults suffer impairment until BACs well above .08% have been reached.

5.3.2 Dynamic visual acuity: Some subjects impaired at BACs as low as .02%, but all subjects impaired at .10%.

5.3.3 Visual field: No appreciable reduction in the extent of lateral visual field in terms of sensitivity, even at relatively high BACs.

5.3.4 Adaptation and brightness sensitivity: Significant impairment of dark adaptation at BACs of .08% or higher.

5.3.5 Glare resistance and recovery: No significant reduction in glare tolerance at BACs of .06%; only a quarter of the subjects suffered reduced glare resistance at BACs under .10%; and approximately as many subjects showed an increase in glare recovery time as showed a decrease.

5.3.6 Critical flicker fusion: Significant impairment of temporal acuity of the visual system at BACs of .08% or higher.

Thus, dynamic visual acuity and dark adaptation were the only sensory aspects of visual function to show significant impairment at BACs in the vicinity of .08% when studied as isolated variables in laboratory experiments. By contrast, real-world driving is much more complex and frequently involves combinations of these sensory aspects of vision operating as a cohesive, coordinated process. For example, driving at night can be exceedingly complex visually; it frequently involves a combination of dynamic visual acuity, dark adaptation and brightness sensitivity, glare resistance and recovery, etc. Although some of these visual functions do not seem to be significantly reduced by alcohol when studied separately in the laboratory, it is nevertheless possible that, when required to operate in conjunction with one another, the net alcohol effect is one of severe limitation on the ability to drive effectively at night.

In any case, dynamic visual acuity seems to be the most important single aspect of visual function for successful driving performance as indicated by its relation to actual driving record (Burg, 1970). Since the study by Honegger et al. (1970) demonstrated that dynamic visual acuity is especially sensitive to alcohol effects, it would seem warranted to hypothesize that individuals with poor dynamic visual acuity when sober probably suffer a proportionally greater alcohol impairment than individuals whose baseline dynamic visual acuity is relatively better. In view of the strong established relation between driving record and dynamic visual acuity, this hypothesis would seem to merit very high priority for future research.

Despite the apparent relevance of dynamic visual acuity for successful driving performance, one possible methodological problem should be mentioned. Since the methods used by both Burg (1970) and by Honegger et al. (1970) involved visual tracking and other ocular-motor coordination, the obtained measures of dynamic visual acuity may very well be confounded by the contributions of "higher" processes, such as selective perception and attention. However, even if such confounding can be established by future research, it would serve more as a conceptual than a practical limitation, since measures of dynamic visual acuity could still be obtained as they are currently and could be used for administrative screening to aid in identifying high-risk drivers.

5.4 Methodological Issues

Alcohol increases variability in many physiological and psychological response measures, even when the means of the response measures themselves may not be significantly changed. Because of this fact, a special responsibility is placed upon the laboratory scientist who conducts alcohol research which has potential implications for drinking-and-driving regulations. In addition to the traditional measures of central tendency, he must be especially concerned with several important aspects of variability: (1) variability associated with increasing concentrations of blood alcohol; (2) variability within a given individual at different points in time, as well as variability between different individuals at a given time; and (3) variability in the investigated behavior itself, without alcohol.

The fact that alcohol increases variability also sets crucial constraints on the main issue in this area: "What is the blood alcohol concentration at which all drivers are impaired?" Two very important sets of questions follow from this issue: (1) What are the specific criteria for determining such a cutting score for blood alcohol concentration; and (2) what are the specific criteria for "impairment"? The first question is essentially judicio-legal in orientation and cannot be meaningfully addressed until the second question has been answered.

The second question raises the fundamental issue of validity; that is, do we have any unequivocally valid indicators of alcohol impairment which we can use to specify the criteria for "impairment"? This formulation returns us to the original question raised at the beginning of the present paper: "Do alcohol influences upon the performance of some tasks observed in a scientific laboratory have any meaningful transfer to real-world driving behavior?"

The validity gap between the laboratory and real-world can only be bridged provisionally by inferences at this point in time. Two widely separated research approaches have been used to date in facing the agonizingly complex and frustrating problem of human loss in alcohol-involved highway crashes. First, post hoc "epidemiologic" sleuthing in a few controlled studies (McCarroll & Haddon, 1961; Borkenstein et al., 1964; Perrine, Waller, & Harris, 1971) demonstrated that alcohol was over-represented among deceased drivers relative to drivers in the population-at-risk. This approach and these studies are discussed at length in the subsequent paper by Hurst.

The second approach consists of laboratory experiments conducted on isolated variables; and it has been the practice to infer alcohol impairment of real-world driving performance from the mosaic of fragmented bits of behavior examined independently in the laboratory (e.g., visual field, adaptation, acuity, etc.). In addition to the problems involved in reasoning from isolated parts to a complex whole, several aspects of human behavior may set further limitations on the extent to which we can extrapolate from laboratory experiments. For example, the grandstand or Hawthorne effect comes to mind in this regard. Accordingly, the subject who knows that he is under observation in the laboratory may exert himself and compensate for the effects of alcohol, especially at lower BACs (perhaps related to the corresponding aspects of biphasic effects of alcohol, as discussed above). On the other hand, it is even more probable that if isolated laboratory tasks such as dynamic visual acuity or standing steadiness were used by the police in the field to evaluate intoxication, then a driver who had been drinking and was in jeopardy of being arrested for DWI could be expected to compensate for -- and perhaps overcome -- the external indicators of alcohol impairment as observed on a particular laboratory task. In either case, any attempt to establish criteria for impairment based upon this aroused, grandstand performance could err seriously in the direction of setting the standards for impairment far too high for the extent actually involved in unobserved driving on the road, during which the depressant effects of alcohol would assumedly be more dominant. A solution to this problem might be attempted by developing valid, unobtrusive measures of alcohol impairment in real-world driving situations.

A further complication stems from the fact that the ultimate criterion measure for alcohol impairment is the crash which is a statistically rare event and therefore virtually impossible to observe systematically. The epidemiologic approach has been used in an attempt to compensate inferentially for this limitation, and it has yielded data to demonstrate that alcohol contributes significantly to a higher probability of crash involvement. Exactly how alcohol makes this contribution cannot be determined by the epidemiologic approach, and thus we come full circle back to the laboratory approach.

A different and perhaps even unique combination of various factors is probably involved in each actual crash. Therefore, we may be laboring in vain under a possible fallacy which has resulted from using two separate and opposite approaches to a common, but complex problem. This fallacy might be expressed as follows: "The contributions of alcohol to crashes are due primarily to one type of effect (e.g., deterioration or impairment) upon one key aspect of behavior (e.g., vision, attention, etc.) and is the same in all drivers above a certain crucial BAC cutting point."

One example of a possible alternative to this probable fallacy is based upon the biphasic effects of alcohol at the neurophysiological level. This example attempts to account for the interaction of age and BAC in crash involvement, whereby younger deceased drivers typically have a lower mean BAC than middle-aged or older drivers. Accordingly, it may well be that the impetuosity of inexperienced youth is enhanced by the apparently arousing effects of the relatively lower BACs and that therefore they are more likely to crash in the process of riskily testing the limits of self, vehicle, and road. By contrast, since they are no longer especially impetuous, the older more seasoned drinking drivers are not significantly impaired until the higher BACs are reached, at which point the depressing or inhibiting effects of alcohol reduce their driving effectiveness and therefore increase the probability of being involved in a crash because they are sedated either to the point of falling asleep or of not detecting an impending threat. However appealing this conjecture might be, it really argues -- in conjunction with the other limitations mentioned immediately above -- for the necessity of obtaining unobtrusive measures of actual driving as impaired by alcohol. Although such studies would doubtless be exceedingly difficult, the net value of one such systematic study should be far greater than that of a large number of separate laboratory experiments on isolated bits of behavior.

6. SUMMARY

Do alcohol influences upon performance in laboratory tasks have any meaningful transfer to real-world behavior such as driving? If so, to what extent is extrapolation from laboratory to highway warranted and valid? Laboratory studies of those aspects of basic psychophysiological functions assumedly relevant for on-the-road driving performance were reviewed critically in terms of these questions, as well as in terms of susceptibility to alcohol influences and individual differences.

Understanding alcohol influences upon more complex behaviors (e.g., perception, attention, or even driving performance) can be facilitated by developing a relevant neurophysiological model; and two important interrelated issues for such a model were reviewed. First, concerning the actual site of alcohol effects in the nervous system, the reticular activating system is probably effected at lower blood alcohol concentrations (BAC) than other important aspects of central nervous system function. This difference could account, for example, for divided attention performance being impaired at lower BACs than intensive attention. Secondly, concerning the apparent biphasic effects of alcohol, low BACs seem excitatory or stimulating, whereas higher BACs are generally inhibitory or depressing. These latter effects can apparently be overridden only at lower BACs, either through attempted compensatory activity by the organism to offset the depressant actions of alcohol or by alcohol depression and disinhibition of some inhibitory mechanism.

Regarding neuromuscular aspects, standing steadiness is one of the most sensitive behavioral indicators of alcohol intoxication, but the validity of this measure for actual impairment of driving performance is not yet conclusively established, especially at BACs from .08% to .15%.

Regarding sensory activity in the most important modality for driving, six aspects of vision were reviewed and are arranged in order of decreasing susceptibility to low and medium BACs: (a) dynamic visual acuity (some subjects impaired at BACs as low as .02%, but all subjects impaired at .10%); (b) adaptation and brightness sensitivity (significant impairment of dark adaptation at BACs of .08% or higher); (c) critical flicker fusion (significant impairment of temporal acuity of the visual system at BACs of .08% or higher); (d) static visual acuity (not a very large proportion of adults suffer impairment until BACs well above .08% have been reached); (e) glare resistance and recovery (no significant reduction in glare tolerance at BACs of .06%; only a quarter of the subjects suffered reduced glare resistance at BACs under .10%; and approximately as many subjects showed an increase in glare recovery time as showed a decrease); and (f) visual field (no appreciable reduction in the extent of lateral visual field in terms of sensitivity, even at relatively high BACs). Although only dynamic visual acuity, dark adaptation, and critical flicker fusion showed significant impairment at medium BACs as isolated variables in laboratory experiments, night driving is very complex visually and may be impaired by the net alcohol effects on all those visual functions which must operate in conjunction for effective performance on the highway.

Regarding methodological issues, the interrelations of variability and validity were discussed. Alcohol increases variability in many physiological and psychological response measures, even when the means of the response measures themselves may not be significantly changed. Therefore, the alcohol experimenter conducting research which has potential implications for drinking-and-driving legislation must consider: (a) variability associated with increasing BACs, (b) variability within a given individual at different points in time, as well as variability between different individuals at a given time, and (c) variability in the investigated behavior itself, without alcohol.

Regarding validity, do we have any unequivocally valid indicators of alcohol impairment which we can use to specify the criteria for "impairment"? At this time, the validity gap between laboratory and real-world can only be bridged provisionally by inferences from two widely separated research approaches: post hoc "epidemiologic" sleuthing, and laboratory experimentation on isolated variables. The former approach is severely limited by having to be conducted after the fact, i.e., after the crash. The latter approach suffers from a number of limitations, including: (a) fabrication from fragmented bits of behavior, and (b) the grandstand or Hawthorne effect on the subjects. Accordingly, the subject who knows that he is under observation in the laboratory may exert himself and compensate for the effects of alcohol, especially at lower BACs. On the other hand, it is even more probable that if isolated laboratory tasks such as dynamic visual acuity or standing steadiness were used by the police in the field to evaluate intoxication, then a driver who had been drinking and was in jeopardy of being arrested for DWI could be expected to compensate for -- and perhaps overcome -- the external indicators of alcohol impairment as observed on a particular laboratory task. In either case, any attempt to establish criteria for impairment based upon this aroused, grandstand performance could err seriously in the direction of setting the standards for alcohol impairment far too high for the extent actually involved in unobserved driving on the road, during which the depressant effects of alcohol would assumedly be more dominant. A solution to this problem might be attempted by developing valid, unobtrusive measures of alcohol impairment in real-world driving situations.

A simplistic fallacy concerning alcohol involvement in crashes was examined in terms of a possible alternative based upon the biphasic effects of alcohol at the neurophysiological level. The example attempted to account for the interaction of age and BAC in crash involvement, whereby younger deceased drivers typically have a lower mean BAC than middle-aged or older drivers. The impetuosity of inexperienced youth may be enhanced by the apparently arousing effects of relatively lower BACs; and therefore, the youthful driver may be more likely to crash in the process of riskily testing the limits of self, vehicle, and road. By contrast, the older, less impetuous, more seasoned drinking driver may not be significantly impaired until the higher BACs are reached, at which point the depressant effects of alcohol reduce his driving effectiveness and therefore increase the probability of crash involvement because he is sedated either to the point of falling asleep or of not detecting an impending threat.

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DISCUSSION

BUIKHUISEN: May I say something more general? This paper here is meant to be a physiological-psychological paper. Actually, it does not discuss the basic physiological problems we have, and I don't see any other place in the symposium at which physiological problems are discussed. Now, I don't say this as a complaint; however, I would like to emphasize that any research program that might come out of this symposium, which stresses the behavioral aspects, but leaves out certain physiological aspects that are no doubt important, cannot be a complete research program.

PERRINE: Quite true, and I am glad you raised the point. However, in the early planning of this symposium on alcohol, drugs, and driving, we considered the great remaining "known unknowns" and they seemed to lie predominantly in the behavioral domain. This conclusion was obviously influenced by our own views, since those of us who generated the program are psychologists. Nevertheless, we are not saying that there is no need for more research in the area of toxicology, or in the area of cellular or membrane physiology, etc. etc.; rather, we are saying that in terms of real-world needs, it seems that some of the greatest, most compelling unknowns lie in the behavioral area. Therefore, our interest in these other levels of activity--particularly some of those I have been discussing at the neurophysiological level--is aimed at developing an understanding of the more complex behaviors, rather than being aimed at understanding the nuances of alcohol influences on the cell, or the membrane, or the synapse per se.

BUIKHUISEN: I don't mean just this part as physiological. For example, we know very little about absorption--about the distribution of absorption--and here may be a possible means for countermeasures. That is, we might be able to block the effect of alcohol on the central nervous system; and we have some research activities going along those lines already. And we have the factor of the relationship of blood to brain uptake. There is a lot of misunderstanding in the literature; and it effects our tests very significantly. Similarly, there are marked misunderstandings about blood flow and pulmonary measures. But the elimination, and possible ways of increasing the elimination of alcohol, etc., these are all very important factors from the physiological point of view and they are not being covered here. Again, I don't want to say that there is anything wrong in the way you do it; I only want to emphasize there are other aspects that we have to consider in our program.

PERRINE: I am really pleased that you mentioned these other considerations; and it's one reason why you and some of the others are here. You notice that the blend of participants is not limited exclusively to psychologists because we had hoped for interchanges of ideas across disciplines.

Now, I would suggest we address ourselves to the dozen or so written questions which have just been submitted. Perhaps the most straight-forward question, in terms of focusing on one of the biggest controversies in the literature, has to do with the apparent facilitative effects of a few drinks. The question is:

"COULD THE SPEAKER BRIEFLY SUMMARIZE THE EVIDENCE FOR AND AGAINST THE VIEW THAT SOME DRINKERS ARE BETTER OFF AFTER ONE OR TWO DRINKS, IN TERMS OF IMPAIRMENT?"

As I understand the literature, the "relaxing" effects of one or two drinks on simple sensory motor functions may give the impression of better performance, simply in terms of the response measure, particularly if some learning or anxiety is involved. However, if the person has already reached plateau, that is, he is fully skilled in the particular performance, and if he is not anxious, then the odds are that a few drinks will not show any effect, either facilitating or impairing. On the other hand, if the person is anxious, if there are motivational, learning, or emotional aspects of performance on the task, then it is possible for alcohol to give the impression of being facilitative; but it is probably facilitative by reducing the inhibiting influence of the anxiety about performance on the task.

CARPENTER: I object to one of the words used, and that was the "apparent" facilitation. If you measure zero condition and then an alcohol condition, and there is a change, that is in fact what happened when we look at it. So, I don't see why it is "apparent." It suggests to me when you say it is apparent that this is an illusion on the part of the observer, and I disagree with you. It is, in fact, better performance.

PERRINE: I was thinking more of the anecdotal level, such that we might say that a person appears to be driving better after a drink or two. However, your point is well taken for laboratory tasks, such as performance on a pursuit rotor. The subject is or is not better after alcohol. And there is evidence that a person's performance on a pursuit rotor does improve after a few drinks, -- particularly if he is still learning -- but it will also improve with practice. Therefore, alcohol effects and practice effects are confounded. Another question, please.

MOSKOWITZ: Well, I think there has been a lot of difficulty in the past due to some conflict about the well-known curves Borkenstein et al. got on drinking and driving frequency. So far, examination of the literature for any group where you control for frequency of use of alcohol has shown in increase in alcohol and accident rates when driving at any departure from zero blood alcohol, and there is no evidence to the contrary. I've looked in the literature and occasionally I have seen one or two reports of improvement at low blood alcohol levels. Every behavioral test that I have ever used has been systematic in either showing no effect or in showing a unimodal, unidirectional effect of decrement. Excuse me, there is one test that I've used in which I have found improvement, which interestingly enough was glare recovery, and in which there is a consistent improvement of glare recovery with alcohol. So I don't really know any behavioral test in which there is any evidence that is reliable for this supposed fact. If you know of any, I would like to have you point it out.

CARPENTER: Right here in my pocket, I have some results of several recent experiments; which I have done that show the same thing. Now, I don't set out to look for these things, but it happens that they turn up.

MOSKOWITZ: No, I don't deny you may have it, but all I am saying is I went through the literature looking for this thing, and ---

CARPENTER: Two of them are published, Herb, one in 1961.

MOSKOWITZ: Oh, well, I have looked at this and I really thought, that on my examination of the literature, it is an "old wives' tale."

KELLER: May I butt in on this and say the argument is going on because the two debaters are talking about different things. Tony (Carpenter) has found some improvement in the performance at lower blood alcohol levels in some functions which are not automobile driving; and Herb Moskowitz is talking about tests directly relevant to automobile driving. Isn't that right?

MOSKOWITZ: No, I tried ---

CARPENTER: I have two intellectual tasks that have been used. Both show this phenomenon, and both of them have very reliable, statistically significant minima in the curves. And we now have a motor task in which this occurs, and there it is.

MOSKOWITZ: What motor task?

CARPENTER: You must be familiar with it; it is called a Stressolizer, and is made in Canada.

MOSKOWITZ: Yes, if you mean that thing Gibbs made? ... Well, I just want to point out that Milner also did some experiments on that which he published in Science, and he didn't get that.

CARPENTER: Well, it doesn't matter; I have the material here, and I can show it to you. But one more thing, I am prepared to be wrong on this point, and I am willing to concede if somebody would come up with some kind of an explanation for it. However, it has been observed in rats also. Hannah Steinberg in London has done this with alcohol and nose-pointing in rats, and she got the same biphasic curve. This is very important because England is the locus of the activity in model building, especially models of joint action. For some reason, they are more applied than we are, and it is not a mark against a mathematician to work in such an area; so, many qualified people have been working in this area for years and they have considered the Steinberg data, which has this same old bump in the curve. Now, this is a non-monotonic function and it makes the math very difficult; but they have been interest in it and they have had to look at Steinberg's data; and there it is, it has this rise and this fall.

WALLER: Coming back to the question of whether we should be concerned with "apparent" versus "real." If I guess right, I think you used the word "apparent" because you are trying to suggest that if we are talking about observed behavior, we may be seeing one thing; and if we are talking about the physiological things that are going on, or the pharmacological things that are going on, we may be seeing something completely different. And, since you were talking at the pharmacological, or physiological, or physio-pharmacological, or however you want to call it level, the term "apparent" was a relevant one. I think it is important to be able to distinguish between what we see at the observed behavioral level and what is going on at a more basic level.

PERRINE: This gets back to some of the old issues in the behaviorist approach, which stated that "what you sees is what you get," as opposed to trying to go inside the black box at the psychopharmacological or neurophysiological level. But, in terms of model building and in terms of what is going on in the real world, I don't think that at this point in time, we should completely exclude the possibility that alcohol is plainly and simply, a neural depressant, and that there may in fact be no basis for a neural biphasic curve.

STERN: I would like to suggest that to the extent that alcohol is an anesthetic agent, it ought to behave like other anesthetic agents and produce an excitement phase at low levels of concentration. And I wonder if you are talking about an excitement phase when you talk about release of inhibition. For example, in the rat, if you measure activity in an animal that is being anesthetized (I don't care whether you use barbiturate or ether), it will initially show a mock excitement phase. I wonder whether you are not observing the same phenomenon with alcohol; it is not unique to alcohol, but is a quite general phenomenon.

BENJAMIN: I think there is one other explanation for the same biphasic response. At very low concentrations, we have vasodilitation which can act as a facilitating factor. The depressing action on the central nervous system appears only at somewhat higher concentrations. Therefore, we get this biphasic response which is not actually any more than points of different effect of alcohol at different doses.

SCHNEIDER: I would like to present an alternative. As I understood your comments on the paper, you feel that the failure of traditional laboratory work to give satisfactory accounting for problems of alcohol and driving may very well be due to the simplifications that were made in taking the task into the laboratory, and the failure of really being able to extrapolate effectively from the laboratory to the "real-world." But there is an alternative possibility and that is, that we have a conceptual failure, such that the models we keep trying to shoe-horn alcohol into are inappropriate, which comes down to this point here: We talk about alcohol as a depressant or an inhibitor; we talk about alcohol as having a site of action, etc. These are terms that are used in a drug modal. But there are alternatives. Alcohol is a solvent. When we take alcohol, it dissolves in us; it doesn't go to a site of action and sit there and do nothing else. It might very well be much more reasonable to look at alcohol as a transformation of the entire neural system, rather than looking at it as having some specific site. Similarly, when we talk about measuring the effect of alcohol, we tend to use analysis of variance models that are designed to look at changes in mean, with invariant changes in the variance of the measure that we take; and it may very well be that what we have to do is look for changes in variance, with only small changes in the mean. So again, our statistical models may be incorrect for looking at the effects of this drug. Psychologists have been hacking away at alcohol -- as a drug, as a psychoactive phenomenon -- for a hundred years with the same models, over and over and over again. Surely, then, our conceptualization of alcohol as a drug ought to be re-examined.

VOAS: Well, I am concerned that a point that Herb made as he started his discussion of the apparent facilitation effect may have gotten lost. Herb mentioned that some of the data appears explainable in terms of adaptation level to alcohol; that is, when there is an inquiry as to the adaptation level, then the curve straightens out. I think that this is an important item to have in reference to this issue, because it is of practical significance. The argument occurs in the real-world that adaptation level effects the extent of any effect of alcohol. Further, there is an extension of this matter of whether two or three drinks is facilitating on the general public (or in most subjects) in the issue of whether to the adapted individual (the addicted individual), there may really be a requirement for a certain amount of alcohol in the system in order for that person to perform effectively. The argument goes that the addicted person, when absolutely dry, actually performs more poorly in all areas than he does with a few drinks, or however many are necessary to get him functioning effectively.

PERRINE: I know there are two individuals in the room who take very strong opposite positions on exactly this point. But even though it is a very important issue, let's postpone it until one of the later sessions, where I think it will be more appropriate. Let me just attempt to terminate by saying that although we have solved no problems, I do hope we have stimulated continued discussion during the various free time we have at Sugarbush. For my part, I have taken somewhat provocative positions to which I don't necessarily subscribe completely in order to stimulate debate -- and the next question emphasizes this.

"The correlation of dynamic visual acuity and driving record is quite low, according to Burg's data. (Nevertheless, it was the highest of the various measures which he had, and he emphasized dynamic visual acuity as being most important.) In driving, visual acuity is probably not used in a dynamic sense. Objects viewed down the road have quite low rates of motion and are viewed focally. High angular velocities occur rather close to the vehicle for objects that would be viewed off-axis, mostly." The question then:

"BASED ON SUCH CONSIDERATIONS, WHY IS DYNAMIC VISUAL ACUITY AN IMPORTANT ABILITY WHOSE ALCOHOL EFFECTS WE SHOULD INVESTIGATE?"

PERRINE: Very good question, and it emphasizes one important issue concerning that portion of the behavioral field which has fallen to me to review; namely, why do these relatively simple aspects have any relevance for driving? Why should we investigate neurophysiological activity if we are interested in alcohol and driving behavior? The point being made by the person who phrased this question is certainly germaine and gets to the nub of why we have chopped up behavior in these different ways, such that I am taking a certain segment of it, in a sense at the lower end of the complexity scale; then Herb Moskowitz is taking another segment of the more complex behavior of visual perception, attention, etc., and Herb Barry is taking the even more complex higher mental processes, including motivation, learning, risk-taking, etc.

If there is anything at the relatively simple level of sensory functioning that is worth further research with alcohol, I would say that dynamic visual acuity is one of them. We should learn much more about dynamic visual acuity on the basis of Burg's work and on the basis of Honegger's experiments. On the other hand, I would say that according to previous laboratory studies, the influences of alcohol on static visual acuity are not worth much more research. The upshot of all this may be that sensory function itself does not have a very high probable payoff in terms of the problem of alcohol and driving -- and that is one of the prospects that we, as specialists, should consider, and our assessment of it should be an important outcome of this conference. It may well be that for the problem at hand, dynamic visual acuity -- as a sensory function -- is not that important relative to other aspects of the visual field (and the visual field itself is not that important here in an anatomical sense). Rather, the more cognitive aspects which require the use of this sensory equipment are doubtless more important for us. Thus, it is very likely that the directing of visual acuity in a dynamic sense (with the directing coming from the cortical or subcortical area as in an attentional model or a visual perception model, or a subjective probability model), is much more important in terms of real-world behavior such as driving. However, I have been addressing myself very specifically to the sensory level; and of those functions we have viewed at the sensory level, dynamic visual acuity is one of the few which seems to be worth further investigation, but in more complex tasks. In other words, we should pursue the study of dynamic visual acuity, but not exclusively at the sensory level. Rather, we should load the subject concurrently with a more complex task involving risk-taking or divided attention, for example.

WALLER: I would take some issue with the person who wrote the question and said that the major involvement here is looking down the road because I think that Dick Zylman's re-working of the Grand Rapids data indicates that at certain times of day -- at times of day when traffic is heaviest -- relatively small amounts of alcohol may be particularly impairing. I think this is likely to relate to exactly the sort of behavior that one gets at intersections and so forth where you don't have the option of looking down the road. So, I think it is a relevant area to examine.

GOLDSTEIN: I think there is a basic difficulty in looking at the correlation between any variable whatsoever and accident record. Nothing -- and no optimally weighted composite of anything -- can possibly have a very high correlation with accident incidence over a period of, say, three years. Basically, one reason is that accident records themselves have what is known in the psychometric world as very low reliability. Therefore, they can have only very low predictability. So I think we have to take another kind of look at what we mean by "relationship," and the most dramatic way I know of saying this is to use some data from research on lung cancer and smoking. In fourteen studies with large samples, the correlation between smoking and no-smoking lung cancer and no lung cancer ranged from .001 to .009. If I stop there, I think most of you who know what correlation means would conclude that there is substantially no "relationship" between smoking and lung cancer; but then if I go on to tell you that the relative incidence of lung cancer among non-smokers versus smokers ranges from 1.2 to 39 times, it tells a very different story. There is a parallel between that and the accident situation in that very few people, even if they do smoke, develop lung cancer. We have a similar situation with accidents (and accidents are a rare event). Take any variable that you will; for instance, how many people are deficient in dynamic visual acuity (and I don't know what that means)? You find that it's a few people, and of them, a fewer number of people become involved in accidents because of their deficiency in dynamic visual acuity. I submit that a far more fruitful way of looking at this is to compare the relative risk of those with this characteristic under study, compared to those who don't have it, (other things controlled, and that is a big issue in itself). This comparison tells a different story, and in the same package, I think you have to consider what proportion of the driving population is so afflicted. Sorry for a long dissertation, but I think this is fundamental for much of what we're concerned about.

BECK: Have there been any short duration studies of acuity? I am thinking of this for two reasons; one the idea of variability, and the other is related to the idea of the inhibition. With short-term samples, you get greater variability, apparently, and in the critical fusion frequency of the dynamic visual acuity, it may be confounded with the actual complexity of the motion of the figure, as well as the short-duration sample.

PERRINE: Now there's a question in there somewhere, and I wonder if you would rephrase it. You are primarily concerned with the short-duration sample ---

BECK: As related to the concept of each of these variables with alcohol.

PERRINE: As I understand the question, can one separate out the acuities you mentioned from any contribution of the meaning of the stimuli presented at short duration, with short duration being defined in terms of microseconds, say, one-thousandth of a second or one five-hundredth of a second, etc. As opposed to the kinds of stimuli which are usually used for determining static visual acuity, such as the Snellen chart, the Landolt ring, etc. The dynamic visual acuity research that Honegger did used a revolving projected disc, so in one sense, it was a tracking task. However, in response to the first part of your question, I don't know of any other relevant studies.

MORTIMER: I just did some quick computations here that are interesting. If you are travelling at 70 miles an hour and you are looking at an object that is three feet laterally off to the side, the object will be 300 feet away from you. One second later (at 70 miles an hour, that is 100 feet per second) it will be 200 feet away from you. The object will have an angular rate of 0.4 degrees per second, which is a very low rate in comparison to the rates used in dynamic visual acuity tasks. The expression of dynamic visual acuities, as such, is quite new, I think, as being a relevant task that is used in driving. What does dynamic visual acuity measure then in the way that it has been used? Does it really have much to do with acuity as such? Maybe it has something to do with the pursuit eye movement capability of the person. My own feeling is that dynamic acuity, as such, is probably of absolutely no relevance whatever in driving. Acuity means detailed vision, and what is the relevance of that, when these rates are so low. At 70 miles an hour and a change of 0.4 degrees, that object is still in the foveal region, anyway.

HURST: Is there a possibility that perhaps we should include under dynamic visual acuity, pursuit eye movements as well; in that there seems to be some confusion as to when one or the other is taking place, and a person might well be confused as to what kind of a rating to give it if he thought it was really pursuit eye movement, and it was both.

PERRINE: We have taken that into account in the next session, since the keywords of the second session get into the more complex level of behavior. This kind of presentation suffers from the same sort of limitations that a textbook does by chopping up interrelated dynamic processes into static chapters. We are really concerned with the whole process or unit, and yet we are forced to chop it up into segments for ease of study.

In the interest of time, let me attempt to pull things together a bit and conclude the first session. Although the technical points that Rudy Mortimer just made are doubtless correct and although the contour-detecting aspects of acuity (whether static or dynamic) are probably not that crucial in view of the overriding considerations of such concepts as attention or visual perception, there may nevertheless be an influence of shifting eye movements, of visual search, etc., etc., which is compounded by an influence on acuity, not only for a detection task in the periphery, but also for a recognition or identification task in the foveal area. In these terms and in view of Burg's work, it would seem highly desirable to examine under more complex circumstances what has been called (perhaps as a misnomer) "dynamic visual acuity." But, now it is time to start the keyword ratings.

Chapter 3

ALCOHOL INFLUENCES UPON SENSORY MOTOR FUNCTION, VISUAL PERCEPTION, AND ATTENTION

Herbert Moskowitz

ABSTRACT

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%.

1. INTRODUCTION

The literature on behavioral changes induced by alcohol is encyclopedic in scope. Undoubtedly, many of the reported behavioral impairments might lead to an increased probability of a driving accident in some situation. Yet, the severe and pervasive influence of alcohol on driving safety suggests an influence upon an essential element of the driving task. Therefore, this review primarily examines aspects of visual perception, tracking, division of attention, and information processing. These areas were selected based upon an analysis of driving as primarily a time-shared activity between a visual search-and-recognition task and a compensatory tracking task (Stephens & Michaels, 1963).

2. ALCOHOL EFFECTS UPON VISUAL FUNCTIONS

As recently as 1962, a review of the effects of alcohol upon visual functions failed to reach definite conclusions due to the contradictions in the evidence then available (Carpenter, 1962). Subsequent research has enabled more recent reviews to report more conclusive evidence. In a review specifically examining drug effects on visual functions in driving, Grant (1970) reported that under drugs (including alcohol), "it seems that visual disturbances are relatively trivial and must constitute only a small portion of the problem" of driving impairment.

An extensive review in Wallgren and Barry (1970) reported that visual acuity, which appears most relevant to driving skills, is "relatively insensitive to alcohol." Among the other visual functions examined by Wallgren and Barry for possible alcohol impairment were: (1) peripheral vision, for which no impairment has been found; (2) glare recovery, for which there are almost as many studies reporting improvement under alcohol as impairment; and (3) critical flicker fusion, for which there is an inconsistent, but general trend of reported small decrements in fusion thresholds. The only area which seemed consistently impaired by alcohol was color perception, but even here the character of the changed color vision varied greatly. Thus, there appears little evidence from the experimental literature that visual sensory processes which are likely to be of significance in driving will show alcohol-induced impairment.

Wallgren and Barry (1970) and others have reported evidence for impairment of ocular-motor control by alcohol. The effect appears primarily as an increase of several diopters in the tendency towards esophoria at far distances, the fixation distance most relevant to driving (Moskowitz, Sharma, & Schapero, 1972). Such a small effect is not reflected in visual acuity scores and is unlikely to be of significance for driving performance. Additional support for impaired ocular-motor control is suggested by the reported interference of alcohol with visual fixation used to control nystagmus and vertigo when subjects undergo caloric and optokinetic stimulation (Schroeder, 1971). While this finding appears relevant to safety in aircraft control under angular acceleration, as demonstrated by Collins, Schroeder, Gilson, and Guedry (1971), such provoking conditions are less likely in driving. Evidence for impairment by alcohol of the amplitude and phase angle of eye movements following a sinusoidal horizontal target is given by Yasui (1971), but the effects are most apparent at target movement rates uncommon in driving.

It should be noted that these literature reviews examined a group of experimental studies which carefully isolated some visual function and then tested for possible ethanol impairment. Under these circumstances, the overwhelming majority of studies on visual sensory processes under alcohol have reported no deficits. Yet recent studies examining peripheral vision in complex situations more analogous to the demands for information processing in driving have uniformly reported extensive impairment by alcohol.

2.1 Peripheral Vision

Von Wright and Mikkonen (1970) examined the signal detectability of intermittently presented lights over an extensive range of the horizontal and vertical visual fields of the subjects. Simultaneously, the central visual field was occupied with a simple tracking task. Alcohol treatment of 0.4 and 0.8 grams of alcohol/kg. bodyweight were compared with a placebo treatment. The smaller dose produced 10% and the larger dose 28% fewer signal detections than the placebo treatment. Nearly all the errors were failures to see the signals. There was little effect on the false alarm rate.

Since the authors presented the individual scores of the 12 subjects, it can be observed that all subjects demonstrated impairment at both doses. The two alcohol doses would be expected to produce mean peak blood alcohol concentrations (BACs) no greater than .05% and .10% respectively.

Further evidence for the susceptibility of peripheral vision to alcohol impairment, when examined in a complex perceptual situation, is offered by

Hamilton and Copeman (1970). The study involved a central visual-tracking task, combined with signal detection of lights in the horizontal peripheral visual field. Signal detectability was examined under three treatments: placebo, 0.21 grams, and 0.63 grams of alcohol/kg. bodyweight. Breath alcohol analysis produced mean peak BACs of .017% and .055% for the two alcohol doses. The two alcohol treatments produced 6% and 20% decrements in the detection of peripheral light signals. No information was available regarding the number of subjects impaired at each level, although both performance decrements were statistically significant.

It is important to note that both studies (Von Wright & Mikkonen, 1970; Hamilton & Copeman, 1970) had an unequal number of light presentations at the various peripheral visual angles. Therefore, in these studies, we cannot determine whether the impairing effect of alcohol was equal for all angles or increased with greater peripheral angle, since the probability of a light appearing is confounded with the peripheral angle itself.

Huntley (1970, 1973) examined the effects of alcohol doses of 0.58 and 0.96 grams of alcohol/kg. bodyweight upon reaction time to photopic signals in the horizontal peripheral field while the central visual field was occupied by counting the blinks of a central fixation light. The two doses produced approximately 5% and 8% increases in time to perceive and respond to the signals. There was no difference in the alcohol effect on the five angles (ranging from 4^{o} to 84^{o}) at which the signals were presented.

A study by Moskowitz and Sharma (in press) also examined peripheral vision while the subject was occupied with a central fixation light. There were three central visual conditions: the fixation light was either unblinking, blinking at a slow rate, or blinking at a fast rate. Signal detection was examined at 32 points in the horizontal peripheral field; at 16 angles from 12^{o} to 102^{o} on both sides of the fixation light. Alcohol treatments of 0.41 and 0.83 grams of alcohol/kg. bodyweight were compared with a placebo treatment.

This study specifically tested the hypothesis that the appearance of an alcohol-induced deficit in peripheral vision is a function of the attention or information-processing demands placed upon central vision or, for that matter, the demands from any source of information occupying the central processing mechanisms. The condition where the central fixation light was unblinking and thus required no major part of the information-processing capacity of the brain duplicates the manner in which the typical studies of peripheral vision under alcohol have executed the experiment which failed to find impairment.

The study failed to find any impairment in peripheral vision at either alcohol dose when central vision was occupied with an unblinking fixation light. However, when central vision was occupied with counting the light blinks, there were deficits in peripheral light detections. Under the slow blinking central light condition, the two alcohol doses produced 14% and 25% drops in signal detections, and under the fast blinking condition, 18% and 36% drops in detections. There was a statistically significant interaction term, indicating that the effect of alcohol upon peripheral vision is a function of the information load upon central vision. Nearly all of the errors were failures to detect the signals. Few false alarms occurred under any treatment.

A fifth experiment by Buikhuisen and Jongman (1970) examined eye movements under alcohol treatment while viewing a film depicting driving through various traffic situations. Under alcohol, subjects concentrated their visual fixations upon the center of the filmed scene and greatly increased their failures to perceive traffic-significant objects on the periphery of the visual scene. Failures to see objects in the center also increased under alcohol, but to a much smaller extent.

It becomes clear that the conflict in experimental reports regarding alcohol impairment of peripheral vision is due to the manner in which the various experiments have been performed. When peripheral vision is examined in isolation with no other information-processing demands upon the subject, alcohol will produce no impairment. When peripheral vision is examined while the brain is occupied with processing information from some source other than peripheral vision, then alcohol will impair peripheral vision. This suggests that the impairment, when it occurs, is not a direct effect upon the sensory transducers or transmission system, but is an indirect result of the impairment by alcohol of the central processing system. This conclusion is supported by a study of the auditory system by Moskowitz and DePry (1968) which demonstrated that two separate auditory tasks examined singly were unaffected by alcohol, but when examined as a combined divided attention task, they exhibited a large and significant deficit.

2.2 Signal Detection

The data on the Moskowitz and DePry (1968) signal detection task for both the concentrated and divided attention conditions were subjected to analysis by the techniques of signal detection theory. Both d' (the index of sensory sensitivity) and beta (the index of set, bias, or motivation) were computed for both conditions. Under concentrated attention, neither d' nor beta was affected by alcohol. However, under division of attention, d' was significantly affected, whereas beta remained unimpaired. This result indicates that the alcohol deficit under division of attention is not a result of criterion change under increased stress, but is a true alcohol impairment of perceptual sensitivity.

Our conclusion regarding the nature of the impairment produced by alcohol on peripheral vision suggests that some of the conflicting reports found by Carpenter (1962) in other areas of visual research may be the result of the contamination of some studies by excessive demands for information processing. In many situations, alcohol will have no apparent or socially significant effect upon visual inputs because the demands for processing information in these situations are simple. However, in situations such as driving where there is a requirement for complex information processing in a situation demanding division of attention, subjects under the influence of ethanol will exhibit a failure in visual perception.

3. ALCOHOL EFFECTS UPON TRACKING

What conclusions can be drawn from an examination of the other major constituent of the time-shared task of driving, i.e., compensatory tracking? Reviewing the area of tracking, Wallgren and Barry (1970) found fairly general agreement that alcohol produced a decrement in tracking performance, but that such a deficit was more likely or more prominent when the tracking task was accompanied by another task which served to divide the attention of the subjects. Such a conclusion must raise the same question considered in our examination of vision; i.e., is the function per se sensitive to the presence of alcohol, or is the performance decrement a result of the context in which the experiment is performed: the demand for complex information processing in a divided-attention situation? Examination of tracking experiments to answer this question is difficult, because the character of the tracking tasks used in the experiments varies considerably in complexity, and it is not clear whether the tracking task itself at times requires monitoring more than a single source of information.

In compensatory tracking, an index has to be maintained at a predetermined position, whereas pursuit tracking requires a control index to be kept in alignment with an index which also is moving (Murrell, 1965). Thus, pursuit tracking involves monitoring at least two separate stimulus sources and is clearly a more complex visual monitoring task than compensatory tracking. In some experiments, the analysis is further clouded by the introduction of a predictive track so that the task becomes compensatory or pursuit tracking with prediction. Moreover, in many of these experiments, the prime tracking task is combined with other tasks, such as pressing a brake pedal whenever a light appears in the periphery.

3.1 Compensatory Tracking

While it is difficult to reach as definite a conclusion as offered regarding vision and alcohol, there are some experiments which suggest that relatively straightforward compensatory tracking tasks are not unduly sensitive to the influence of alcohol.

Newman (1949) examined alcohol, and alcohol in combination with decreased oxygen supply upon performance on a two-dimensional compensatory tracking task. The average BAC at which a significant impairment first appeared was .182%, although in combination with a reduction of oxygen to 10%, impairment appeared at .127%. (This is equivalent to an altitude of 18,000 feet.)

Pearson (1968) examined a compensatory tracking task combined with a concurrent monitoring of two meters. Alcohol effects were examined at ground and at 12,000-foot altitude levels. Subjects achieved a mean peak BAC of .085%. Alcohol failed to significantly affect the tracking task at ground level, although under the stress of the hypoxia, a trend towards an alcohol effect appeared. The subsidiary monitoring task, however, did show an alcohol effect.

Collins, Schroeder, Gilson, and Guedry (1971) also used a compensatory tracking task to examine the effects of an alcohol dose which produced a mean peak BAC of .074%. Subjects were examined under two conditions: while stationary, and while subjected to 48-second cycles of angular acceleration reaching a peak velocity of 120° per second. Under the stationary condition, there was a significant increase in tracking errors in only one of five test sessions, whereas under angular acceleration, tracking errors increased in three of five sessions. The authors concluded that "although eye-hand coordination may show little or no impairment following alcohol ingestion in a static situation, it may be seriously degraded during motion." They suggested that studying alcohol impairment requires presentation of the "total array of stimuli that will impinge upon the individual."

A study by Chiles and Jennings (1969) examined performance in a compensatory tracking task while simultaneously the subjects were intermittently required to perform a series of subsidiary tasks. Peak BACs were near .10%. Since the subsidiary tasks were intermittent, the authors analyzed the tracking performance with and without the presence of a subsidiary task. They reported that "the results of these tests showed that for no measure (there were several measures of tracking) was tracking significantly affected by alcohol when tracking was performed by itself." However, tracking was impaired by alcohol when the subject was concurrently performing some of the subsidiary tasks. The authors concluded that "a decrease in the ability of the subject to time-share the performance of tasks requiring the exercise of different psychological functions may be the most important detrimental effect of alcohol on trained subjects. Motor effects may be somewhat less important."

3.2 Pursuit Tracking

In contrast to the compensatory tracking tasks which generally have failed to find alcohol impairment except at very high BACs, most studies which have examined pursuit tracking, or which have combined a tracking task with a concurrent subsidiary task, have found impairment at BACs of .05% to .09%.

For example, Newman and Fletcher (1940), using a pursuit tracking task combined with a subsidiary visual recognition task, administered 0.79 grams of alcohol/kg. bodyweight to most of their subjects and obtained impairment of performance at a mean BAC of approximately .095%.

Newman et al. (1942) used the same pursuit tracking task as did Newman and Fletcher (1940), but no mention was made of the simultaneous recognition task. While the study used inadequate statistical analysis, the scatter plot of BAC versus change in performance on the tracking task suggests that impairment is significant by BACs of .07% to .08%.

Aksnes (1954) examined performance in a link trainer. Subjects were flying blind and were required to monitor seven instruments, as well as a map of the course they were required to maintain. The course imposed limits in regard to altitude, airspeed, vertical speed, turning speed, and time. Subjects were administered either 0.2 or 0.5 grams of alcohol/kg. bodyweight. The larger dose produced about .05% BAC and appeared to cause an impairment, although no statistical analysis was reported.

Another study of pursuit tracking was reported by Loomis and West (1958). They combined a pursuit tracking task with a subsidiary recognition and response task and found impairment at .05% BAC.

Mortimer (1963) used an alcohol dose which produced a mean BAC above .06% and found substantial impairment of pursuit tracking performance.

Hughes and Forney (1964) tested performance on a pursuit tracking task with four levels of complexity of the function to be pursued. They administered 0.52 grams of alcohol/kg. bodyweight, resulting in about .05% BAC, and reported that all functions showed large degrees of impairment at this dose level. A later study by Manno et al. (1970), using the same instrument, and the same dosage again producing .05% BAC failed to replicate the deficit. However, still another study by Forney et al. (1964) using the same instrument and a 0.5 grams of alcohol/kg. bodyweight dose obtained .046% BAC and reported impairment on two of the four test pursuit patterns.

A pursuit tracking task was combined with simultaneous signal detection in the previously cited study by Von Wright and Mikkonen (1970). Tracking was impaired at the 0.8 grams of alcohol/kg. bodyweight dose, but not at the 0.4 grams/kg. bodyweight dose. Signal detection was impaired at both doses.

Another previously cited study (Hamilton & Copeman, 1970), also combined pursuit tracking with signal detection. They included a condition where additional stress was introduced by noise. Under the quiet condition, the lower alcohol dose of 0.21 grams of alcohol/kg. bodyweight did not affect tracking scores, but the higher dose of 0.63 grams of alcohol/kg. bodyweight did impair tracking performance. With the additional stress of noise, both alcohol doses produced impairment.

Binder (1971) utilized a pursuit tracking task combined with a subsidiary cue recognition task to examine subjects recruited from local bars. Although statistical analysis did not test the lowest blood alcohol group versus controls, the figures imply that subjects with an average peak BAC as low as .06% showed impairment.

Although most studies of pursuit tracking under alcohol have found impairment, there are a few equivocal studies. In an experiment by Gibbs (1966), using a pursuit step-tracking apparatus which involved steps of unequal probabilities, alcohol treatment resulting in a peak BAC of .10% showed impairment on improbable steps, but no impairment on probable steps. Using a modified version of the Gibbs pursuit step-tracking task, Landauer, Milner, and Patman (1969) failed to find any evidence for an alcohol deficit at a BAC near .05%.

The following very tentative conclusions are offered regarding this short survey of tracking:

1. There is little evidence that a compensatory tracking task comparable to the task difficulty of driving will exhibit a performance decline under alcohol when attention can be devoted solely to the tracking task.

2. Tracking performance declines are very likely to occur under alcohol when the tracking task is a pursuit tracking task which requires monitoring two or more sources of information, or where the tracking task (of any type) is performed concurrently with another activity with which it must time-share the brain's capacity to process information. Under these circumstances, impairment will be exhibited at very low BACs, with most studies reporting impairment by .05%.

While driving is usually a compensatory tracking task, it rarely is performed unaccompanied by the demands for concurrent processing of information from the environment in addition to the information-processing demands generated by the tracking task itself. Therefore, although compensatory steering itself is reported to be relatively insensitive to alcohol when examined in isolation, these studies do not indicate the potential impairment of tracking under alcohol in the complex information-processing situation of driving.

Strangely, pursuit tracking which does show impairment at low BACs is closer in character to the information-processing demands imposed on the automobile driver who is faced with the combined compensatory tracking and search and recognition tasks of actual driving. This suggests that the reason for the greater susceptibility of pursuit tracking to alcohol impairment is due to increased information-processing demands rather than any increased impairment of neuromuscular control. Examination of the tracking functions faced by subjects suggests that the function is likely to be as complex, or even more complex, in studies of compensatory tracking as compared to those found in pursuit tracking, so it is not the motor character of the tracking function which accounts for the diversity of results.

Not all compensatory tracking tasks will be resistant to alcohol influence. The previous discussion on ocular-motor control suggests neuromuscular impairment at relatively moderate alcohol dose levels. Data to be presented later will suggest also an impaired rate of information processing. These findings suggest that alcohol would affect a rapidly changing complex compensatory tracking function. The compensatory tracking tasks used in the studies discussed above have not had the complexity (demand for rapid neuromuscular movement and information-processing rates) to reveal an alcohol impairment. But in two studies which utilized fairly complex tracking functions, compensatory tracking was impaired. Both studies were attempts to develop a "describing function" of tracking behavior under alcohol. Russell (1951) examined one subject under a 4.5 ounce dose of alcohol (which would produce well above .10% BAC) and found a decrease in "gain" and "lead." Reid, Hansteen, and Miller, (1971) examined 12 subjects at .00, .03 and .07% BAC and reported that alcohol produced increased "effective reaction delay time" and "random output uncorrelated with input."

These two compensatory tracking studies were discussed separately since their task difficulty was uncharacteristic of the requirement for tracking skills associated with contemporary roads and vehicles. The difficulty of tracking associated with current driving is reflected in the relative ease with which even seriously physically handicapped persons control their vehicles.

There is one study which has determined experimentally the amount of attention or information required to maintain the lane position of a vehicle upon a highway (Senders, Kristofferson, Levison, Dietrich, & Ward, 1967). Drivers wore a helmet with a movable opaque visor which intermittently occluded their vision. The study then established how frequently and for how long subjects had to observe the road in order to maintain various speeds on the highway. Some subjects were able to drive within their lane position on the highway at nearly 50 miles an hour while obtaining a 0.5-second glance at the road every 4.5 seconds. A 0.5-second viewing every 3.5 seconds permitted speeds averaging over 60 miles per hour. Even upon a complex sports car course, 0.5-second views every 2.5 seconds permitted speeds ranging from 22 to 72 miles per hour. The frequency of viewing (or inversely the speed) was determined by the complexity of the road at that point. The results supported the authors' views on the intermittent character of the demand for information for controlling vehicle tracking. For our purposes, it illustrates the relatively light attention load imposed by the tracking requirements of the highways.

4. TIME-SHARING

This brief survey of the two time-shared activities which are the basis for driving, visual perception and compensatory tracking, suggest that it is the time-sharing requirement itself which is most susceptible to alcohol influence in the driving situation.

When we combine these two activities into a time-shared, divided attention task, there is an overall performance decrement on the combined task under alcohol. Since neither of the two elements of the combined task is particularly sensitive to alcohol when performed alone, the question arises as how the errors on the combined task will be distributed. In the studies examined where a peripheral visual task was combined either with a central visual tracking task or a central visual blink-counting task, the greater errors have occurred in the peripheral visual task. As noted above, it is clear that alcohol does not affect peripheral vision itself, so why is this the area of greater impairment? Perhaps this is due to the majority of the brain's information-processing capacity being allocated to the central visual task; i.e., prime attention is on central vision. This is not due to an a priori preference for central vision, but due to the emphasis in the above experiments on the central visual task. Similarly, in driving, the constant demands for attention by the ongoing tracking task overshadow the intermittent demands of the peripheral search and recognition task.

An illustration of this last point can be found in a recent study of flying under the influence of alcohol (Billings, Wick, Gerke, & Chase, 1972). Sixteen subjects took off, instrument flew, and landed a plane under four alcohol treatments resulting in 0, .04, .08, and .12% BAC. Eight subjects were highly experienced professional pilots, while the other 8 were non-professional pilots. Flights took place with a safety co-pilot, plus a physician behind the pilot to incapacitate him, if necessary. Although the tracking demands of flying are far more difficult than those of driving, the experienced pilots suffered no significant decrement in their tracking ability, even at the highest dosage. However, even at the lowest dosages, they committed procedural errors which were a hazard to flight. At the highest dose level, the safety co-pilot had to take command of the plane eleven times to prevent an imminent accident. The inexperienced pilots exhibited impairment both in their tracking skills and accumulated far more procedural errors than the experienced pilots. Major procedural errors included: taking off with full flaps, flying without lights, taking off with carburetor heat on, turning the wrong way in response to instructions, and flying a landing approach tuned to the wrong frequency. Catastrophic procedural errors included: loss of control in flight, turns towards oncoming traffic, and landing errors which would involve striking the ground.

The authors comment, "If we assume that instrument-rated pilots, flying ILS approaches, consider the job of guiding their aircraft to a position from which a visual landing can safely be made as their primary task, then it follows that the other, discrete, procedures involved, while no less essential to safe operations, are relegated to a secondary role. The evidence is clear this is in fact the hierarchy which exists. It is equally clear that as pilots are progressively affected by alcohol, they become progressively less able to cope with the various facets of their task, and it is the secondary tasks which suffer first and most."

The prime alcohol deficit does not impinge on the tracking task because more attention is paid to it than to the search and recognition task. This suggestion has additional support from an experiment involving another stressor, noise.

In an experiment similar to Hamilton and Copeman (1970), Hockey (1970) had subjects detecting various visual signals over a wide range of visual angles while simultaneously performing a pursuit tracking task. There were two conditions of signal probabilities: equal frequency of signals at all angles, and a condition where some angles had greater probability of having a signal present. Under the additional stress of the presence of noise, there was an increased reaction time. Where the signal probabilities were the same, all angles showed similar increases in latency of response. Where the probability of signals was unequal, the less probable angles showed a greater deficit. Further support for the notion that the distribution of errors under alcohol for a complex task is related to the distribution of attention can be found in the previously cited study by Gibbs (1966).

Having implicated division of attention in a time-shared activity as the site of the prime action of alcohol in driving, this review will selectively examine the literature on alcohol and attention to determine if it supports the above conclusion.

5. ATTENTION

5.1 Concentrated Attention

The only aspect of attention which has been discussed in this paper is that related to the time-sharing of attention, the problem of the selectivity of the central information processor. There is considerable evidence that there is no impairment of attention conceived as arousal level or vigilance. Thus, for example, Colquhoun (1962) found no alcohol impairment in performance of a vigilance task involving detection of color intensity differences in sets of 6 discs exhibited in over 2,000 trials in each experimental session. Similarly, Talland, Mendelson, and Ryack (1964) found no alcohol effects in a variety of tests of concentrated attention. In fact, a study by Docter, Naitoh, and Smith (1966) suggested that alcohol impedes the performance decline normally found over time in a vigilance task. Additional evidence is provided by the studies of Moskowitz and DePry (1968) and Moskowitz and Sharma (in press) which failed to obtain alcohol impairment of signal detection tasks under concentrated attention. Finally, Moskowitz and Sharma (unpublished) compared marihuana and alcohol in a vigilance task situation using the classic technique of the Mackworth clock. There was a large marihuana effect, but alcohol did not impair performance.

In contrast to the lack of alcohol influence on concentrated attention situations, there is evidence, in addition to that previously reviewed, that performance of a time-shared activity is sensitive to the effects of alcohol.

5.2 Concentrated and Divided Attention Comparisons

A series of studies by Gruner (1955, 1963, 1964) on the effects of alcohol on the performance of two simultaneous tasks found considerable evidence for alcohol impairment. His subjects were required to perform a cancellation task on every "E" in a long string of printed letters and simultaneously to respond to lamps in the periphery of their vision. The accuracy of the cancellation task and speed of responding to the lamps were impaired under alcohol.

The previously cited study by Moskowitz and DePry (1968) directly tested the hypothesis that there is a differential effect of alcohol on concentrated attention tasks versus divided attention tasks. Utilizing an auditory signal detection task in combination with an auditory short-term memory task, the study demonstrated that alcohol had no effect on either of the two tasks when attention was concentrated upon each singly, but did show a sharp performance decrement on the combined task at an alcohol treatment of 0.52 grams of alcohol/kg. bodyweight.

Finally, in the previously cited study by Buikhuisen and Jongman (1970), little evidence was found for an impairment in the alcohol-treated group in situations where there was only one visual aspect to be monitored in the driving scene. The prime differences between the alcohol-treated and the placebo-treated groups occurred in scenes where it was necessary to monitor several activities simultaneously. Emphasis is now being placed by experimenters on further examining the character of division of attention to determine what aspects of central mechanisms are impaired by alcohol.

It should be noted that where relatively simple operations are required on incoming information, even from two diverse sources, the individual may be able to process both sources of information in parallel, at least in the early stages where fairly low-level analysis will suffice. Under these circumstances, the decremental effects of alcohol would be expected to be minimal. However, as the complexity of the information-processing demand from two sources increases, it would be expected that the brain must process the material intermittently in some serial order. Under these circumstances where time-sharing is required, there are at least three possible reasons for the experimentally observed alcohol impairment of the division of attention.

1. Under the necessity for time-sharing the central processor between two or more sources of information, a switching mechanism is necessary for the material to be alternately presented to the central processor. Alcohol might directly impair the rate at which switching can occur. Should the switching rate be slowed, material waiting to be processed in an immediate memory system might be lost.

2. The immediate memory system which is holding material in line to be processed might itself be impaired by alcohol.

3. Finally, the rate of information processing by the brain might be slowed, in which case information stored in the immediate memory system would be lost due to the enforced wait.

5.2.1 <u>Reason 1:</u> Attempts to determine the time function of a switching mechanism have produced disparate estimates from various investigators. No direct study of the effect of alcohol on the switching of attention has been accomplished. Possibly relevant evidence on this issue is from a study by McDougal and Smith (1920) who argued that the spontaneous alternation of ambiguous visual illusions is the result of alternating attention. They examined two visual illusions under alcohol and reported a decreased rate of alternation. Franks (1964) reported comparable results from a similar experiment.

5.2.2 <u>Reason 2:</u> The duration of an immediate memory, which has been postulated as necessary for time-sharing, is of the order of one second or less, and Sperling has demonstrated the existence of this kind of "iconic" memory. Moskowitz and colleagues (unpublished study) have investigated the effects of alcohol on this memory system. Although alcohol impaired the <u>perception</u> of briefly exposed material, there was no evidence that the iconic image disappeared more rapidly as a result of alcohol treatment. It should be noted, however, that short-term memory (defined variously from a few seconds to hours) is reported by many investigators to be impaired by alcohol.

5.2.3 <u>Reason 3:</u> The <u>rate</u> of central processing, as affected by alcohol, has been investigated by Moskowitz and Burns (1971) in a study of the psychological refractory period. The refractory period is that increase in reaction time to the second of two stimuli presented closely in time. The shorter the interval between the two stimuli, the longer the second response is delayed, presumably because the processing mechanisms are occupied with the first stimulus, and the second is delayed for the time required to process the first. It should be noted that there is evidence indicating some overlapping of processing of the two stimuli, but clearly the second response is delayed as a function of the time between the two. An alcohol dose of 0.69 grams of alcohol/kg. bodyweight significantly increased the refractory period, suggesting that the alcohol slowed central processes.

An experiment by Moskowitz and Roth (1971) examined the effect of alcohol on the task of naming a visually presented object. The alcohol dose of 0.52 grams of alcohol/kg. bodyweight was smaller, but the increased latency of responce was larger than that of the Moskowitz and Burns study. It is believed that the larger effect of alcohol is due to the greater complexity involved in retrieving the name of an object, as compared to a key-press reaction time in the Moskowitz and Burns study.

Huntley (1972) examined the effect of a 0.97 grams of alcohol/kg. bodyweight dose on the time to locate a projected dot in a cell matrix. There were several possible cells, varying from 1 to 3 bits of stimulus uncertainty. Impairment was found to vary with the number of cells in the stimulus matrix, rising to a maximum of 12% at the 8-cell matrix, which had the greatest demand for information processing.

Galarneau and Krenek (1971) examined reaction times in situations involving several levels of stimulus and response uncertainty. Subjects were examined under 0, .04, and .08% BACs. While simple reaction time was essentially unaffected by alcohol, there was an increasingly greater effect on reaction time by alcohol as the stimulus and response uncertainty increased.

An unpublished study by Moskowitz and Burns also examined reaction times to a highly compatible stimulus-response series, using 0.69 grams of alcohol/kg. bodyweight. Alcohol significantly increased reaction time, but in information theoretic analysis, the only interaction between alcohol and information load occurred between the condition of no uncertainty and any of five levels of stimulus uncertainty. The alcohol effect was no larger with five bits of information than with, for example, two bits of information.

Auxilliary evidence to support the findings that information processing is slowed by alcohol comes from an eye-movement study by Belt (1969). He reported longer fixation times while driving under the influence of alcohol than when not under alcohol, as did the previously cited Buikhuisen and Jongman study (1970).

What is clear from all of these studies is that tasks measuring time for complex information processing show a greater alcohol-induced performance decrement than simpler processing situations. Whether this is the result of interference with some processing of the potential range of stimuli and responses -- as implied by an information theoretic view -- or whether it is due to the number of central processes involved in the task, is of less immediate concern than the unanimous agreement that alcohol causes greater response impairment when the response requires complex information processing than when only simple motor reaction times are involved.

Thus, our brief review suggests that the site of the alcohol impairment of division of attention is most likely an impairment of the rate of information processing, with some secondary evidence to suggest involvement of the attention switching mechanism per se.

6. BLOOD ALCOHOL CONCENTRATION

One matter of some social concern is the BAC at which it can be presumed that driving is impaired in nearly all subjects. The following conclusions are based on the assumption that the ability to time-share (divide attention) is a necessary requirement for most driving situations.

6.1 Time-shared or divided attention tasks are impaired by low levels of alcohol intake.

Hamilton and Copeman (1970) reported impairment at .017%. Moskowitz and Sharma (in press), and Moskowitz and Roth (1971) demonstrated impairment with dosages which on the average produce BACs well below .05%. Moskowitz and Shea (unpublished study) examined 5 treatment levels (0, 0.207, 0.278, 0.414, and 0.828 grams of alcohol/kg. bodyweight) using the techniques discussed in Moskowitz and DePry (1968). The divided attention condition occurred one hour after drinking was finished. At that time, the BAC due to the lowest dose was less than .015%, yet the auditory signal detection task under division of attention exhibited significant impairment.

The appearance of alcohol effects at these low levels agrees with epidemiological data. For example, Allsop (1966) found accident probability rates to increase with any measurable departure from zero blood alcohol. Moreover, the alcohol-induced impairment is clearly related both theoretically and empirically with driving.

6.2 Divided-attention tasks show almost universal subject sensitivity to alcohol effects by .08% or less.

In Von Wright and Mikkonen's study (1970), all subjects exhibited impairment at 0.4 grams of alcohol/kg. bodyweight. In Moskowitz and Sharma's study, (unpublished), 10 of the 12 subjects were impaired by 0.41 grams of alcohol/kg. bodyweight, and all subjects were impaired by 0.83 grams of alcohol/kg. bodyweight.

Not all studies report the performance of individual subjects. Even if such complete data were available, it still would be difficult to determine whether all subjects are impaired since the response variable is newly learned, and rarely has training been sufficient for performance to reach asymptote before drug testing begins. Under these circumstances, an order effect interferes with definitive statements as to whether all subjects are affected. However, in the two studies just cited, even though order effects confound the data, it appears that the impairment is virtually universal.

Additional support for the universality of the impairment is evident in the previously cited Moskowitz and Shea drug-dose study (unpublished). Two training sessions were followed by five test sessions in a 5 x 5 Latin-square design. The data were examined for order effect, and no further improvement in performance occurred after the second test session. In this case, 7 of 10 subjects were impaired at 0.21 grams of alcohol/kg. bodyweight, and all subjects showed performance impairment at 0.41 grams of alcohol/kg. bodyweight.

Although it is noteworthy that nearly all subjects show impairment in the ability to divide attention by .05% BAC, there is a data limitation which should be mentioned. Subjects in these studies tend to be members of readily available populations, such as students in the university where the study is conducted.

In another study by Moskowitz (1971a), subjects were persons convicted of drinking while under the influence of alcohol. They showed significant impairment of the auditory divided attention task at a dose of 0.83 grams of alcohol/kg. bodyweight, but the impairment was somewhat less than that exhibited by students at comparable doses. Since it is the potential or actual DWI populations about whom we are most concerned, it seems necessary to examine this group with these techniques to ascertain the universality of the alcohol impairment.

7. METHODOLOGY ISSUES

Despite the apparent contradiction between many of the studies, it is the reviewer's impression that generally both subjects and treatments were adequately controlled and appropriate experimental designs and statistical analyses utilized. If there has been confusion because of conflicting results, the problem has lain in the presence of hidden variables, such as attention, set, and information-processing limits of which the experimenters have been unaware. It is unrealistic to expect researchers to be aware of such issues prior to their general appreciation and dissemination in the field of study. The prime problem for research is asking the right questions, including an awareness of relevant variables. The problem of experimental design or statistical analysis is secondary.

Another manner of expressing the same thought is to note that psychology does not have a taxonomy of behavior. If a pharmacologist asks what behaviors are affected by drug X, or if an engineer asks what behaviors are important for driving, psychologists cannot produce a list of behavior components to be tested for possible relevance. There is inadequate knowledge of the behavior components and/or brain processes used to organize the socially significant complex behaviors. Depending upon one's theoretical orientation, different behavioral investigators use different behavioral variables for response measures while believing they are investigating the same basic behavioral mechanism. The result is apparent experimental disagreement, which often is rashly ascribed to experimental inadequacies of investigators.

An illustration in this paper can be found in the conflicting report of the effects of alcohol upon peripheral vision. Until one becomes aware of the importance of possible demands for division of attention and then notes its presence or absence in a given experiment, experimenters will arrive at conflicting results.

7.1 Reaction Time

Other illustrations can be found in the literature on reaction time, a cursory examination of the literature revealed considerable disagreement as to whether there is an effect of alcohol upon simple reaction time, and as to whether this effect increases with increased complexity in the reaction time situation. Again, the disagreement rests not upon inadequacies in experimental techniques of the various investigators, but appears to be due to an inadequate definition of the behavior being studied and its isolation from confounding variables.

Reaction time experimentation does not define a meaningful behavioral segment. It is a dependent response variable measuring the time taken to initiate a response. This response can, and often is, based on quite dissimilar brain functions. In fact, it was the belief in the dissimilarity of central processes involved in various reaction time experiments that led to its frequent use by Wundt and Donders in the early history of experimental psychology.

Given the wide range of stimulus and response configurations that have been involved in reaction time experimentation under alcohol, it is unlikely that the same central processes were intermediate in these various situations and therefore most unlikely that alcohol would have a uniform effect.

More profitable than past arguments regarding the effects of alcohol, which have been based on quite disparate situations, are some recent studies in which some aspect of the complexity of the reaction time situation has been systematically varied and its interaction with alcohol and resulting reaction time measured. Two examples are by Sanders and Wassen-van Schaveren (1970) which varied stimulus-response compatability, and Moskowitz and Burns (unpublished) which varied the quantity of information in the stimulus configuration.

A tentative conclusion regarding reaction time experiments can be ventured despite the considerable variability of results. Simple reaction studies will usually exhibit a small and statistically significant increased reaction time by BACs of .08%. However, these increases appear of little importance in view of their small size. On the other hand, studies involving complex reaction time will exhibit a wide range of ethanol influence from small to quite large effects. It is suggested that the source of this great variability lies in the differing degree of participation of various central processing functions in the various experiments, depending on the particular stimulus and response configurations utilized. It is in some of these more complex reaction situations that the degree of impairment is sufficiently large to be of potential significance for safety.

7.2 Driving Simulators

An additional function assigned to this reviewer was to comment upon studies of the effects of alcohol upon performance in driving simulators. This task has been admirably accomplished by the recent paper of Heimstra and Struckman (1972). After examining a wide variety of studies performed in quite dissimilar simulators using a wide range of response variables, such as speed, tracking, pedal and steering usage, they concluded that "there appears to be no behavior on which the effects of alcohol have been reported more than once with complete consistency. In many cases alcohol appears to have had opposite effects on the same behavior in different investigations (Heimstra & Struckman, 1972, p. 17)."

However, performance decrements in more complex situations occurred frequently enough for the authors to suggest that "perhaps the most important factor determining the impairment of the driving task is the effect of alcohol on the higher mental processes (Heimstra & Struckman, 1972, p. 27)." It appears that this review of simulator studies might again contain the problem of hidden variables affecting the results rather than the variables the experimenters initially believed they were investigating.

8. RESEARCH DIRECTIONS

One function of this symposium is to suggest areas of importance for future investigations. If any conclusion can be derived from this review, it is that drivers under the influence of alcohol have their information-processing capacity reduced and thus must restrict some of their information inputs which might normally have been processed concurrently. Questions which arise from this conclusion include the following: what determines the strategy for selection of inputs for attention under the restricting influence of alcohol? For example, how does alcohol affect the patterns of visual search which typically characterize the driving situation? Such knowledge could assist in developing better techniques for communicating the presence of potential danger to the driver under the influence of alcohol.

It would appear that limits on information processing are at the heart of the problem, but little is known about what specific aspects of information processing are affected by alcohol. Greater knowledge of what specific central processes are affected by alcohol might assist in developing techniques of presenting information necessary for the driving task so that it is less susceptible to disruption by the presence of alcohol.

One factor in considering future investigations is the greater inclusion of subjects drawn from the heavy drinking groups in the population. As Allsop (1966) has demonstrated, accident probabilities as a function of BACs differ depending on the frequency of drinking practices. Most studies examined in this review utilized the readily available sample of student subjects. While general conclusions would not likely change with other drinking populations, estimate of BAC where significant changes in performance decrements occur would be likely to be a function of drinking practices.

The above conclusions are based primarily on laboratory and driving simulator studies of the effects of alcohol. Few epidemiological studies have investigated alcohol accidents in the depth necessary to offer evidence regarding how alcohol causes increased driving accidents. More intensive studies of the causes of alcohol-related accidents (for example, by on-site accident teams) would assist in clarifying theories of causation and possibly offer new postulates regarding techniques for accident avoidance.

9. SUMMARY

Laboratory studies of the effects of alcohol were reviewed for three topics considered essential for good driver performance: vision, tracking, and division of attention.

When examined by isolating a specific function, most visual sensory functions appeared resistant to the influence of alcohol. While ocular-motor functions showed impairment at moderate blood alcohol levels, these deficits appeared small and unlikely to be of major significance. Studies of the tracking most often found in driving -- compensatory tracking -- found little impairment until high alcohol dose levels. However, when either visual or tracking functions were examined in more complex situations typical of the requirement of driving for simultaneous visual and tracking responses, there appeared large performance decrements at low blood alcohol concentrations.

The evidence suggests that the source of the alcohol impairment in complex situations is in interference with the ability to process large quantities of information from more than one input at a time. Alcohol affects driving because driving demands division of attention between a visual search-and-recognition task and a tracking task. This conclusion is supported by evidence that alcohol impairs the rate of processing information, an important ingredient in rapid time-sharing of attention between several inputs.

Studies which have specifically examined the ability to divide attention have found that this impairment occurs significantly at levels below .02% BAC and moreover occurs for nearly all subjects below .08%, supporting epidemiological studies which have found alcohol-related driving accidents to increase significantly by the .05% BAC.

The review indicates that the significant site of influence for alcohol is in central processing of information, rather than in the more peripheral sensory or motor functions.

It is suggested that future research into alcohol causation of driving accidents examine the effects of the limited central processing of information on the strategies of sampling of information inputs.

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Chapter 4

MOTIVATIONAL AND COGNITIVE EFFECTS OF ALCOHOL

Herbert Barry, III

ABSTRACT

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.

1. INTRODUCTION

Human behavior involves a combination of excitatory and inhibitory components. These opposite forces can be seen in the organization of the brain, in sensorimotor coordination, in long-term planning, and in social behavior. Excessive excitation leads to convulsion or to disorganized activity. Excessive inhibition means unresponsiveness to stimulation and failure to initiate new responses. Each person needs to develop a controlled, selective balance between the opposite forces, with predominance of the excitatory component under some circumstances and of the inhibitory component under others.

Safe driving requires a well-controlled combination of excitatory and inhibitory forces. The excitatory components of this behavior include vigor and speed of motor responses, mediated by alert, attentive cognitions and impelled by motives of zeal and achievement. These excitatory components are always necessary, but they are especially important for prompt, vigorous reaction to a sudden, unexpected crisis. The inhibitory components of safe driving include restraint and delay of motor responses, mediated by suppression of some cognitions in the development of selective attention and impelled by motives for caution and restraint. These inhibitory components provide the mechanism for performing routine, well-practiced responses automatically, with a minimum of conscious attention. This selective suppression of attention enables greater concentration on novel or sudden stimuli and, in particular, conserves mental and physical energy during prolonged driving.

During normal driving, the excitatory and inhibitory components are well-balanced, both contributing to alert, careful, safe driving. The pharmacological actions of alcohol can give rise to traffic accidents by interfering with both the excitatory and inhibitory processes. The normal attentiveness may be overcome by the sedative action of alcohol, which can lead to unresponsiveness, stupor, or sleep. The normal caution may be replaced by excessive speeding and other risky behavior which characterizes many intoxicated drivers. Table 1 summarizes some motivational and cognitive components which may participate in the alcohol effects. Motives are defined as the internal stimuli which impel the individual to perform responses which alleviate unpleasant conditions or attain pleasurable ones. Therefore, motives involve the emotions and moods which express desires and impulses. Cognitions are defined as awareness and understanding of the internal and external environment. The intellectual processes of perception and interpretation are involved.

Motivations and cognitions are both highly complex processes which change continuously and rapidly and which affect each other. They are internal events which cannot be measured directly, but must be inferred from physiological accompaniments or behavioral responses. Different motivational influences are concurrently active, some of them conflicting and therefore counteracting each other. The motivations may change rapidly, especially because they are associated by previous learning with certain objects or events which serve as signals for arousal or relief of physical discomforts. Therefore, cognitive processes of awareness and understanding may arouse or relieve particular motivations. The cognitions also are complex and may change rapidly in response to various sources of stimulation, including the external environment and internal motivations. Cognitions may conflict with each other and attain different degrees of development, as exemplified by partial or distorted awareness when certain thoughts or memories are repressed from conscious knowledge.

The motivational and cognitive elements are inextricably combined with each other in automobile driving or in the causation of an accident. However, it is possible for laboratory studies to investigate effects of alcohol on particular motivations or cognitive capabilities. The present paper reviews and evaluates studies of this type in humans. The findings may provide indirect but valuable evidence concerning the differential influence of various motivational and cognitive effects of alcohol as causes of the increased risk of traffic accidents during acute alcohol intoxication.

2. REVIEW

It would be desirable to measure the effects of alcohol on a specific motivational or cognitive element. However, even in carefully controlled laboratory experiments, performance is affected by a complex combination of motivations and cognitions which cannot be separated from each other. Therefore, the present review is divided into five broad categories, each of which provides information about various motivations and cognitions. These categories are named as follows: (a) direct expression; (b) indirect expression; (c) arousal and conflict; (d) intellectual performance; and (e) memory. Studies are grouped into the same category primarily on the basis of research technique rather than motivational or cognitive topic. Therefore, research reviewed in several categories may contribute useful information about the effects of alcohol on a particular motivation or cognition.

All five categories of alcohol effects have been reviewed in Chapter 7 (Volume 1) of a two-volume survey (Wallgren & Barry, 1970, pp. 331-400). The

TABLE 4-1

Summary of Effects of Alcohol on Motivational and Cognitive Components of Behavior which can cause Highway Accidents.

	Depressant effects	Disinhibitory effects
Motivational components	Sedation or fatigue; Self-destructiveness	Fear reduction; Assertiveness
Cognitive components	Memory loss; Learning deficit	Dissociation from sober habits; Impaired self-criticism
General behavior	Inattention; Sleep	Risk-taking; Disorganization
Driving performance	Driving off road or into obstacle; Insufficient response in emergency	Excessive speeding or risky maneuvers; Loss of control in emergency

TABLE 4-2

Depressant and Disinhibitory Effects of Alcohol on Reported Mood in Several Laboratory Experiments on Humans

Experiment	Subjects	Alcohol dose	Depressant effects	Disinhibitory effects
Hurst et al. (1969)	70 men	0.5 g/kg	Less concentration	More surgency More social affection More elation More vigor More confidence Less anxiety
Hurst et al. (1972)	34 men, 16 women	0.9 g/kg	More relaxation Less aggression Less goal-directedness	More surgency More social affection Less nervousness Less insecurity Less depression
Hurst & Bagley (1972)	50 men, 9 women	0.63, 0.85 g/kg	More relaxation Less aggression Less goal-directedness	More surgency More social affection Less nervousness Less insecurity Less depression
Kelly et al. (1970)	16 policemen	1.4 g/kg		More elation More talkativeness Less sleepiness
Kelly et al. (1971)	16 men	0.7 g/kg	Less working capacity	More elation More talkativeness Less tiredness
Reisby & Theilgaard (1969)	34 men, 10 women	1.1 g/kg	Less alertness Less motor coordination	More exhilaration
Hollister & Gillespie (1972)	11 men, 1 woman	0.8 g/kg	More drowsiness Less activity	More stimulation
Warren & Raynes (1972)	6 men, 6 women	.05, .10% BAC	More depression More fatigue More confusion Less vigor	Less tension More anger
Williams (1968)	91 men	0.7 g/kg	Less intraception Less endurance	More exhibition More heterosexuality Less order Less succorance Less abasement

present paper summarizes the conclusions from that earlier, more detailed review. However, the classification of categories and application of the findings to problems of highway safety are new contributions of the present paper. Some additional research reports are also cited, most of which have been published subsequent to 1968. In order to avoid redundancy, none of the references in Chapter 7 of Wallgren and Barry (1970) are cited in the present review.

2.1 Direct Expression

People's self-reported moods and emotions may be distorted by various motivational and cognitive processes. These include repression or denial of desires or perceptions; selective inattention to certain feelings; deficiency of verbal labels for non-verbal behavior; the rapid changes in mood and emotion, which can be altered even by the process of introspecting about them; and purposeful concealment or deception in the report to the experimenter. However, the subjectively perceived emotional reactions are important components of the effects of many drugs. Most people are strongly interested in the effects of drugs on their moods, and a trusted experimenter can obtain honest reports quickly and easily. Useful evidence about motivational and cognitive changes under the influence of a drug can be provided by direct expressions of self-perceived moods, especially when they are corroborated by objective measures of drug effects.

Several standard questionnaires about mood and emotion have been devised. Wallgren and Barry (1970, pp. 345-349) have reviewed laboratory studies which include a variety of alcohol doses and procedures in human subjects. Alcohol predominantly induces pleasant and exhilarated moods. The stimulant, euphoric effect is often manifested by loud, boisterous, cheerful, and friendly behavior and accompanied by a decrease in anxious, depressed, tired, or tense feelings. According to some atypical reports, alcohol increases aggressive and nervous moods. These adverse changes further indicate the disinhibitory effects of alcohol which have been observed at various levels of integration of behavior in humans and laboratory animals.

Other self-perceived moods indicate the opposite, depressant actions of alcohol. Many people report that under the influence of alcohol they feel more sleepy, calm, and contented. Some disadvantageous or unpleasant aspects of the depressant effect are reports of feeling more hazy, distant and withdrawn, more tired, less willing to trust their own judgment, less clear-headed, and less energetic. In some cases, depressed feelings have been reported.

Two studies of intravenous alcohol administration, included in the review, provided important evidence that the changes in mood were not due solely to people's expectations about the effects of alcohol. Disinhibition was indicated by increases in elation or excitement and by a decrease in depressed feelings. Depressant effects were indicated by subsequent relaxation, sleep, or stupor and by a decrease in the feeling or clear thinking.

Subsequent experiments, summarized in Table 2, have demonstrated still more clearly the opposite effects of alcohol on mood. Despite differences in alcohol dose, drinking situation, and measures of mood, the depressant and disinhibitory effects of alcohol are both evident in most of these experiments. The specific mood changes generally correspond closely to those reported in the experiments reviewed by Wallgren and Barry (1970). One of the experiments summarized in Table 2 (Kelly et al., 1970) showed exclusively disinhibitory effects of alcohol.

This might be attributable to the procedure of consuming a large alcohol dose during a prolonged interval (1.5 hours) together with a meal.

Two of the experiments in Table 2 were conducted in Sweden (Kelly et al., 1970; 1971), one in Denmark (Reisby & Theilgaard, 1969), and the others in the United States. In general, rather similar results have been obtained under diverse conditions. Warren and Raynes (1972) tested their subjects on different occasions under isolated and social conditions after oral consumption of alcohol. Another test under the isolated condition was preceded by intravenous infusion of alcohol. Each of these tests showed a similar difference from the preceding baseline of the same day for most of the moods. A control test (isolated condition preceded by intravenous infusion of saline) showed little difference from the baseline. Williams (1968) conducted the test in a social, party setting.

In addition to the self-rated moods, Reisby and Theilgaard (1969) reported on observations of the subjects by the two testers. They found that alcohol increased sociability, self-esteem, and expressions of an exhilarated mood, but decreased psychomotor tempo seen in speech, facial expression, and rate of movement. These observations likewise indicate both depressant and disinhibitory effects of alcohol.

Some of these experiments provide evidence about effects of different durations and amounts of alcohol consumption. Warren and Raynes (1972) found that in comparison with the blood alcohol concentration of .05%, vigor was more greatly decreased and fatigue more greatly increased in the ratings at .10% after further drinking. Likewise, Hurst et al. (1969) found that vigor was increased and fatigue slightly decreased at one hour after drinking began, whereas vigor was decreased and fatigue increased one and a half hours later. Williams (1968) found that at the end of the alcohol drinking, after an average consumption of 2.0 g/kg, the earlier increase in heterosexuality had disappeared and decreases had emerged in deference, affiliation, and nurturance. These changes indicate less stimulation and also less pleasant moods. Kelly et al. (1971) found that more than five hours after drinking, two hours after a meal, most of the alcohol effects had disappeared with the exception of an increase in tiredness. In order to test effects of hangover, Kelly et al (1970) obtained mood ratings on the following morning, more than 12 hours after drinking began. Drowsiness, tiredness, and sleepiness were increased, but working capacity had returned to normal.

Women were included in some of the experiments summarized in Table 2, but sex differences were not reported. It is suggestive that a preponderance of depressant effects of alcohol were found in three studies which included one or more women (Reisby & Theilgaard, 1969; Hollister & Gillespie, 1972; Warren & Raynes, 1972). Also, in the studies by Hurst et al. (1969; 1972) and Hurst and Bagley (1972), the smallest number of depressant effects was found in the one which included no women (Hurst et al., 1969).

Other categories of people might react differently to alcohol. In Table 2, no depressant effect of alcohol was found by Kelly et al. (1970), as already noted. The subjects were policemen in this experiment, whereas they were college students in most of the other experiments. Haertzen and Miner (1965) found that in 80 men who were hospitalized narcotic addicts, self-rated mood showed increased subjectivity and femininity under the influence of alcohol (0.7 g/kg followed by smaller amounts).

Wallgren and Barry (1970, pp. 516-517) have summarized several experiments on acute effects of alcohol in chronic alcoholics. The prevalent finding is a normalized or elevated mood. When the experimental drinking is continued for a number of days, the initial pleasurable reaction is generally followed by anxiety, depression, and psychopathic tendencies. In a subsequent study, Tamerin and Mendelson (1969) reported that four alcoholic men initially felt more relaxed, less inhibited, and generally elated during drinking, followed during subsequent days and weeks by frequent painful emotions which included depressing memories, feelings of remorse and self-depreciation, guilt, extreme emotional lability, and crying spells. In a similar experiment, Tamerin et al. (1970) found that during the several days of drinking, 13 alcoholic men tended to see themselves as more aggressive, more active, with more painful affect (dysphoria), and less responsibility. In a comparison with 50 alcoholic men not given alcohol, Vanderpool (1969) found that the acute effects of alcohol in 50 alcoholic men included lower self-esteem, less defensiveness, more intraceptiveness and novelty seeking, stronger heterosexual and weaker aggressive feelings, and less tolerance to stress and strain.

The topic of acute effects of alcohol in alcoholics is reviewed and discussed by Mello (1972) and by Barry (1973). Alcoholics seem to differ from nonalcoholics with respect to the effects of drinking on moods and emotions. The predominantly aversive reactions to intoxication reported in alcoholics may be due to the controlled drinking situation in the laboratory experiments, applied to people who are already hospitalized for alcoholism and with strong incentives for achieving and maintaining sobriety. In the normal drinking situation, a substantial degree of pleasure or at least relief seems required to explain the repeated choices to drink rather than to abstain. Pleasurable and relieving effects of alcohol in nonalcoholics are shown in Table 2. Observations or studies of the usual drinking situations would probably show the same effects in alcoholics.

2.2 Indirect Expression

A variety of projective tests are designed to measure indirect expressions of emotions and moods. These tests may provide information about motivations and cognitions which are repressed, unverbalized, or otherwise not accessible to direct questions about subjective feelings. Wallgren and Barry (1970, pp. 349-353) have reviewed effects of alcohol on responses to standard projective tests and on other expressive behavior such as handwriting. Depressant effects have been predominant in these studies, indicated by measures such as superficial responses and inaccurate or incomplete perception. However, stimulant and disinhibitory effects are also manifested by an increased occurrence of impulsive and hasty responses.

Reports on the specific projective tests (Wallgren & Barry, 1970, pp. 349-353) show these dual effects of alcohol. The Rorschach inkblot test is generally regarded as a measure of deep levels of motivation and personality organization, but it seems to reveal very little about effects of alcohol except that the perceptions of forms become more vague and stereotyped. The Thematic Apperception Test (TAT) enables analysis of various attributes of stories told about pictures. Under the influence of alcohol, the stories are more superficial and poorly organized, but they also show less inhibited expressions of aggressive and sexual feelings. In a test of response to humorous cartoons, alcohol enhances the ratings of humor, especially for aggressive rather than nonsense humor. Measurements of handwriting and of pictures drawn reveal greater expansiveness under the influence of alcohol. In tests of word associations reviewed by Wallgren and Barry (1970, pp. 332-334), alcohol causes the associations to be made more impulsively and quickly, and the words are more superficial, and more likely to be related in spelling (homonyms) than in meaning (synonyms or antonyms). In these diverse tests, alcohol appears to depress any tendencies for organized meaningful expression of cognitive or emotional responses while showing a stimulant, disinhibitory effect on the style of responses.

An extensive series of experiments on effects of alcohol on TAT stories of men has subsequently been reported by McClelland et al. (1972). Alcohol increased themes of power in the stories. The greatest increases were in themes of socialized power after medium alcohol consumption and in themes of personalized power after heavy alcohol consumption. In many cases, the increase in power themes involved increases in themes of physical sex, physical aggression, and sharply contrasting ideas (contrast of meaning). At the same time, alcohol decreased two measures of inhibitory tendencies: themes of time concern and themes of activity inhibition. These effects of alcohol were greatest in an informal, party setting. The experiments with non-alcohol control groups were all conducted on college students, but the same changes in TAT stories after drinking were found in a study on working-class men. However, evidence for a sex difference in effects of alcohol on TAT stories has been reported by Wilsnack (1972; 1973). In women, drinking decreased themes of personalized power and had no reliable effect on themes of socialized power. Drinking increased fantasies related to feminity, indicated by similarity to fantasies of mothers while breast-feeding their infants or by perceiving as female the picture of an adult playing with a child. These may also express maternal or general nurturant feelings.

Although some of the subjects tested by McClelland et al. (1972) were heavy drinkers, the effects of alcohol on TAT stories differ in hospitalized alcoholic men according to a report by Cutter, Key, Rothstein, and Jones (1973). Their subjects showed no differential effect of the occurrence or amount of drinking on themes of power or of activity inhibition. However, their procedures had several novel features and involved drinking by most of the alcoholic men between the first and second set of TAT stories. There was an overall increase in themes of power, which seems to agree with the effects of alcohol found in nonalcoholic men. However, there was also an overall increase in themes of activity inhibition, contrary to the inverse relationship between power and activity inhibition themes in nonalcoholic men.

Two recent experiments on handwriting have provided new information about effects of alcohol on various attributes of this highly habituated expressive behavior. Hilton (1969) asked 20 young men to copy a printed passage, before and after one hour of drinking liquor. The amount of consumption was self-selected; the blood alcohol concentrations generally ranged from 0.06% to 0.10% at the time of the test. In all cases after drinking, the handwriting showed poorer alignment on the unruled paper, and the majority were larger, the writing more spread out, and the forms less legible or less accurate. These changes indicated relaxation in the control of handwriting. However, in most cases, there was no change in the signature, written at the beginning of the task. Also unchanged after drinking were writing pressure, variation in pressure or thickness, and speed. A more carefully controlled experiment was conducted by Brun and Reisby (1971) on 57 men and 21 women who drank a specified amount of alcohol (1.1 g/kg) or placebo beverage in different sessions in a different sequence for different subgroups. Alcohol increased fluctuations in size, uneven pressure, and thready connections. Other effects of alcohol were increase in size, heavier pressure, increased fullness, tendency to limpness, accentuation of movements, and decrease in uniformity. These results also indicate impairment or relaxation in control of the handwriting.

The foregoing effects of alcohol reported by Brun and Reisby (1971) were found in two groups of subjects, one copying an orally dictated passage and the other self-selecting their written texts. Further tests with meprobamate generally showed the same differences between alcohol and placebo. The copying test was conducted as part of a series of tests reported elsewhere (Reisby & Thielgaard, 1969), cited in other portions of the present review, including Table 2. Individual differences in personality were related to magnitude of alcohol effects. This aspect of the study was aided by the fact that some of the subjects were selected for low or high scores on the Taylor Manifest Anxiety Scale. Among 23 subjects whose handwriting was only slightly altered by alcohol, most were well-controlled, stable, and purposeful in their work. Some of these were efficient, well-balanced, and ambitious, whereas others were perfectionistic, compulsive, and inhibited against expressing aggression. Among 20 subjects whose handwriting was severely altered by alcohol, most showed emotional lability and poor control of their impulses. Some had difficulty in concentrating, whereas others were sensitive and anxious.

Effects of intravenous infusion of alcohol (approximately 0.6 g/kg) or placebo were tested on responses by 12 men to the Holtzman Inkblot Test (Mayfield, 1968). The alcohol had little effect on the forms perceived, but reliably increased the color score. This effect suggests an increase in impulsiveness, in immediacy of emotional expression, or in response to environmental stimuli according to the usual interpretations of color response. These effects are consistent with the more superficial and disinhibited response to various projective tests found under the influence of alcohol.

2.3 Arousal and Conflict

Various motivating forces involve strong stimulation experienced by the individual and an arousal response to the stimulation. In this situation, the opposite effects of alcohol are both manifested. Depending on the conditions, alcohol may depress and sedate the arousal response, or may stimulate and disinhibit it. In a conflict situation, alcohol may relieve the fearful or avoidance component of the conflicted responses, thereby releasing more bold and active behavior.

The sedative action of alcohol is indicated by decrease in various physiological measures of responsiveness, such as the galvanic skin response, reviewed by Wallgren and Barry (pp. 176-180). This effect has generally been found with the rather small doses of 0.4-0.5 g/kg, but under some conditions, alcohol appears to increase responsiveness. Response to various types of painful stimulation is also decreased by alcohol according to several studies reviewed by Wallgren and Barry (1970, pp. 294-295). Sexual and maternal functions are also decreased by alcohol (Wallgren & Barry, 1970, pp. 180-182), although most of this research has been on laboratory animals. A review by Cappell and Herman (1972) evaluates the experimental evidence for the widely accepted hypothesis that alcohol reduces tension. Most of this evidence has been obtained from laboratory animals. Wallgren and Barry (1970, pp. 359-367) have reviewed experiments on motivational effects of alcohol in laboratory animals. Sedative or generalized depressant effects are most prominent; stimulant effects are attributable to a fear-reducing or other disinhibitory action in a conflict situation.

Intoxicating doses of alcohol cause pituitary-adrenal activation and other physiological stress responses, reviewed by Wallgren and Barry (1970, pp. 172-176). This physiological activation accompanies the sedative effect and indeed may constitute a compensatory response to counteract the depression of function. In various situations, alcohol releases a stimulant or disinhibited type of behavior. The animated, excited, exuberant behavior of the intoxicated person is often seen at parties, but is less clear in laboratory experiments.

Wallgren and Barry (1970, pp. 351-352) reviewed several experiments which indicate that medium doses of alcohol increase people's willingness to accept risks. However, this effect is small and not entirely consistent. Subsequent research likewise shows a small increase in risk-taking under the influence of alcohol. Hurst et al. (1969) found that alcohol increased the percentage of maximum bets in a card game. An additional non-significant trend was for alcohol to increase the size of the bets, especially when this decision was in accordance with good strategy. Hurst et al. (1972), in a game of bidding on bridge hands, found a slight, non-significant tendency for alcohol to decrease the percentage of passes. In both experiments, the paid subjects wagered for bonus money; the effects of alcohol on their self-rated moods are summarized in Table 2. In contrast to the small effect of alcohol on wagers for money, Katkin et al. (1970) found that alcohol (0.64 g/kg) substantially increased the choice of the riskier alternative in a series of hypothetical questions. This effect was greater with bourbon whiskey, which has a high congener content, than with vodka or synthetic alcohol.

Alcohol intoxication has often been observed to release aggressive or sexual behavior, but laboratory experiments on humans show little evidence for these effects. In studies of self-rated moods (Table 2), aggression is more often reported to be decreased than increased after alcohol consumption. In a review by Carpenter and Armenti (1972), very little evidence was found for increases in sexual or aggressive behavior under the influence of alcohol. Most of the studies in humans were with projective tests such as the TAT. In an experiment on the intensity of shock punishment the subject believed he was inflicting on another person, Bennett et al. (1969) found no significant effect of alcohol (0.33, 0.67, 1.00 g/kg), tested in the same subjects in different sessions. However, the average aggression score was lowest in the placebo condition and highest with the middle dose of 0.67 g/kg. Williams (1968) found an increase in self-rated mood of heterosexuality, as shown in Table 2.

Differences among people in response to alcohol have been reviewed and discussed by Wallgren and Barry (1970, pp. 353-358). Many of these differences are attributable to different motivational or emotional changes caused by alcohol. In an amplification of a report included in that review, Petrie (1967) has classified people into augmenters and reducers on the basis of whether they tend to emphasize or minimize the subjectively perceived effect of painful stimulation. Alcohol has an overall tendency to reduce the response to pain, but the effect is primarily in the augmenters. Alcoholics may be expected to differ from nonalcoholics in their general motivational condition and in their response to alcohol. Tamerin and Mendelson (1969) reported increases in aggression and in heterosexual and homosexual expression among alcoholic men during a prolonged period of drinking in the hospital. Cutter, Green, and Harford (1973), in a comparison between 15 introverted and 15 extraverted alcoholic men, found that risk-taking in wagers for money was higher in the extraverts when sober, but this difference was completely reversed after drinking a moderate amount of whiskey, resulting in an alcohol dose of approximately 0.6 g/kg.

2.4 Intellectual Performance

All tests of sensory or motor performance involve complex, interrelated motivational and cognitive factors. Even the simplest, most habitual behavior is governed by the integrating, organizing activity of the cerebral cortex. Therefore, evidence about motivational and cognitive effects of alcohol can be obtained from tests of sensori-motor functions, such as those reviewed in Chapter 6 of Wallgren and Barry (1970, pp. 287-314). However, complex intellectual functions provide much broader scope for showing effects of changes in motivation and cognition.

Effects of alcohol on problem solving were reviewed in Chapter 7 of Wallgren and Barry (1970, pp. 334-341). Detrimental effects of alcohol have been found in most of the experiments, with various doses, tests, and procedures being sampled. With these highly integrated and skilled types of behavior, the depressant actions of alcohol are predominant. The stimulant or disinhibitory actions of alcohol are generally expressed by hasty, careless, disorganized performance. However, a few experiments have reported that low alcohol doses improved certain types of intellectual performance.

These conclusions are supported by subsequent experiments, but some new comparisons of alcohol effects in a variety of tests provide valuable information on differential magnitude of effects. Experiments by Jones (1972) and by Jones and Vega (1972) indicated that alcohol (1.0-1.1 g/kg) had a greater detrimental effect in a test of abstractions than in a vocabulary test. Other recent studies indicate that intellectual functions are more resistant to detrimental effects of alcohol than are sensori-motor functions. Sidell and Pless (1971) found that three alcohol doses (0.8, 1.1, 1.4 g/kg) caused greater decrement in a sensori-motor tracking task than in the more intellectual tests of arithmetic and reproducing a brief time interval. Reisby and Theilgaard (1969), in an extensive study which has been cited already (Table 2), found a greater detrimental effect of alcohol in the Romberg test of standing steadiness than in a variety of intellectual functions. In an experiment by Hurst and Bagley (1972), also cited in Table 2, combined standing and hand steadiness was much more impaired by a higher alcohol dose (0.85 g/kg) than by a lower dose (0.63 g/kg). A coding test showed apparently less detrimental effect of alcohol and slight difference between the two doses.

Various characteristics of the test may alter the effect of alcohol. Generally, more difficult tasks are more vulnerable to impairment by alcohol. Landauer and Milner (1971) reported that alcohol (0.64 g/kg) impaired performance of complex, concurrent tasks in a driving simulator more than performance in simple tests of tapping speed, tracking, and reaction time. Lewis (1973) tested effects of two alcohol doses (0.41, 1.23 g/kg) in tests of card sorting and visual-motor coordination, both given in two versions which varied in difficulty. Alcohol had a greater detrimental effect on the more difficult version of both tasks. Alcohol also had a greater detrimental effect on the test of visual-motor coordination, and in fact, the low dose tended to improve card-sorting performance.

Other findings likewise indicate greater detrimental effects of alcohol when the task is more difficult. Hurst and Bagley (1972), testing motor steadiness by the number of contacts made against the side of an aperture, found that the effect of the higher alcohol dose (0.85 g/kg) was much greater with the smaller aperture. However, the lower dose (0.63 g/kg) did not have consistently different effects with three aperture sizes. Collins et al. (1971) reported that alcohol (0.8 g/kg) caused greater increase in tracking errors from a moving rather than stationary cockpit. Gilson et al. (1971) confirmed that effect of a moving cockpit with two alcohol doses (0.4, 0.8 g/kg), although the lower dose tended to improve performance in the stationary cockpit. In addition, the detrimental effect of the higher alcohol dose in the moving cockpit was greater if the test instrument was dimly rather than brightly illuminated.

Several recent experiments give evidence that the detrimental effect of alcohol is augmented by stressful or distracting conditions. Such conditions may elicit divided attention, which has been shown highly susceptible to impairment by alcohol in the preceding paper by Moskowitz and in some earlier studies reviewed by Wallgren and Barry (1970, p. 299). Hamilton and Copeman (1970) tested effects of two alcohol doses (0.21, 0.63 g/kg) under a quiet (70 db) and noisy (100 db) condition. Tracking performance was impaired by the higher alcohol dose under both conditions and by the lower dose only under the noisy condition. Both noise and alcohol decreased the frequency of detecting peripheral lights, with little effect on detection of central lights. Manno et al. (1971) found that a low alcohol dose (0.5 g/kg), which had no consistent effect in a tracking test, impaired performance in eight of nine tests under the stressful, distracting condition of delayed auditory feedback. Enhancement of alcohol effects by boredom or fatigue may account for a finding by Lewis (1973), in a study already cited, that the detrimental effects of alcohol were generally greater in the later portions of the 15-minute tests.

Some of the recent experiments indicate certain components of performance which are differentially affected by alcohol. Rafaelson et al. (1973) found that in simulated driving, alcohol (1.0 g/kg) slowed the braking response to a red light more than the starting response to a green light. Alcohol also increased the number of gear changes. Lewis and Salamis (1969), in another driving simulation test, studied effects of approximately 0.08% blood alcohol concentration on response to a change from green to amber light at various distances from the intersection. Alcohol increased the tendency to continue through rather than stop and increased errors of judgment, but not of execution. Both of these experiments suggest a stimulant or disinhibitory effect of alcohol, resulting in impairment of control.

Other tests of perceptual rather than motor performance appear to measure primarily the effects of alcohol on cognition, although motivational changes also influence the responses. Alcohol generally has a depressant effect, impairing performance. Buikhuisen and Jongman (1972) showed a 5-minute film of traffic events. Blood alcohol concentrations averaging 0.08% delayed perception of events and increased the number of events missed, especially those to the left or right of the road and nonmoving objects. A decrease in perceptual activity under the influence of alcohol was further indicated by less variation in direction of eye fixations; in particular, fewer rapid eye jumps when more than one event occurred simultaneously. Kristofferson (1968), using the Rod and Frame Test, found that alcohol (0.8 g/kg) increased the tendency for the perceived verticality of a rod to be influenced by a tilted background (the frame), thereby increasing the deviation of the rod from the true vertical. This "field dependence" has been reported as a characteristic of chronic alcoholics (Wallgren & Barry, 1970, pp. 735-736).

Several experiments on perceived time duration, reviewed by Wallgren and Barry (1970, pp. 339-340) generally showed that alcohol caused time to be perceived as passing more quickly, so that, for example, a one-minute time interval is judged to be shorter, or a longer interval elapses before the person estimates that one minute has been completed. This suggests a depressant effect of alcohol, slowing the subjective processes in relation to the fixed rate at which time passes. Subsequent experiments have confirmed this effect under various conditions. Reisby and Theilgaard (1969) instructed Danish subjects to look up rare English words in a dictionary for two minutes. Alcohol (1.1 g/kg) prolonged by about 20% the time spent in this task. Ehrensing et al. (1970) presented various time intervals ranging from 0.15 to 1.95 seconds, which were judged as shorter or longer than one second. Alcohol (0.6 g/kg) increased by about 10% the time interval judged to be one second. The difference between alcohol and placebo conditions was disguised from the subjects by intravenous administration, but there was apparently no double-blind procedure of disguising the conditions from the experimenter also. Jones and Stone (1970) studied two methods of time estimation by heavy marihuana users. Alcohol (0.75 g/kg) decreased by about 15% estimation of how much time had elapsed when a 15-second duration was given and increased by about 10% the time duration when the subjects judged that 15 seconds had elapsed. McMillan (1970) instructed subjects to space responses between 55 and 60 seconds apart. Two doses of alcohol (approximately 0.35 and 0.70 g/kg) decreased the proportion of correct responses within that 5-second span and tended to increase the proportion of incorrect responses at longer rather than shorter intervals.

All these foregoing effects of alcohol on time estimation are consistent with acceleration of time passage as perceived by a person whose responses are slowed by a depressant drug. However, under some conditions, alcohol has a stimulant or disinhibitory effect, which might cause time to be perceived as passing more slowly. This would be related to an attitude of impatience and a tendency to drive too fast. Wallgren and Barry (1970) reported this effect of alcohol on time estimation under some conditions (page 340) or in people whose mood is depressed (page 358). A recent experiment (Cappell et al., 1972) provides some evidence for this effect. Subjects were given 3 cents for each response within a limited, variable time span (0.5 to 4.0 seconds) longer or shorter than 20 seconds after the prior response. Alcohol (0.48, 0.72, 0.96 g/kg) had little effect on performance, but the lowest dose tended to increase the percentage of premature responses. This trend is opposite to the effect of alcohol in the similar procedure used by McMillan (1970), which involved a longer required time interval (40 seconds) and no financial incentive for correct responses. In the experiment by McMillan (1970), the amount of information (feedback) given about the intervals between responses was varied in different groups of subjects. The maximal feedback condition (information that each interval was too short, correct, or too long) was the same as the procedure used by Cappell (1972). Under this condition, McMillan (1970) found that the effects of alcohol (decreasing the percentage of incorrect intervals and increasing the percentage of premature responses) were small and inconsistent.

A prevalent cognitive deficit caused by alcohol is the belief that performance is unimpaired or even improved, contrary to the objective measurements (Wallgren & Barry, 1970, pp. 344-345). This does not seem attributable to inability to perceive the physical symptoms of intoxication, because rather accurate self-ratings of intoxication have been reported in experiments reviewed by Wallgren and Barry (1970, p. 345) and in recent experiments by Kelly et al. (1970; 1971) and by Reisby and Theilgaard (1969). The observed tendency for alcohol to increase risk-taking behavior might result from this cognitive deficit in assessment of performance capability and thus an underestimate of the degree of objective hazard rather than from a decision to accept a higher degree of risk. Ward Edwards (personal communication) has recently given evidence that in a simulated driving test, alcohol does not increase the probability of deciding to risk money on a difficult maneuver, but increases the probability of failure. Assuming that the subjects are unaware of their impaired capability under the alcohol condition, this indicates that alcohol affects the objective risk or hazard, but not the decision to perform a risky response.

Various individual differences in effects of alcohol on performance have been reviewed by Wallgren and Barry (1970, pp. 353-358). Most of the differences studied have been motivational or emotional factors, but they may be expected to influence the changes in intellectual performance caused by alcohol. Reisby and Theilgaard (1969) reported that the detrimental effect of alcohol was more pronounced in a "labile" subject, characterized by chronic emotional arousal, than in a "stable" subject. The differences between these contrasting personality types were investigated more extensively in a separate report on effects of alcohol on handwriting (Brun and Reisby, 1971). Wambsganss and Bredenkamp (1968) compared subjects with high and low scores of neuroticism on the Maudsley Medical Questionnaire. A low alcohol dose (approximately 0.6 g/kg) tended to impair performance only for the subjects who were low in neuroticism. This differential effect was very small, but consistent with a large difference, showing that alcohol improved performance of the highly neurotic subjects in a test of emotional stability. Another type of individual difference is indicated by a report (Goodwin, Othmer, Halikas, & Freemon, 1970) that a young man with a history of narcolepsy fell into a deep sleep after an alcohol dose of approximately 1.0 g/kg. This indicates unusual susceptibility to the depressant action of alcohol and is an obviously dangerous response in an automobile driver.

Some other individual differences in response to alcohol may be attributable to differences in drinking history. Goodwin et al. (1971) tested effects of alcohol (1.2 g/kg) on male medical students. Motor performance was more greatly impaired and risk taking more greatly increased in light drinkers than in heavy drinkers. A comparison of alcoholics with nonalcoholics provides a more extreme difference in drinking history. Wallgren and Barry (1970, p. 515) concluded that acute intoxication often fails to impair and may even improve performance of alcoholics. Mello (1972) and Barry (1973) have further reviewed research on acute effects of alcohol in alcoholics. Cutter et al. (1970) compared performance of alcoholic and nonalcoholic men guessing which of two alternatives would occur; the actual probability was 75% for one choice and 25% for the other. Correct choices could be maximized by always selecting the high probability choice, and the incentive for a high score was to receive an alcoholic beverage. The percentage choice of the high probability alternative was higher for men who accepted than for those who rejected the earned drink, and this difference was greater for the alcoholics than for the nonalcoholics. In this situation, individual differences in motivation clearly affected performance of a primarily cognitive task.

2.5 Memory

All intellectual functions require memory and thus may be affected by changes in overall retention of information or by selection of what is remembered and what is forgotten. Wallgren and Barry (1970, pp. 341-343), in a review of experiments on effects of alcohol on memory, pointed out that decrements might be attributed to impairment of the original learning, of its retention, or of attentiveness. These potential impairments are primarily cognitive functions, but are influenced by motivation. The original learning must be established before retention can be tested

The review by Wallgren and Barry (1970, pp. 341-343) indicated rather small effects of alcohol on learning to associate a response with a new anticipatory stimulus by classical, Pavlovian conditioning. Tests of alcohol effects on short-term memory have mostly been conducted with simple, well-practiced types of response, such as reciting a series of digits in the Digit Span test of the standard intelligence test. The effects of alcohol are generally rather small, but they appear to be enhanced if the material is more complex or if the task requires reorganization of the information, such as reciting the digits backward.

Tests of long-term memory generally show much larger effects of alcohol, but the test usually involves a change in drug condition, usually from the intoxicated to the sober state. The apparent decrement in memory might be due to state-dependent learning, with incomplete transfer of the learned response from one state to another. This has been demonstrated by experiments showing poorer retention of information learned under one condition (intoxicated or sober) when tested under the other condition. Generally, the poorest retention is found in tests while sober for information learned while intoxicated. This might be attributable to inferior learning in the intoxicated than in the sober condition. A complete amnesia after this shift in condition is the well-known blackout, which is an important diagnostic sign of alcoholism (Wallgren & Barry, 1970, p. 720; Barry, 1973), although not limited to alcoholics. Wallgren and Barry (1970, p. 515) reviewed evidence that the blackout in alcoholics typically is related to a conflicted, highly emotional topic, suggesting that the amnesia serves as a mechanism for motivated repression of threatening memories or desires.

Ryback (1971) has reviewed effects of alcohol on immediate, short-term and long-term memory. Similarities were pointed out between alcoholics and nonalcoholics and between the Wernicke-Korsakoff syndrome and the amnesic effects of acute alcohol intoxication. Effects of alcohol on memory and on state-dependent learning were reviewed by Mello (1972) and more briefly, but more recently by Barry (1973). In general, recent research has revealed large detrimental effects of alcohol on short-term memory, and alcoholic blackout seen in the sober state may constitute a continuation of amnesia which occurred while the person was still intoxicated. A serious limitation to this research is that alcoholics have been used as the subjects in most of the experiments.

Nonalcoholics were tested in an experiment by Ryback (1970) on recognition of pictures. Alcohol (0.9 g/kg) greatly decreased the percentage of pictures correctly identified as having been seen a few minutes earlier. Alcoholics were compared with nonalcoholics by Weingartner and Faillace (1971a). In an experiment on learning and short-term retention, alcoholics were given alcohol doses from 0.8 to 2.4 g/kg, increasing gradually on successive days. The alcohol had no effect on the highly structured task of serial verbal learning, but impaired memory in the less structured tasks of reproducing free associations and free recall of words. Nonalcoholics, given alcohol doses from 0.4 to 1.2 g/kg, showed a decrement in serial verbal learning, but not in reproducing free associations or free recall of words. In a second experiment, long-term memory (48 hours) and state-dependent learning were tested in alcoholics and nonalcoholics, both given the same dose of alcohol (1.2 g/kg). The alcoholics showed poorer retention. Also, the alcoholics, but not the nonalcoholics showed state-dependent learning, indicated by poorer retention when tested under a different condition (alcohol or placebo) rather than under the same condition as the learning 48 hours earlier. In an experiment on alcoholics, Nathan et al. (1972) found slower learning during several days of steady drinking in the laboratory than during several nondrinking days.

Short-term and long-term memory of alcoholics has been investigated in several recent experiments. Goodwin, Freeman, Ianzite and Othmer (1970) reported that the experiences occurring under the influence of a high alcohol dose (2.4 g/kg) which were forgotten 24 hours afterward in the sober condition, were generally also forgotten 30 minutes after the experience, while the subject was still intoxicated. However, no impairment was found in memory tested at 2 minutes after the experience. Goodwin et al (1973) found that a lower dose of alcohol (1.2 g/kg) had no statistically significant effect on memory at the intervals tested (immediately, 30 minutes, 24 hours). Ryback (1970) described amnesia for experiences during prolonged drinking under experimentally controlled conditions in some, but not all the alcoholics studied. The amnesia was typically for a block of time rather than a specific experience, and during that time interval, short-term memory was impaired.

Tamerin et al. (1970), in a study of prolonged drinking under experimentally controlled conditions, reported a number of examples of amnesia, after return to sobriety, for types of behavior expressing aggressive, sexual, or other feelings which were repressed from conscious awareness during sobriety. This gives evidence for repression as a mechanism for the alcoholic blackout. Tamerin et al. (1971), in a study of experimentally controlled drinking by alcoholics for 12-14 days, found impairment of memory at intervals as short as one and five minutes. The impairment of 24-hour recall appeared to depend on the degree of intoxication at the time of the experience. Blackouts usually occurred only when short-term memory had also shown impairment. In another experiment on alcoholics (Nathan et al., 1972), 7 days of experimentally controlled drinking were alternated with 5 days of abstinence. Short-term recall (5 seconds, 2 minutes, 20 minutes) was greatly impaired on drinking days. The amount of decrement depended on blood alcohol level.

In general, recent evidence has emphasized short-term memory loss, with little new evidence for state-dependent learning. However, it is difficult to reproduce in the laboratory the dissociation between the intoxicated and sober conditions which may occur in normal social settings. In the experiments, all conditions are generally equated as closely as possible, except for the presence or absence of alcohol. Various customs and circumstances with regard to drinking help to differentiate the intoxicated from the sober condition and thus may be expected to enhance the degree of state-dependent learning.

The effect of differential reinforcement on short-term memory has been compared in alcoholics and nonalcoholics by Weingartner and Faillace (1971b) in a single 40-minute session under the sober condition. The alcoholics and nonalcoholics both showed superior memory for words which had been reinforced during the original learning; the nonalcoholics but not alcoholics showed inferior memory for words which had been punished during the original learning. This finding suggests that alcoholics were less sensitive to the effect of punishment, in accordance with experiments reviewed by Wallgren and Barry (1970, p. 736). This might reflect a deficiency in ability to associate drinking behavior with its aversive, damaging consequences. Alternative possible interpretations might be a masochistic, self-destructive motivation or the effect of habituation and insensitivity developed as a result of the painful, aversive concomitants of the excessive drinking. Whatever the reason, these experimental findings suggest important differences between alcoholics and nonalcoholics in learning and memory.

3. EVALUATION

The laboratory studies constitute a serious effort to isolate and test effects of alcohol on particular motivational and cognitive responses. However, conclusive results cannot be expected and were not obtained. Most of the behaviors tested are not specific or quantitatively precise measures of motivation or cognition. The test situations have not been standardized in the small number of studies measuring complex effects of alcohol. Therefore, the findings thus far constitute fragmentary and suggestive results rather than a firm, integrated body of knowledge. A further complicating factor is the existence of important individual differences in motivational and cognitive conditions, and in the effects of alcohol on these conditions.

The complex motivational and cognitive responses are hard to isolate and measure effectively. For example, a test of intellectual performance is affected both by cognitive abilities and by the motivational factors of eagerness to succeed and willingness to persist in a difficult task. A projective test of aggression may measure other factors, such as the overtness of expression or on the contrary, the degree of repression. In addition to the motivational factors, cognitive variables may influence the result; for example, by perception and interpretation of the stimulus which elicits aggression.

The motivational responses are in a continual balance with each other. An effect of alcohol on one motivation may produce adjustive changes in others. For example, a decrease in fear may thereby release expression of aggression or other motives ordinarily inhibited by fear. Also, the motivational and cognitive responses maintain a balance with each other. Change in motivation will alter the cognition, and the cognitive change in turn may further alter the motivations.

Several major research methods may be distinguished in the foregoing review. Motivation is generally measured in humans by a projective test, such as the TAT, or in an experimentally contrived situation. A quantitative measure is obtained, but it is probably often misleading. A more trustworthy technique is to measure a type of performance or behavior indicating motivation. This has been successfully accomplished in a number of studies on laboratory animals. Some of the best evidence on motivational effects of alcohol has been obtained from such studies. However, equivalent data on humans are very meager. One of the reasons is the difficulty of controlling a person's motivational state for experimental purposes.

Effects of alcohol on cognition have generally been measured by tests of intellectual performance. Many of these tests are rather simple functions of perception and attention, which were reviewed in the preceding paper by Moskowitz. A smaller number of studies have been done with tests of more complex, problem-solving performance. Some of these have involved such difficult, tedious, and prolonged tasks that they appear to measure primarily the motivational rather than cognitive conditions.

An important cognitive behavior is memory. The distinction frequently made between short-term and long-term memory is especially valid for alcohol effects. Change in short-term memory is one of the more striking effects of alcohol intoxication. Long-term memory loss seems to pertain to the phenomenon of partial or complete dissociation between intoxicated and sober condition. The initial work on this phenomenon of dissociation or state-dependent learning has been done with laboratory rats, and rather high doses of alcohol seem necessary to establish this effect. In humans, a decrement in memory has been demonstrated as a consequence of the shift in condition between intoxicated and sober state. However, the effect seems small and has been tested only with memory for specific verbal stimuli, which show a generally short duration of retention. The research has failed to test or establish adverse effects of alcohol on the type of long-term memory which involves retention of the habitual driving skills.

4. CONCLUSIONS

In spite of the difficulty in isolating specific motivational and cognitive effects of alcohol, the laboratory experiments on humans lead to some general conclusions. The increased risk of traffic accidents under the influence of alcohol can be attributed to two opposite types of response involved in intoxication: (a) inattention or sleep; (b) risk-taking or disorganization. Each of the specific motivational and cognitive effects of alcohol acts upon both types of intoxicated response.

Inattention or sleep is obviously an outcome of sedation. An additional contributory factor may be self-destructiveness, expressed by a mood of depression and by a weaker urge for self-preservation. Fear reduction is an important additional factor which enables the driver to become inattentive or even fall asleep while the vehicle moves at a high speed. Another motivational element is an increase in assertiveness which causes the driver to feel liberated from the need for attentiveness to the driving and which gives rise to distracting fantasies. A cognitive element which may contribute to inattention is memory loss, which loosens the connection with immediately preceding stimuli and with the previous learning of prudent, careful driving. These factors dissociate the driver from the external environment. The dissociation from sober habits, together with impaired self-criticism, further diminish the attentive concentration needed for safe driving.

A more general behavioral effect of alcohol is increased risk-taking, which is related to various specific motivational and cognitive effects. Risk-taking is obviously enhanced by fear reduction, but other motives which interfere with avoidance of danger may include sedative indifference, self-destructive behavior, or preoccupation with assertiveness. These motivational changes refer to the concept of decision-making to accept a higher degree of risk. Another component of increased risk-taking is the cognitive change of underestimating the degree of objective hazard. This is logically separate, but in practice very difficult to differentiate from the motivational component. Other cognitive factors also may interfere with avoidance of danger: short-term or long-term memory loss may decrease awareness of risk; dissociation from sober habits weakens restraints against the behavioral effects of alcohol; and impairment of self-criticism results in underestimation of the degree of danger. All these factors contribute to increased risk-taking, which in turn is an important basis for the elevated frequency of accidents.

Both types of alcohol effect have in common loss of control, whether due to inattentive or risky driving, together with diminished awareness of the dangerous situation. This combination of characteristics is very likely to result in an accident. It is doubtful whether any other drug has such a dangerous combination of sedative and disinhibitory effects impairing driving performance. Some individuals may be more susceptible to the dangerous effects of inattention or sleep, associated with the depressant or sedative effects of alcohol. Other individuals may be more susceptible to the dangers of increased risk-taking or disorganization, associated with the stimulant and disinhibitory effects of alcohol. Thus, both extreme types would be vulnerable to the adverse effects of alcohol on safe driving.

Two types of traffic accident should be distinguished, because they may help to differentiate the motivational from the cognitive factors. One type of accident is due to failure in the routine, prolonged, highly learned and habituated behavior of normal driving. Falling asleep and excessive speeding are different types of failure to cope with the demands of the tedious, monotonous task. These failures may be attributed primarily to a motivational rather than cognitive defect. The other type of accident is due to failure to cope with a sudden emergency. In some cases, such an emergency may arise due to falling asleep or excessive speeding during the routine, prolonged driving situation. However, a more typical emergency is presented by an event such as sudden appearance of another car or an obstacle in the driver's path. The normal, adaptive response is a prompt reaction based on previous experience and on rapid cognition. Failures to cope with this situation may be classified on the basis of two opposite alcohol effects: (a) inhibitory or depressant action, so that the response is slow and insufficient; (b) an excitatory action, resulting in disorganized or impulsive behavior, failing to select the best response.

The present review of laboratory research indicates that alcohol should cause accidents by failure of routine control more often than by deficiency in reaction to an emergency. The simple, sensori-motor capabilities, measured in brief tests reviewed in the two preceding papers, generally seem to be highly resistant to alcohol effects. These are the capabilities which are primarily involved in sudden emergencies. Even the sensori-motor impairments caused by alcohol may be partly due to motivational factors or complex cognitions, such as general preparedness and alertness. These are very hard to distinguish from the specific capabilities which they influence. Performance in long-term, routine driving depends largely on motivational factors which seem to be more sensitive to effects of alcohol. Wallgren and Barry (1970, p. 814) suggested that alcohol probably impairs attentiveness during uneventful driving more than ability to cope with difficulties. This conclusion is supported by various statistical data on alcohol-related highway fatalities, such as preponderance of single-car crashes.

5. RECOMMENDATIONS

The principal research need is for experiments on motivational and cognitive factors under conditions which simulate driving. These conditions do not necessarily require a steering wheel or a vehicle. A more important characteristic for comparability with actual driving is the performance of a routine, highly learned task over a prolonged duration. The effects of alcohol should be tested both under the normal conditions and in response to sudden emergencies. In particular, the experiments should measure a single motivational or cognitive element under these conditions. A good example of this method, although applied to a single sensori-motor task, is the research by Moskowitz, reviewed in the preceding paper, on the effects of a distracting stimulus on tracking performance.

These experiments should include simultaneous measurement of the major motivational and cognitive responses which appear to be affected by alcohol. Tests of sensory and motor effects of alcohol should be made in conjunction with various experimental manipulations of motivational and cognitive elements. Such experiments would help to determine the extent of complex motivational and cognitive influences on simple performance. Also, well-designed experiments would help to distinguish the effectiveness of the particular motivational and cognitive elements in modifying the effects of alcohol.

An important need, which would enhance the value of the laboratory experiments, is to obtain more detailed data from studies of highway accidents. The standard statistics on time and place of accident, single or multiple car, and other such items provide very weak indications of the motivational and cognitive determinants. It should be possible to obtain data on the motivations and perceptions of the intoxicated driver from self-reports and observations by passengers. It would also be possible to undertake tests of both sober and intoxicated performance in laboratory situations. This type of research would be suitable for studying non-fatal accidents. In accidents which are fatal to the intoxicated driver, biographical information could be obtained, including the preceding few hours, which could shed light on the motivational conditions.

With regard to methods in conducting laboratory experiments, large-scale research is very scarce and badly needed. A comprehensive study should include several doses, with tests at a wide range of time intervals. A particular need is for more research on the hangover effect, 12-24 hours after consumption of alcohol. Systematic, carefully controlled experiments, with appropriate tests conducted on an adequate number of subjects, would yield standard, quantitative data which would increase the scope and, in particular, the trustworthiness of our knowledge about the effects of alcohol.

Contrary to these desirable characteristics, most experiments have been with one or two alcohol doses, tested over a limited time-interval in a small number of subjects. There should be sufficient incentive for undertaking the needed large-scale, parametric experiments. One such study would have greater impact -- and would be cited much more often -- than a dozen additional small studies of the usual type.

Once the parametric characteristics of dose and time effects are established for several measures of complex behavior, it will be worthwhile to concentrate on studies of some differential effects. Characteristics of the test situation appear to modify the effects of alcohol, and these variables should be manipulated in future experiments. Also, individuals have been shown to react differently to the same dose of alcohol. More research is needed on sex differences. Various attributes of personality and previous experience can be fruitfully tested.

It is more difficult to make recommendations for future research in terms of the specific motivational and cognitive components to be studied since these are difficult to isolate. However, it is often possible to infer the influence of particular motivations or cognitions, and information about them may be contributed by diverse experiments.

5.1 Motivational Effects of Alcohol

Research is needed on four main motivational effects of alcohol, demonstrated in laboratory experiments, which can account for increased incidence of highway accidents.

5.1.1 The sedative effect of alcohol, due to generalized central nervous system depression, is a powerful motivation. This is expressed by inattentiveness; by lack of emotional responsiveness; and, at the extreme, by sleep or unconsciousness. Fatigue, both preexisting and caused by intoxication, contributes to these effects. An important question is whether fatigue is more likely to result from prolonged, uneventful vigilance or from a tiring, demanding task. The physiological basis for emotional unresponsiveness should be studied, especially because alcohol intensifies certain emotional expressions. Therefore, the particular conditions favoring a sedative response to alcohol should be investigated. There might be large individual differences in this respect.

5.1.2 Self-destructiveness is a deeply underlying, powerful motive. It is evident in the suicidal behavior of the chronic alcoholic. This motive, even in a mild or transient degree, could account for many highway accidents. The main difficulty is developing a valid and reliable measure of this motive and its change during intoxication.

5.1.3 Fear reduction is a prominent effect of alcohol, but it does not seem to occur effectively in all situations. Much of the research has been on laboratory animals. Studies are needed in humans on the effectiveness of alcohol in reducing various types and intensities of fear, with comparisons among environmental situations and different types of people. The presumed tendency for fear reduction to cause an increase in risk-taking should also be studied.

5.1.4 Assertiveness is aroused by alcohol, at least in some people. The motives of hostility, aggression, or power needs are assumed to be closely similar, but further research might specify differential effects of alcohol. It is possible that this motivational syndrome is closely related to fear reduction, expressing a general disinhibitory effect of alcohol. Analyses of TAT stories distinguish between socialized power needs, increased by small amounts of alcohol, and personalized power needs, increased by large amounts. This distinction should be verified, and similarly precise distinctions should be made between other elements of the motivational syndrome.

5.2 Cognitive Effects of Alcohol

In comparison with motivational factors, cognitive factors are more easily measured, but the alcohol effects on them are harder to distinguish from each other and from the motivational changes which influence them.

5.2.1 Short-term memory loss may be closely related to the motivational and perceptual functions of attentiveness. It is easy to demonstrate that alcohol impairs ability to perceive complex stimuli correctly and to make correct interpretations, thus showing cognitive deficiencies. It is harder to demonstrate that the cognitive deficiencies contribute to highway accidents. However, it is very important to determine the role of cognitive deficiency in automobile accidents. The short-term memory loss may result in low attention span, lack of perseveration, and a tendency to fall asleep or become unconscious.

5.2.2 Learning deficit means impairment of the higher intellectual functions of reasoning and problem solving. This may result in failure to react appropriately to a sudden emergency. These functions also are closely related to motivational factors. It is important to measure these complex intellectual functions accurately and assess their importance in highway accidents.

5.2.3. Dissociation from sober habits is a phenomenon recently discovered, but widely publicized among students of alcohol effects and alcoholism. This implies a long-term memory loss. Since sober habits are thereby weaker, they are less active in counteracting the motivational and cognitive deficiencies caused by intoxication. The state-dependent memory or learning usually appears to be a weak effect, but is a strong influence under some conditions, such as the alcoholic blackout. Studies are needed on the conditions which influence the strength of this dissociation between intoxicated and sober state.

5.2.4. Impairment of self-criticism is one of the most frequently observed emotional responses to intoxication. The person under the influence of alcohol is subjectively impaired, but perceives in himself an unrealistically high level of performance. This response might reflect assertiveness, generalized disinhibition, fear reduction, or dissociation from the sober state. Since accurate self-evaluation is an important factor in determining judgment and decisions, it might play an important role in the risky behavior which leads to accidents. Research is needed on conditions which give rise to a more accurate self-perception or which enable learning to compensate for this effect of alcohol on mood.

6. SUMMARY

Safe driving requires excitatory functions -- including cognitive alertness and zealous motivations -- combined with inhibitory functions -- including selective attention and restrained or cautious motivations. Alcohol increases the risk of highway accidents both by its depressant and disinhibitory actions. The depressant action of alcohol 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 action 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.

A particular need is for experiments under conditions which simulate the situation of driving, especially performance of routine, well-learned tasks for a prolonged duration. Effects of alcohol should be tested under the normal conditions and also in response to sudden stimuli which simulate emergencies.

Large-scale experiments should be undertaken, including tests with several doses and at a wide range of time intervals. There has been very little research on the hangover effect, at 12-24 hours after consumption of alcohol. Also, more research is needed on sex differences and other characteristics which give rise to differences among individuals in response to alcohol.

Four principal motivational effects of alcohol should be studied: (a) emotional unresponsiveness; (b) suicidal and other self-destructive behavior; (c) decrease in fear and increase in risk taking; (d) increased assertiveness, including hostility and power needs. Four principal cognitive effects of alcohol should be studied: (a) short-term memory loss; (b) tests of reasoning and problem solving; (c) dissociation between the intoxicated and sober state; (d) impaired perception of the detrimental effects on one's own performance.

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DISCUSSION

EDWARDS: I have been concerned about so-called increased risk-taking after consuming alcohol. The term risk-taking should be distinguished from decision-making. Risk-taking is an extraordinarily ambiguous term. It is very easy to entertain the hypothesis that no change in risk-taking whatsoever occurs after consuming alcohol, and instead, what is being interpreted as a change in risk-taking is a change of a quite different kind. I have some data which suggest that this is so.

From the point of view of decision analysis, there are at least six ingredients to the process of making a risky decision: the payoff if you do one thing and are successful, the payoff if you do it and are unsuccessful, the payoff if you do the other thing and are successful, the payoff if you do it and are unsuccessful, the probability of success, and the decision rule. These are six different things, any one of which might be influenced by alcohol. The hypothesis that I would like to suggest is that people at very high blood alcohol levels make decisions that involve neither more nor less risk-taking than they would if sober. The real issue, the problem they get into, is that they do not have a way of adapting their judgments to their temporarily impaired perceptual-motor skills.

I would like to summarize the results of an experiment. Subjects made an extreme lane change maneuver at 20 mph on a test track. On each trial, the subject looked at the lateral displacement which he had to accomplish in a given forward displacement, that being the independent variable, and then said either that he wanted to try it or that he did not. Regardless of whether he wanted to try it or not, he went ahead and tried it. There was a reward for doing it successfully no matter what he said and a punishment for doing it unsuccessfully no matter what he said. However, if he had chosen to say "I don't want to try it," then there were no other punishments. If he had chosen to say "I do want to try it," he received an additional reward if he made it and a severe punishment if he did not. Thus, there were two separate superimposed reward structures, one of them concerned with the perceptual-motor aspect of the task, and the other concerned with whether or not the subject wished to take a substantial risk. The decisions about whether a subject wanted to try it or not are directly analyzable by standard signal detectability theory techniques. The finding is that for BACs up to and including .15, there was no change in either d' or beta as a function of BAC. There was, however, a gross decrement in overall performance and thus in overall money gained simply because subjects made judgments appropriate to the perceptual motor skills that they have when sober, but were doing the task when drunk. I speculate that this kind of effect may be what people are encountering when they speak of increased risk-taking by high BAC subjects.

BARRY: So if he were rational and had the same degree of risk-taking as before, a high BAC subject ought to decrease his frequency of choosing the risky alternative.

EDWARDS: This would be true if he had a basis for evaluating the change in probability of success. Instead, the hypothesis I suggest is simply that he evolves an opinion about what he can manage to do in the sober state, and then transfers it to the drunken state to which it is inappropriate.

BARRY: One of the few things Bud Perrine asked me to do was to include risk-taking as a keyword and as a concept here, and I attempted to resolve whether risk-taking was more motivational or more cognitional. I finally decided it is really neither -- it is such a hopeless combination of both that I think of it as a behavior rather than either a motivation or cognition.

BECK: Would the experienced drunken driver have more knowledge of what changes to expect in his driving performance?

EDWARDS: That, of course, is not a question directly addressed in my experiment, but it is indirectly addressed because some of our subjects are experienced drinkers and others are not. It is not possible to infer from the data that the experienced drinkers are also experienced drunken drivers. It is a separate question, whether experienced drinkers can do an appropriate job of learning how to change their judgments of probability of success in the light of their own intoxication.

WALLER: If I remember the Cohen et al. study correctly, it came out with conclusions that were directly the opposite of yours, that individuals were willing to take greater risks, whether or not they were able to complete the task successfully.

MOSKOWITZ: In the Cohen et al. study, there was little change in the objective test of the width of the space they could drive through after having alcohol; there was a difference in their judgment.

EDWARDS: You are both right. There was no difference in performance; it was completely a difference in judgment. This was completely opposite to the findings of my recent study.

HUNTLEY: It may not be as parsimonious as your suggestion, but it is possible that the driver who has been drinking knows the extent of his impairment and yet operates as if he were sober.

EDWARDS: If that were true, it should have shown up in his judgments since we had in this situation an opportunity to clearly discriminate between judgment and performance, and his judgments did not change while his performance did change.

HUNTLEY: If he were aware of this potential performance decrement in terms of pre-alcohol risk-taking, his judgments would change.

EDWARDS: His judgments would change if he were aware of his performance decrement. Incidentally, there is another point to make here, namely that it is quite possible to calculate how appropriate his judgments were in this kind of task, and the answer turns out to be that his judgments in the sober state are very precisely appropriate to his capability in the sober state. So if he knows of his impairment and he is making sober-type judgments, he is making incorrect judgments.

DRIESSEN: Can he get a feedback as to whether he is successful or unsuccessful right away?

EDWARDS: Yes. Incidentally, that feedback takes the form of a $4.00 fine for saying he is going to try it and missing, and he is running a trial every minute and a half, so it is rather significant feedback. And that is part of my explanation of the difference between these findings and Cohen's.

VOAS: I believe the feedback may be a very important element if we think of this as a divided attention problem. Missing information in the periphery due to divided attention may mean that the impaired driver is missing data, thereby making him unaware of the risk. He is not getting feedback. Therefore, when he makes a choice, he is not evaluating the risk properly. He is evaluating only a part of the data. Thus, it may not be a matter of his judgment changing, but rather his perception of the actual threat may be faulty.

BARRY

<u>EDWARDS</u>: My interpretation is simply that his perception of his capabilities does not change because he has no real basis for changing. Yes, in our study, it is true with experienced drinkers. I am not able to tell you whether it is true with experienced drunk drivers, for obvious reasons.

<u>CARPENTER</u>: The drunk driver may not have any basis for changing his perception of this skill from the normal state because he misses, and is not aware of, the targets coming at him on the periphery that just missed him.

<u>EDWARDS</u>: And in any case, unless he is keeping careful state-specific records, whatever experience he accumulates in this state is bound to be utterly overwhelmed by his experience in the sober state. Perhaps the real issue may be a sort of record-keeping or memory. Unless a drinking driver is able to keep state-specific records, he can never learn what the probability changes are from one state to the other.

<u>VOAS</u>: But if it also blocks feedback, it does not matter what the memory condition is because it never entered into the memory in the first place.

<u>EDWARDS</u>: He has little opportunity to observe and he may not be able to remember what he did observe.

<u>MOSKOWITZ</u>: There is no effect on that state. There is a lot of literature which indicates very little effect of alcohol on memory, so there is no reason to suppose it that way.

<u>VOAS</u>: He was getting feedback in terms of punishment, right? He gets fined $4.00 every time he does the wrong thing. Then, he is given the same task again and he still makes the same stupid mistake. Therefore, he is not profiting by his recent experience. Is that not risk-taking behavior then?

<u>EDWARDS</u>: At least six different things could be meant by change in risk-taking behavior.

<u>VOAS</u>: If he continues to behave when drunk as he did when he was sober, in the face of evidence that he is performing poorly, something must be changing.

<u>EDWARDS</u>: No, I do not think so. My point is something is not changing. In this situation, there is no evidence of significant change. Of course, we are not doing an elaborate training study on these people in the drunken state, although we are collecting plenty of data so that if there were systematic effects, we might discover them. But in fact, in our data, there is very little evidence of state-dependent learning or acquisition.

<u>NICHOLS</u>: I think that it does not fit well with other research results to say that the form of risk-taking which may occur following drinking involves no change in judgmental factors. Other studies such as those by Light and Keiper in the Providence, Rhode Island laboratory, have indicated, if I remember correctly, that not only did subjects under the influence of alcohol engage in more "misses" in a simulated passing situation, but that they also made significantly more attempts to pass in the alcohol condition. That is to say, they changed their level of responding. Also, I think from a correlational rather than an experimental point of view, that there is some suggestion of a change in judgment in the epidemiological crash literature. For example, several such studies have indicated a high positive correlation between blood alcohol concentration and deviant driving practices such as excessive speed, passing on curves and hills, driving in the wrong lane, etc.

Therefore, from data of this sort, there are indications of a change in the decision-making process due to something which we have labeled "judgment." Whatever the case may be, if we define risk-taking as the willingness to engage in behavior that has a higher probability of adverse reactions, whether perceived as such or not, I think there is considerable evidence, both epidemiological and laboratory, which indicates that alcohol raises the level of this type of behavior.

EDWARDS: I agree with your laboratory evidence, but I have some skepticism about it. The epidemiological evidence does not persuade me at all because you do not know how that relates to behavior of the same drivers in the sober state.

WALLER: If I may be goal-directed toward what I think the Department of Transportation would like to get out of this. You had thrown my medical hat into the ring a bit earlier, Bud (Perrine), and now I would like to put on a sociological hat for the moment. You asked that we try to identify areas where future research is needed. As I look through all of these keywords, I see the need for additional variables to be considered also. For example, in each of the keyword areas, I think we have to look at cultural differences also. I am thinking, for example, of some of the work that Don Cahalan has been doing, suggesting that drinking problems are most common, or most commonly reported, in those cultural groups that tend to have a pattern of acting out. I think that as we look at decision-making, emotion and mood, motivation, problem solving and risk-taking, etc., we have to look at these in relation to specific cultural patterns and cultural differences. As we are talking about alcohol, we also need to look at the relation of various keyword areas to the hangover phase. As has already been suggested, we need to look at all of these in relation to the individual's basic drinking background, such as the Quantity Frequency index of the individual.

BARRY: Let me add to that one type of cultural difference which I am very interested in is the sex difference, because boys and girls are brought up with different traditions, at least in most elements of our society. Indeed, McClelland and his group have suggested that the motivations for drinking and the motivations that underlie alcoholism are different in men from what they are in women.

MOSKOWITZ: I just want to make one point which may or may not be in agreement with what Ward (Edwards) said. I think there are two problems in the definition of risk-taking -- I think it is important that we distinguish between them because one carries a different implication. I think it is clear that any person who drives while under the influence of alcohol is taking a greater risk, all you have to do is look at the epidemiological tables and see that if he had alcohol, he is more likely to be involved in accidents. That does not carry the same implication that is often conveyed when people say he is taking a greater risk, with the implication that some kind of psychological process going on within him leads him to be willing to do things that he understands consciously at some level that makes him more likely to be involved in an accident. There is considerable evidence of the objective fact that he is taking a greater risk, but I think that Ward (Edwards) is saying that there is no evidence for any internal psychological process by which we can demonstrate that this individual is making a kind of decision that he is willing to take a greater risk.

EDWARDS: That is exactly what I am saying. Moreover, I have a smidgen of evidence that affirmatively says he is not willing to take a greater risk.

BENJAMIN: The use of keywords, as discussed by Julian Waller, raises a problem of interpretation of the resulting numerical rating. This symposium comprises people of diverse background and the same keyword may be interpreted differently by different people. For instance, take the word "risk-taking." One group may look at risk-taking as a problem of finding suitable testing procedures; another group may consider it in view of the psychological effects of alcohol; and a third group may think of risk-taking as an epidemiological factor in traffic safety. All these approaches are combined in one numerical value, indicating the need of applied research in the field of risk-taking. We have no means of determining in which of the three risk-taking areas the group would like to see further research performed. Therefore, the rating may easily be considered endorsement of something the group never intended to endorse.

PERRINE: We should do the rating on the basis of the laboratory evidence with human beings at the medium levels of alcohol. The instructions provide for making the differentiation between applied research in traffic safety and basic research, with the consistent assumption that we are always talking about alcohol, not risk-taking per se. A further point which we should mention is that we have not attempted to distinguish among the number of possible subdivisions of any one of these categories, such as risk-taking. Such an attempt would end up with an individual who is a super-specialist doing all the rating involved in all these nuances, and the rest of us rating our personal qualifications as zero or as off the scale on the negative side. So we have attempted to achieve a reasonable balance between insufficient and excessive differentiation among categories, but the result is admittedly far from perfect.

EDWARDS: Since we are provided with a very clear taxonomic distinction by Herb (Moskowitz), I suggest we accept it, and treat these as two concepts. Since you have two phrases here, namely decision-making and risk-taking, why don't we associate one of those words with one of the concepts and the other with the other. Risk-taking might be appropriate for the objective phenomenon; it is a fact about the world, not a fact about what people do. Decision-making might be appropriate for the subjective one that I was talking about.

HURST: There is a terminological distinction that may help to clarify matters. It is sometimes customary to refer to the so-called objective probability as hazard and the subjective one as risk. I always speak of "hazard" in my epidemiological studies, which are involved with actual frequencies of crashes on roads. But for present purposes, we can make the distinction by defining risk-taking in terms of the objective hazard incurred, and use decision-making to include all the more subjective phenomena. This would include the difference or discrepancy between risk and the actual hazard, and the willingness to take a risk once you have perceived a risk, which can be called utility of gambling or what have you.

PERRINE: In accordance with this discussion, I would suggest that you make some sort of notation on your Session III keywords and keep it in mind as you do the different ratings. After risk-taking, you might put down any memory-joggers you wish, such as objective, real-world hazard. However, after decision making, I will not attempt to tell you what you might jot down.

Now we have a written question, submitted by Jerry Driessen, on risk-taking as such, which gets it out into the real world, namely:

"DO YOU HAVE ANY IDEAS ABOUT HOW TO MEASURE THE RISK-TAKING AMONG DRINKING DRIVERS WHILE ON THE ROAD?"

BARRY: I guess by the objective hazard definition of risk-taking, the best measure would be the frequency of crashes, although you do have the problem that you cannot be sure what is the contribution of this risk-taking motivation and what is the contribution of muscular incoordination and such factors.

EDWARDS: I have a suggestion on how to measure the subjective side on the road: just ask a lot of the right questions of a lot of drunk drivers.

VOAS: In relation to the specific term, how would you measure it under real driving conditions on the road? There are two techniques that are currently much in use, though not in connection generally with alcohol research. One of these is the monitoring of speed, which is quite easy with radar. The other is visual observation of passing behavior. I think that if one monitored both of these phenomena in real-life populations and set up roadblocks down the road to request breath samples, one might be able then to relate real-life data with specific alcohol levels.

PERRINE: In terms of hazard, there is Farber's work at Franklin Institute. But analyze the epidemiologic data for the proportion of alcohol-impaired drivers on the road and then think of the logistics involved in trying to study them by stopping them on the road as Bob Voas has suggested, which would be an excellent study. With about 2% of the drivers exceeding the presumptive intoxication level of .10% blood alcohol, think of how many drivers one would have to screen before one got an adequate sample of impaired drivers using a tedious, frustrating, passing situation similar to Farber's. Not impossible, but certainly a very expensive study.

MOSKOWITZ: On weekends, we might get up to 20% or 25% intoxicated drivers.

PERRINE: We have one more written question:

"IS THE SUPEREGO SOLUBLE IN ALCOHOL?"

BARRY: I think this is a very good question. It points up what I think is a real gap in the coverage I have made of the motivational factors. The question may be familiar to you, but not in this context; and it is worth discussion.

One of the motivational features that you see is very wild, unrestrained behavior, the so-called psychopathic behavior which has been described more often in alcoholics than in people who become intoxicated, but yet there is at least some of this in the ordinary person who becomes intoxicated, and there are a couple of things that can be said about this. One is that pharmacological solubility is always a relative term, so there is a scale of different degrees of solubility and yet when people who are not pharmacologists say solubility they tend to think of an all-or-none effect, but it is not. Indeed, there are some people who drive more carefully after they have been drinking and so they will actually compensate for this, and some people become more inhibited and restrained when intoxicated because they are so afraid or so determined not to release these antisocial or disinhibited behavior.

There is another aspect to this, the person who seems to be the so-called moral imbecile, the psychopathic personality, the person who is very antisocial, compulsively antisocial. I think it is not a matter of his superego or his conscience being completely decerebrated, or completely cut off, but rather it is a certain complex reaction to the moral constraints. Some of the behavior, certainly of a psychopathic personality, indicates some of this conflict and some of the quite maladaptive self-destructive behavior. The chronic alcoholic has been described as a slow suicide, a person who is very self-destructive, and so it is bringing out in a very overt way some very deep conflicts. Now most of the laboratory studies do not try to get at these deep conflicts, but I think that particularly this self-destructive tendency or some degree of suicidal tendency may be an element in a good many of the drunken driving crashes and in particular if the person has a certain degree, even if it is a minor part and usually very well suppressed part of his personality, to destroy others or to destroy himself. The driving situation is one in which such a tendency could be expressed; for example, the reaction to a sudden emergency, an emergency of a car coming into the wrong lane which requires a very quick, a very rapid, and a very good judgment and response. If the person has some degree of self-destructive or destructive tendency, then that might be just enough to prevent the right behavior from occurring.

DRIESSEN: If you consider driving as a continuous process of risk-taking or as a continuous process of accident avoidance, whether you are sober or drunk, it becomes important to stay within the margins of safety or outside of the zone of danger. I have heard of situations where the person under the influence of alcohol perceives the risk and perceives the threat, but does not give a damn. He makes the judgment when he gets in the car that he is going to go, he is going to go fast, and he does not care. Now, that would tie in somewhat with a masochistic or slow suicide approach to the driving. Sooner or later, he gets clobbered, but precisely when is not clear; and there is almost a total disavowal of the normal risk-taking process, the risk-taking usually associated with driving has become irrelevant or non-meaningful to him in general.

BUIKHUISEN: I would like to make a more general comment. What strikes me is that in all these studies which have been referred to us here, the starting point is a kind of normal group of people in which we are interested to learn: what effect does alcohol have on this normal sample of people. I would like to remark that, in my opinion, the population of drunken drivers, in regard to their personalities, is not representative of the general population of people. Our studies in the Netherlands, for example, show that with regard to many personality traits, drunken drivers differ from people not convicted for drunken driving. Therefore, I wonder about the possibility of generalizing from alcohol studies on normal populations to drunken drivers, which are another sample. What do we know about the interaction of alcohol to certain traits present in the person? What happens, for instance, if you give alcohol to an aggressive subject or to a subject who has a propensity to take risks? Their reactions might be quite different from those of average subjects.

PERRINE: I am aware of several studies in which convicted drunken drivers (DWIs) are being used as subjects. Herb Moskowitz has mentioned one in the preceding session, and we are just beginning one now in Vermont, using convicted DWIs in induced-intoxication experiments on their operation of an instrumented car. Professor Buikhuisen, are you interested in using convicted DWIs as subjects in experiments?

BUIKHUISEN: Not yet.

PERRINE: From what we learned in a recent study in Vermont as well as from several other studies, convicted drunken drivers as a group differ greatly from the rest of the driving population in terms of personality and social dimensions; but we do not really know whether they also react differently to alcohol. This is clearly a very important area of concern.

BUIKHUISEN: It has been said that the contents of the hallucination during LSD use differ in terms of the user's personality structure and the user's problems. I wonder if a different reaction to alcohol likewise occurs in drivers as a function of very different personality structures.

WALLER: Regarding this belligerence in the personality of the drunken driver, one of the things we have to watch out for is that personality may relate to the types of people that get arrested by policemen, as well as whether or not there is a crash. Policemen who have been interviewed indicate that one of the factors determining whether they actually make an arrest is whether the driver is belligerent or not. Now the belligerence may or may not relate to crash risk, but it does sometimes relate to whether a person gets arrested.

PERRINE: In talking with some of the police with whom we have worked, we have often been told what many of you already know, namely that in the real world, it is so difficult and cumbersome for the officer to write up a DWI charge and then follow through all the subsequent administrative levels, that they frequently avoid doing it unless the motorist is so belligerent and nasty that they cannot in good conscience avoid giving him a ticket for DWI. Therefore, the policemen have a certain threshold of provocation which must be exceeded before they write up a DWI charge, and this is an important selective factor in evaluating the kinds of individuals who meet the criterion which we call "convicted DWI." Thus, it is clear that a selective factor is involved. It need not necessarily be socio-economic; it might be based on personality.

WALLER: I think this is also borne out by studies at the University of Southern California where the conviction rates they found were higher for arrested drunken drivers than for crashing drivers, another symptom of this perhaps. I also want to raise a question with regard to the superego factor and the matter of social psychology or sociology related to risk-taking. I am concerned about the matter of social pressures relative to risk-taking. There is quite a bit of literature on the risky shift, for example, the pressure that an individual feels to change his level, or his perceived level, of risk-taking to conform to a mean or to be perhaps just a little above a mean. We suspect that with young drivers, there are pressures to take greater risks, and I do not know if we actually know whether the risky shift is greater when the subjects are under alcohol than when they are not under alcohol.

BARRY: Dr. Waller prior to this session mentioned some statistics showing that accidents or fatalities with high blood alcohol levels tended to be overrepresented in cases where the drunken driver had two passengers.

WALLER: That was a study in Australia on the risk of crashing per unit miles driven. The highest risk was for a young male in his early twenties with two passengers. I think a corollary to this, is exactly what is the influence of one's peers who are in the vehicle with the driver?

BUIKHUISEN: I think this meeting is dealing in a too easy way with the question of whether the population of drunken drivers is different or not from the general population. There is one suggestion that established differences between the two groups are due to selection procedures of the police. This assumption might be true, though I believe that in the Netherlands, this factor cannot account for the many differences we found between drunken drivers and control groups. As, especially from the point of view of countermeasures, we are dealing here with a matter of crucial importance, I think we should pay more attention to this issue. We could for instance eliminate the influence of the police selectivity in arresting people by comparing non-arrested DWIs with subjects not engaged in drunken driving (both categories identified by dark number questionnaires). These kind of studies can help us to answer the question whether a drunken driver is a kind of normal subject who happened to drink too much or a subject confronted with alcohol or other problems. Needless to say that the answer to such a question is of vital importance for the countermeasures to be developed.

WALLER: I agree with Prof. Buikhuisen completely; this is why I have suggested the need for looking at cultural differences and other differences in drinking patterns. One thing that I think is relevant here is that in some of our earlier work appearing in the Quarterly Journal of Studies on Alcohol, we had compared the types of crashes by drivers known to have alcoholism with the types of crashes by drivers who were not known to have alcoholism (or who were presumed to be social drinkers). We looked at the speed at which the crash occurred according to whether the police officer reported that the person had not been drinking, had been drinking but was not under the influence or questionably "under the influence," or had been drinking and was "under the influence." Among those who would be classified as "social drinkers," there was no increase in speed, as one followed across these three categories. For those who were known alcoholics -- known by us, but not known by the police to be alcoholics -- there was a progressively greater speed, with increasingly apparent impairment according to the police officer. This again would suggest that there are some differences according to the particular characteristics of the individual over and above the strictly pharmacologic factors involved.

PERRINE: This is a very good observation. I wonder, Julian (Waller), on the basis of the more recent work you have been involved in, whether there is any basis for suspecting a selective bias on the part of the police at the time when they checked whether the drivers had been drinking, which might have influenced their estimate of the probable rate of speed at the time of impact.

WALLER: This would be a reasonable hypothesis, were it not refuted by the data for the social drinkers who had been drinking and were "under the influence." For the social drinkers, we got a flat line with respect to speed, whereas for the known alcoholics, the line went up, even though in both cases we were talking about all three impairment categories.

PERRINE: The same with blood alcohol distribution for the social drinkers and for the alcoholics?

WALLER: I am talking here about two groups; first, people who are not known to be problem drinkers, and we have presumed some of them are social drinkers; second, the others, all of whom were known alcoholics with respect to the persons who were obviously impaired. I cannot say what the blood alcohol concentrations were, but in each case, they were high enough so that the police officer said either he could identify that this person had been drinking but not that he was impaired, or that he could identify that this person had been drinking and in fact was impaired.

PERRINE: Bob Voas stated earlier that we are expected to come up with a statement suggesting areas that need more research, and this is clearly one of them.

Chapter 5

ALCOHOL INFLUENCES UPON CLOSED-COURSE DRIVING PERFORMANCE

M. Stephen Huntley, Jr.

ABSTRACT

Alcohol-and-driving research has ranged broadly in terms of technical sophistication and adequacy of experimental design. Some studies can be considered no more than demonstrational, whereas others provide a solid basis for much-needed additional work. 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 BACs between 50 and 75 mg%. However, it cannot be assumed that all drivers are always impaired at these concentrations, for even BACs as high as 130 mg% are not sufficient to impair performance in all instances. The magnitude of alcohol effects is modified by driving skill, drinking experience, personality, the nature of the 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.

1. INTRODUCTION

The misuse of alcoholic beverages constitutes the basis of an acknowledged social problem -- a problem which was recognized and described statistically as early as 1934 by Heise. More recently it has been estimated that $13,000,000,000 worth of damages result each year from alcohol-associated incidents. Recognizing the relationship between alcohol and highway fatalities, the federal government has recommended that alcohol concentrations of 100 mg per 100 milliliters of blood (100 mg%) be used as the legal level of presumptive impairment.

Such a recommendation is an important first step in reducing alcohol associated crashes. However, the annual carnage on the highway that is associated with alcohol will probably not be reduced appreciably until driving itself is made alcohol-proof in some fashion. The acceptability and success of procedures used to do this will depend to a large degree upon our understanding of the manner in which alcohol influences driving -- an understanding which might best be achieved through the rigorous and systematic study of these alcohol effects in the driving situation. Unfortunately, the conclusions which can be confidently drawn from much of the driving research done to date are severely limited by the manner in which the studies have been conducted. Some of the limitations have been imposed by unavoidable real-world constraints; others are the result of poor experimental design and perhaps the rather narrow purposes of the research.

To the first point, research in real-world conditions must be conducted under a number of confining conditions. For example, the welfare of the subject must be of paramount importance. Aside from possible legal constraints, certain types of studies must be considered unethical because of the unacceptable probability of physical harm to the subject. Accordingly, the effects of alcohol on driving are rarely studied on active public roads or in high speed conditions. Experiments under such conditions are best investigated using driving simulators. However, the simulator approach to driving research is often not a viable one, since this technique is often employed at the expense of operational validity and perhaps even face validity as well. By their very nature, simulators can only provide partial representations of actual situations, with the very real possibility that the elements of driving most important to the experimental question have not been included in the simulation. A recent investigation of simulator validity comparing the scores obtained by taxi drivers on a variety of simulated driving tasks to their actual performance on the road showed a striking lack of correspondence between the two (Edwards, Hahn, & Fleishman, 1969).

In the absence of correspondence, it would seem most advantageous to study the influences of alcohol during actual driving, even though such an approach must necessarily be contrived to some extent and, therefore, can only be an approximation of the real world to varying degrees. Three important limitations of such driving studies have been: (1) the low speeds at which most testing was done; (2) the short durations of the tests; and (3) the simplicity of such tests, in the sense that the driver often has only had to concentrate upon a single aspect of driving at any one time. In contrast, automobiles are normally driven at relatively high speeds, placing a premium on rapidity of responses; single trips are frequently longer than one hour in length and so may result in alcohol and "fatigue" occurring in combination; and real driving is complicated by the requirement to divide one's attention between driving and monitoring the actions of others who also use the highway.

Regardless of the obvious artificialities which most closed-course experiments necessarily have, the fact that such studies measure actual driving behavior in real cars provides them with the potential for both high face validity and operational validity, two characteristics which serve to increase the generalizability of experimental results to real-world driving conditions. This paper is a critical review of investigations of this type reported since 1950.

Since there appeared to be little other basis for grouping, the studies have been presented in nearly chronological order. In addition, because of differences in the apparent themes of the studies and their levels of experimental sophistication, the earlier studies (with some exceptions) have been classified as primarily demonstrational and the later ones (again, with some exceptions) as being more concerned with achieving a fundamental understanding of alcohol impairment.

2. DEMONSTRATIONS OF ALCOHOL IMPAIRMENT

Although earlier studies have been reported (e.g., Heise, 1934), the classic and most often quoted investigation of alcohol influences upon proficiency of actual driving was done by Bjerver and Goldberg in 1950. These investigators compared the performance of a control group with that of a group of drivers who had consumed either beer or distilled spirits. The course consisted of a series of backing, parking, and starting maneuvers which required precise positional control of the vehicle. Tasks not completed perfectly had to be repeated, e.g., if one of the limit-defining stanchions was upset while accomplishing a maneuver. The dependent variable was the time taken to complete all maneuvers perfectly. It was found that relative to the control group, alcohol was associated with a 27.9% impairment. The mean blood alcohol concentration (BAC) was approximately 48 mg%, but ranged from 16 to 74 mg%.

Individual differences in impairment were also noted, as compared to the control group mean. Since one driver seemed to show impairment at approximately 35 mg% whereas another showed no change at a BAC exceeding 60 mg%, it was concluded that some drivers were more susceptible to alcohol effects than others. Furthermore, some trends were found which suggested that those who performed more slowly on the initial trials were also more impaired by alcohol. The authors concluded that "the threshold of impairment of driving ability in expert drivers . . . is an alcohol concentration of . . . 0.035% (35 mg%) to 0.04 (40 mg%) in the blood (p. 28)." However, since each driver was only tested at one BAC level and the experimental design provided no means of assessing test/retest variability of individuals, statements cannot legitimately be made concerning individual susceptibility to the influences of specific BACs. The data only permit the conclusions based on comparisons with the non-alcohol control group, i.e., that (in general) driving is impaired at BACs approximating 48 mg%.

As employed by Bjerver and Goldberg (1950), the low speed closed-course driving tasks have several advantages for studying driving: (a) the difficulty of the task can be readily manipulated, (b) the tasks and procedures are easily standardized and therefore repeatable, and (c) a variety of quantifiable performance measures can be collected with a minimum of instrumentation. Perhaps because of these features, a number of researchers have employed such non-representative driving tasks in their investigation.

Examining the influence of drinking experience upon alcohol-associated impairment, Coldwell, Penner, Smith, Lucas, Rodgers, and Darrock (1958) required 50 drivers categorized as light, intermediate, and heavy drinkers to negotiate an intricate, low speed closed-course in alcohol and no-alcohol conditions. Following a practice day, all subjects were tested before and after drinking on two consecutive days. It was found that 25 drivers showed driving impairment at BACs approximating 85 mg% as indicated by stanchion hits -- the measure found to provide the single most sensitive index of impairment. When stanchion hits, time to complete the task, and errors (e.g., incorrect gear changes) were combined in a weighted fashion, significant ($p < .10$) impairment for half of the group was indicated at 78 mg%. Furthermore, trends suggested that increases in BACs at high levels caused more stanchions to be hit than similar increases in BACs at lower levels. Twelve of the drivers not impaired by the standard experimental dosage were given increasing doses until driving impairment was manifested. Six drivers resisted the effects of alcohol at 100 mg% and one at a BAC as high as 131 mg%. Regression analyses of driving performance changes indicated that the heavier drinkers showed less driving impairment than the lighter drinkers, at any particular BAC. This impairment was defined primarily in terms of reductions in lateral control (indicated by stanchion hits) and smooth manipulation of the vehicle controls (according to subjective evaluation of passenger-observers).

Due to the magnitude of the alcohol/no-alcohol performance differences obtained in the Coldwell et al. study, there is little doubt that alcohol-associated driving impairment was shown. However, the particular BACs at which these effects occurred and the size of the effects obtained should be interpreted with caution, since they may reflect the combined influences of alcohol and sequence-related factors, such as fatigue. Because all alcohol trials were conducted later in the day, no control was provided for practice, fatigue, or even possible time-of-day effects -- any one of which may have served to magnify the influences of alcohol.

Another report of the same study (Penner & Coldwell, 1958) emphasized the reliability (or lack of it) of estimating potential driving impairment from clinical tests, such as balance, coordination, and mood. It was reported that out of the 49 drivers who manifested driving impairment, only 25 were predicted to do so by physicians who examined them following drinking, but prior to driving. In fact, of the 25 drivers who had BACs ranging from 100 to over 131 mg%, only 13 were judged impaired by one physician and 15 by the other. Furthermore, in several instances the examiners called drivers alternately impaired and unimpaired at the same BACs on different days. The clinical test having the most predictive power was the presence or absence of nystagmus. Only 1 out of 25 drivers judged impaired did not manifest this characteristic, even at a BAC as high as 173 mg%.

Longhetti and Barnett (1965) also tested drivers in a low speed (approximately 6 mph) driving task before and after drinking alcohol. They found that BACs ranging from 70 to 120 mg% increased the number of pylons upset; the time necessary to negotiate a winding, 0.6 mile driving course; and the times the curb was hit while doing so. Interestingly, 5 of the 6 drivers passed field sobriety tests given by state patrolmen following completion of the "wet" laps.

A three-day test sequence was used by Taylor and Stevens (1965) in controlling for sequence effects. They required nine drivers to perform on the first and third days without alcohol and on the second day after having consumed a quantity of beer calculated to raise BACs to over 100 mg%. Two basic driving courses were used. The first was identical to that described by Coldwell et al. (1958), and driving performance was assessed on the basis of time required to complete the course, with an assigned time penalty for each stanchion that was hit. The second course consisted of a system of horizontal and vertical roads forming a 3-by-3, 9-cell grid. Selected combinations of rectangles were used to form each of the eight different, 1.6-mile patterns that were employed. Performance on this course was subjectively evaluated by a passenger-observer in terms of gear-change coordination, driving smoothness, stalling, and other similar measures of driving behavior. In addition, the drivers were observed by a police officer on each of the three days and subjectively rated with regard to their <u>apparent</u> degree of intoxication as they performed a series of balance and coordination tests.

Driving on both courses was worse (slower and less coordinated) after alcohol ingestion, but only five of the nine drivers were so judged on the balance and coordination tests. It was also reported that impairment was apparent at lower BACs on the driving tasks than on the balance and coordination tests for these five drivers. Accordingly, it was concluded that driving impairment occurs at BACs lower than those necessary to impair balance and coordination. Unfortunately, as is the case in so much alcohol research, the results of this study cannot be considered anything but suggestive, since the car used for testing in the alcohol condition was not the same vehicle that was used in the no-alcohol trials.

One of the first reported studies to examine alcohol effects on driving at speeds even remotely approximating those at which serious accidents occur and to use crash-relevant tasks was conducted by Chastain in 1961. This investigator required six drivers to approach a right-angle turn at 20 mph, slow down for the turn, go through a pylon-defined alley which converged from an opening of 8 feet at the entrance to 7 feet at the exit, and then resume the 20-mph speed before bringing the car to a stop as close as possible to a line drawn across the track. The car was then driven at 20 mph through a slight offset in the track, stopped, driven in reverse back through the offset, and then driven forward again at 20 mph. Upon presentation of an auditory signal, the car was stopped as quickly as possible. BACs determined from blood samples, ranged from 100 to 120 mg%. Relative to no-alcohol performance on the previous day (there was no control for order effects), driving errors (tire skidding, turn-signal omissions, pylons hit, etc.) increased for each driver and brake reaction times were 17% longer.

An excellent way to control for order effects is to compare the performance of a group which does not consume any alcoholic beverages with that of another group which does (a procedure used by Bjerver and Goldberg, 1950). However, when the two-group design is used and performance on the task of interest is highly variable, very strong treatment effects are frequently necessary in order to obtain statistically significant differences because of the masking effects of individual differences among the typically small number of drivers run in experiments such as these. Perhaps because of these factors, the low BACs used (50 mg%), and the skill and high motivation level of the drivers employed, Forney, Hughes, Hulpiew, and Davis (1961) found that alcohol had little effect on competition driving in an automobile gymkhana. The task included acceleration runs, tests of stopping precision, and driving in reverse through a serpentine course. Performance scores were calculated from a weighted combination of time to complete the course, number of pylons upset, and distance by which the stopline was missed, etc. When determined in this fashion, driving performance was not impaired by the alcohol treatment. However, when performance on each aspect of the overall test was analyzed separately, it was found that alcohol significantly ($p < .01$) reduced performance in the event requiring driving in reverse. The importance of this finding may be that driving in reverse for any distance is a relatively unfamiliar task. Unfortunately, the reason for this effect is not clear since the order in which the individual driving tasks were attempted was not counterbalanced. Thus, not only was the task which appeared most susceptible to alcohol a reversing task, but it was also the first task attempted following consumption of the alcohol beverage, i.e., it was accomplished when the driver's BAC was probably highest and when he had the least time to adapt to its effects.

2.1 Additional Comments on Procedure

Each of the first three studies (Bjerver & Goldberg, 1950; Coldwell et al., 1958; Longhetti & Barnett, 1965) has provided interesting data regarding the effects of alcohol upon driving. Unfortunately, due to the experimental designs employed, their informational yield was less than otherwise might have been the case. For example, Bjerver and Goldberg (1950) confounded driving time with driving accuracy in calculating their performance scores and so make it difficult to determine the relative effects of alcohol upon these two aspects of driving. They did, however, obtain a reliable estimate of non-alcohol performance through the use of a separate control group. In contrast, the two subsequent studies (Coldwell et al., 1958; Longhetti & Barnett, 1965) employed the procedurally questionable before/after design in obtaining their results. Such designs are economical in that alcohol and no-alcohol testing can be done on each driver on the same day, but this is done at the cost of incurring sequence effects which are difficult to assess and which must influence the interpretation of the data obtained.

Researchers who estimate the influences of alcohol by comparing performance after drinking with performance demonstrated before drinking must assume that fatigue is not an important factor in the task examined. This assumption might be reasonable because of the short durations of the test sessions typically used in such investigation; and it would also be logical to assume that the alcohol effects found with such designs occur in spite of any learning which may have taken place during the "dry" trials. Accordingly, it might be further assumed that such effects provide conservative estimates of the magnitude of the alcohol influence. However, it should be recognized that there are other effects with which the investigator should be concerned. Drivers tend to be ego-involved in driving tasks, try hard to perform well in them, and thus may be readily frustrated by experience on the dry trials. As a result, different performance criteria may be adopted on subsequent trials. Furthermore, regardless of the experimenter's assumptions, anxiety and fatigue may also be present at these times. Thus, it is possible that repeating the task following consumption of the experimental beverage will be associated with criterion change, frustration, and fatigue, any one or all of which may combine synergistically with alcohol to increase the apparent effects of the beverage. Thus, no valid appreciation of the precise nature or actual magnitude of alcohol effects can be obtained from studies failing to control for sequence effects.

It may be felt that the criticisms of all the preceding studies have been unwarranted and unduly severe, since for the most part these studies have not been touted as rigorous scientific investigations and in some cases were conducted only to demonstrate that alcohol reduces driving ability in some fashion. Their contribution lies in having shown this and in the important role they have played in stimulating further work in this area. Nevertheless, it is still useful to point out the limitations of these studies as an introduction to some of the shortcomings which are not uncommon in alcohol research, and as a means of evaluating earlier data which, improperly interpreted, could serve as the basis of an inaccurate body of "knowledge" from which subsequent works might derive.

In addition to the design limitations already discussed, three other characteristics of early work reduce its usefulness. First, estimates of performance have often been based upon subjective evaluation by observers who must have been aware of the treatment condition in which the driver was performing (e.g., in some studies, the early trials were no-alcohol conditions, whereas all drivers in the later trials had ingested alcohol). This procedural weakness is particularly important when qualitative judgments (which are more readily influenced by expectations) must be made about continuous measures such as driving smoothness and control-use coordination. Secondly, driving tasks employed in early studies were usually highly contrived. With the exception that a real automobile was actually driven, they bore little resemblance to the real-world driving situations in which alcohol-associated driving fatalities occur. Thirdly, apparently satisfied with demonstrating that alcohol impairs driving ability in some way, early researchers made little attempt to determine the mechanisms by which alcohol reduced performance. Thus, although it has commonly been reported that more limit-defining pylons are hit after alcohol consumption than before, no known attempt has been made to determine if, for example, this is due to impaired visual perception or inaccurate steering responses.

At least a partial solution to these deficiencies is to free the assessment of performance from the biases and limitations of human observation by employing instrumented methods for the automatic sensing and recording of data. Because of recent innovations in automobile instrumentation, this approach is more feasible now than when the first studies were conducted.

3. THE NATURE OF ALCOHOL IMPAIRMENT

Recently, more attention has been paid to the automobile as a research tool and, perhaps consequently, the cars used in driving studies have become increasingly instrumented. At the same time, there seems to have been a decreased emphasis on such relatively awkward performance measures as number-of-stanchions-hit, and the influences of alcohol have been studied in more realistic driving situations.

One study which employed a task approximating an important (from a crash-avoidance standpoint) driving maneuver, i.e., a rapid lane-change response, was conducted recently at the General Motors Proving Ground (McLellan, 1969). The study was designed for the expressed purpose of making people more aware that "they were not as capable or as safe drivers after they have been drinking (p. 193)," rather than to gather scientific data; and so a number of procedural compromises were made, e.g., drivers were always tested in the non-alcohol condition prior to the alcohol condition. However, the study is notable on at least two counts. First, the driving tasks were realistic; and second, important elements of the stimulus conditions, (e.g., onset time of signal lights) and response characteristics, (e.g., reaction time) were controlled and monitored electronically and therefore were relatively independent of human bias. To be sure, the instrumentation was no challenge to that commonly used in other fields of science, but it was a first in drinking-and-driving studies and indicates a welcome concern for precision of measurement.

Each of the seven drivers were tested on two separate courses. In one, the driver was required to approach a set of three adjacent gates at 40 mph. A red and green signal light was suspended above each gate, with the green light normally activated. When the car was within 100 feet of the gates, two of the lights turned to red and the driver had to swerve into the appropriate lane in order to pass through the "green" gateway. The other course consisted of a pylon-defined lane which was 10-feet wide and included three curves and one straightaway. Performance on this task was scored in terms of the number of pylons upset and the elapsed time per run. Each driver was tested prior to drinking and following drinking at four consecutive BACs ranging from approximately 50 to 115 mg%, with the final concentration depending upon the target BAC selected by the driver, since some elected to go much higher than others.

Reaction times in the lane-change maneuver were not changed by alcohol. However, it was reported that driving ability was noticeably reduced at the 100 mg% BAC. Unfortunately, driving ability is not clearly defined in the report. Most likely, driving accuracy (as measured by the number of times the car struck the gate-defining barrels and swerved out of the chosen lane) was the basis for the ability judgments. Performance in the driving circuit appeared most sensitive to alcohol, with the number of pylons upset being increased noticeably by BACs between 40 and 80 mg%. However, the reliability of the difference is unknown since no statistical tests were done on any of the data, and wide individual differences were apparent in all conditions. Although no formal attempt was made to determine what aspect of the driver's information processing functions were most impaired, it does appear that response accuracy was more influenced by alcohol than the speed of responding, i.e., reaction time.

Lovibond and Bird (1970) examined the influences of driving experience upon alcohol-associated driving impairment by comparing the driving performance of 16 highly skilled racing and rally drivers with that of 26 drivers without competition experience under alcohol and no-alcohol beverage conditions. The drivers were tested at BACs of 0, 50, 80, and 100 mg%, with the order of concentrations being counterbalanced across drivers. Each driver was tested at each concentration over a period of four days, with only a single dose being consumed on each day. The tasks included negotiating a corner at approximately 45 mph while keeping the left wheel on a white line, going through a pylon-defined slalom, entering a pylon-defined garage, and driving in reverse through a winding lane of rubber pylons. Lateral position was recorded using a radio-controlled camera mounted on the car and lateral and longitudinal forces generated during cornering and braking were measured using accelerometers. The effects of alcohol on braking were also measured during separate driving trials; the observer in the car fired a charge of yellow powder onto the roadway which gave the driver an auditory cue to depress the brakes. Brake pressure fired a second yellow charge onto the roadway. The distance between the two yellow spots provided a measure of brake response time.

The praiseworthy aspects of this study by Lovibond and Bird (1970) include increased emphasis on instrumentation, attention to experimental design, and realism of the driving task. Unfortunately, the scientific contribution of this research is limited to some extent by the rather "traditional" fashion in which the results were analyzed. In fact, as is often characteristic of driving research, the data were not even subjected to statistical analysis. However, many of the trends appear systematic enough to allow confident inferences about the nature of the beverage effects.

In general, increasing BACs resulted in a progressive impairment of driving performance in terms of number of pylons upset, decreases in cornering stability, and remarkable increases in braking distance. As compared with braking distance following consumption of the placebo beverage, the 100 mg% alcohol condition was associated with a 35% increase in braking distance. Considering the magnitude of such effects obtained in laboratory research (Huntley, 1972; Moskowitz & Burns, 1971) and the lack of alcohol effects in steering-response times reported by McLellan (1969), the size of this effect is surprising. Unfortunately, the driving and braking task was not described in much detail and therefore provides little means of determining why reaction time (as represented by braking distance) was so highly sensitive to alcohol in this study.

Impairment in the overall driving skill of non-competition drivers was apparent at 50 mg%, whereas competition drivers did not show appreciable impairment until the 80 mg% dose. Notably, the performance of the competition drivers at the 80 mg% dose was measurably below the non-alcohol performance of the non-competition drivers. Alcohol-associated changes in lateral acceleration seemed to be particularly sensitive to differences in driving experience. Accelerometer recordings showed that the tail-wag generated by the competition drivers as they left the corner was moderate and did not change appreciably as BACs increased. By comparison, tail-wag of the non-competition drivers increased steadily with increases in BAC. In contrast to the apparent interaction between alcohol and driving experience, no relationship was found between drinking experience and the magnitude of alcohol effects.

A number of studies have reported that BACs between 50 and 100 mg% indeed impair certain kinds of driving performance. Unfortunately, because of the limited purposes of these studies and consequently the rather unsophisticated experimental procedures employed, little can be determined from their results concerning the mechanism of alcohol-associated impairment, e.g., whether it is the perceptual and/or motor aspects of driving that are/is modified. A more analytical approach to the study of drinking and driving is required if the manner in which alcohol influences driving is to be understood.

Perhaps responding to this need, Seehafer, Huffman, and Kinzie (1968) conducted one of the first studies investigating the influence of alcohol upon a broad band of dependent variables during driving. Control-use data were collected and displayed in digital format using an electromechanical device called a Drivometer (developed by Greenshields, 1962) which included steering wheel reversals, accelerator reversals, and brake applications. In addition, heart-rate, respiration rate, lateral eye movements, and fixation durations and frequencies were recorded while driving. Performance measures included: times the left tire missed the line to be tracked, observer estimates of uneven speed and improper shifting, and distance the car was stopped from an indicated spot.

Analyses of variance revealed that alcohol dosages (calculated to produce BACs of 50 to 70 mg%) significantly ($p < .01$) increased the number of steering reversals, rough shifting, engine stalling, and in general reduced performance on almost all dimensions observed. The increases in wheel-reversal rates were similar to those obtained by Drew, Colquhoun, and Long (1958) in a simulated driving task and were interpreted as indicating decreases in vehicle control. Other interpretations are also possible, of course. For example, this change could be due to an anxiety-associated increase in attention to the steering aspect of driving. Alcohol also decreased the frequency of lateral eye movements and increased the frequency of fixation durations longer than one second. The reduction in movement frequency would be expected to occur with increases in fixation duration, but may also have resulted from a reduction in eye movement speed (Mizoi, Hashida, & Maeba, 1969). The increased fixation duration is open to a number of interpretations, all of which are not mutually exclusive. For example, it may indicate a reduction in information processing speed and/or could be due to alcohol-associated reductions in speed of accommodation. Other interpretations are possible and indicate the usual necessity of more research.

Using an eye marker camera system, Belt (1969) examined visual search patterns of two subjects at BACs approximating 0, 37, and 75 mg% during open-road driving and car following on a four-lane highway. Alcohol was associated with a significant ($p < .05$) narrowing of the visual scan pattern in the former, but not the latter condition. Furthermore, although the effect was not statistically significant, alcohol seemed to be associated with an increased number of long-duration (0.25 - 0.75 sec.) fixations and a reduction in the percentage of fixations of short duration, a finding similar to that of Seehafer et al. (1968). It was suggested that these longer durations are necessary to satisfy an increase in the driver's demand for visual information. Since apparently alcohol is also associated with a reduction in responsiveness to peripheral signals (Hamilton & Copeman, 1970; Huntley, 1972), it may also be that the information concerning where to look next is not processed as readily, thus making it more difficult for the driver to determine the direction of his next saccadic response. With the data presently available, such explanations must, of course, be considered highly speculative, but the implications for safe driving are evident.

Belt also found that BACs of 75 mg% caused significant ($p < .01$) increases in velocity variance when subjects were required to maintain a constant highway speed of 60 mph. However, alcohol had no significant effect upon the ability to produce velocities from 45 to 70 mph without speedometer feedback.

Normally, while looking straight ahead in a moving car, there is a tendency for the eyes to follow roadside objects moving towards the periphery, which is called optokinesis. Heifer (1971) found that BACs averaging 97 mg% reduced the amplitude of the optokinetic saccades by 35%, indicating that the sensory-motor aspects of the visual system are markedly susceptible to the influences of alcohol. The practical import of this finding is shown by the work of Mortimer (1967) and Salvatore (1968) who have found drivers reluctant to maintain even moderate driving speeds when deprived of inputs from the peripheral areas of the visual field.

In addition to the procedural limitations apparent in much alcohol research, the accumulation of reliable information and the development of sophisticated techniques for obtaining it has been impeded by the lack of an ongoing interest and commitment to the study of alcohol effects by most researchers (as has been noted by Carpenter, 1962). Interpretation of the results of most psychological experiments is subject to some degree of qualification and speculation and usually involves rethinking concerning procedures and instrumentation. Without follow-up studies, unclear but potentially important relations may not be clarified, and the experience gained in the single study, as well as much of that study's potential import -- heuristic and otherwise -- may be lost.

One exception to this criticism is a recent series of studies that has been conducted at Project ABETS of the University of Vermont using an instrumented car (Huntley & Centybear, 1972; Huntley, Kirk, & Perrine, 1972; Huntley, Perrine, & Kirk, 1973; Perrine & Huntley, 1971). In one study (Perrine & Huntley, 1971), the influences of legally impairing BACs (108 mg%), extraversion (measured with the Eysenck Personality Inventory), and a mental subtask requirement (addition of the single digits composing two-digit numbers) upon driving in a gymkhana situation were examined using a counterbalanced repeated-measurements design. The principal apparatus was the commercially available HSR car developed by Ford Motor Company. Using this vehicle, 2° and 12° steering reversals, accelerator reversals, brake depressions, number of speed changes (in 2-mph increments), and average speed were recorded during all trials. In addition, the more traditional performance measures of number of pylons upset, stopping accuracy, and elapsed time were recorded. Drivers were instructed to drive the course as well as they could. Neither speed nor accuracy was emphasized, although the importance of speed was implied in the nature of the task.

Analyses of variance revealed that alcohol significantly ($p < .05$) increased the number of accelerator reversals, but did not have reliable effects on the use of other controls. Alcohol also significantly decreased ($p < .05$) stopping accuracy. The effects of alcohol on tracking accuracy, as indicated by the number of path-defining pylons upset, were subject to individual differences. A Spearman rank correlation coefficient calculated between the alcohol-associated change in tracking accuracy and the extraversion scores produced a significant ($p < .05$) positive correlation (r_s=.67), indicating that alcohol-associated reductions in tracking accuracy were enhanced by increases in extraversion. The mental arithmetic task had no apparent effect on control-use, but did interact significantly with alcohol, such that when the task was required, alcohol was associated with a smaller number of pylons upset. Conceivably, the loading task had an activating effect which counteracted the depressant effects of alcohol. However, if such were the case, it was not reflected in the other dependent measures and therefore reasons for the effect must remain speculative.

A second study (Perrine & Huntley, 1971) was conducted during the following year and was similar to the first in that a gymkhana driving course was used and the influences of alcohol, extraversion, and a mental subtask were examined. Important differences were: (a) driving accuracy was stressed as the most important index of driving performance, although drivers were instructed to maintain a speed of 10 mph whenever possible; (b) the mean BAC was 74 mg% rather than the 108 mg%; and (c) the task involved driving in reverse gear and more straight-ahead driving, and included several different parking maneuvers. As before, pylons were closely spaced in an attempt to make the tracking aspect of the task very difficult.

Analyses of variance revealed that alcohol significantly ($p < .05$) increased accelerator reversals and, perhaps consequently, the number of speed changes. Tracking accuracy, as measured by pylons upset, was not significantly reduced by alcohol, and the loading task requirement had no significant effects.

The lack of alcohol effects upon tracking and its increased influence upon steering behavior in the second experiment was probably due to the track configuration and/or the instructional emphasis upon the importance of not hitting pylons. It is logical that, in an attempt to satisfy a high criterion of tracking accuracy, the drivers would try to compensate for assumed alcohol effects by attending more to the steering controls. In addition, the turns in the second experiment were much less severe than in the first, which reduced the difficulty of driving the course.

Correlation coefficients calculated between control-use rates and the number of pylons upset revealed no significant ($p > .05$) relationships in either study so the relationship between alcohol-associated changes in control-use behavior and driving performance is unclear. However, it does appear that control-use behavior may be a more sensitive indicator of alcohol effects than driving performance (i.e., tracking accuracy) since the former occurs even in the absence of the latter.

Two factors were identified which appear to modify the influence of alcohol on driving and which indicate that the relation of alcohol to driving varies with task demands and individual differences. First, it was shown that alcohol-associated reductions in tracking accuracy were less when the driver was required to perform a concurrent mental task than when he was not. Although this effect was not verified in the follow-up study, it should receive additional research attention since it suggests that special ancillary procedures could be incorporated in the driving task which might increase the ability of the alcohol-impaired driver to perform in certain situations. Secondly, when measured in terms of tracking accuracy and increases in control response, the extent of alcohol-associated driving impairment increased with increases in degree of extraversion. Post-test interviews indicated that high and low extraverts may have used different criteria for evaluating their own performance. Maintaining non-alcohol driving speed seemed the more important for high extraverts, whereas low extraverts verbalized willingness to sacrifice speed in order to maintain non-alcohol tracking accuracy. Additional research should be conducted to explore the nature of these differences. It is possible that an understanding of the critical differences could be employed in driver education and licensing programs to reduce driving risks.

3.1 Additional Comments on Procedure

Perrine and Huntley (1971) controlled for many of the time and sequence effects which have served as a basis of criticism for earlier work. Practice sessions were used to familiarize subjects with the tasks, warm-up trials were used before testing, placebos were employed, and the designs were counterbalanced factorials. Such controls were adequate for the purposes of these experiments, since they were not concerned with establishing impairment thresholds. However, with regard to evaluating studies which do propose to establish thresholds, it is important to recognize the nature of the data from which such limits may be developed.

The particular BAC at which specific effects are proposed to have occurred (i.e., the impairment threshold) is usually a statistical entity (as are all psychological thresholds) and, therefore, is representative of a range of BACs. The BACs reported are frequently averaged across subjects, as well as across several points in time during testing. Thus, in one study (Perrine & Huntley, 1971) the reported mean BAC of 108 mg% was the average of a mean (across subjects) BAC of 103.5 mg% determined at the beginning of testing and a BAC of 112.5 mg% determined at the end of testing. The BACs from which these means were derived ranged from 45 to 148 mg%, even though dosages used to produce them were calculated to produce BACs of 100 mg% and were determined for each subject on the basis of body weight. Furthermore, four subjects were tested while their BACs were rising, three while falling, and the same BAC was obtained for the remaining subject on both determinations. The differences among these data are probably typical of those which exist in most alcohol and driving studies, and they illustrate the range of conditions represented by the statistics frequently used to describe alcohol-performance relationships. Accordingly, the results of studies summarized and reported in this fashion should be interpreted with caution. If parametric data are required, more rigorous data collection procedures must be used.

Both scientific and anecdotal reports indicate that time-sharing is an aspect of human performance which is particularly susceptible to the effects of alcohol (Moskowitz, 1973). Thus, after drinking, the driver, whose primary task is to keep his car on the road, is likely to be less responsive to signals (e.g., the headlights of a car approaching from a side road) which are not immediately related to the tracking aspects of driving. This potentially important relationship was investigated by Huntley, Kirk, and Perrine (1972) who examined effects of alcohol upon brake response times to peripheral light signals which were presented during driving. Two drivers, characterized as heavy drinkers, were required to drive an instrumented car over a 2.72 mile circuit of deserted roads at speeds of 15 and 25 mph on each of eight separate nights. A placebo beverage was consumed on four nights, alternating with consumption of the alcohol beverage (1.21 ml of 100% ethanol per kg of body weight) on the remaining four nights. The mean BAC of the two drivers across the four alcohol days was 85 mg% for one and 116 mg% for the other. The only driving constraints were to maintain the specified driving speed and keep the vehicle on the right side of the road, with the driver being instructed prior to each trial that accurate speed maintenance was his most important task. Concurrently, the driver was required to depress the brake as quickly as possible after detecting one of three possible dim lights presented from the center of the visual field or from 60° eccentric, left and right, on the horizontal meridian. The experimental design was a counterbalanced factorial, with each driver being tested in all condition combinations.

Control-use rates and brake response times were increased by alcohol. Students <u>t</u>s calculated on the data revealed that alcohol significantly ($p < .01$) increased coarse steering reversal, accelerator reversal, and speed-change rates. It is interesting that steering-reversal rates were subject to the effects of alcohol in this task which placed little emphasis upon steering precision, a relationship which indicates the sensitivity of this measure to BAC. The increase in accelerator reversals and speed-change rates indicates increased attention to the speed-control aspects of the task. Since the importance of accurate speed maintenance was emphasized, the drivers may have attended disproportionately to this aspect of the task to compensate for possible alcohol-associated impairment of speed-maintenance skill. Similarly, increases in steering reversal rates indicate an increase in attention to the lateral tracking aspect of driving -- an element of the task not emphasized explicitly as being particularly important, but one which is naturally given a high priority in driving situations. Since the amount of attention available to the human operator is finite, the alcohol-associated attentional redistribution must have been done at some cost, e.g., a reduction in attentiveness to the signal monitoring aspects of the task. The magnitude of the effects of alcohol upon brake response times to the light signals provides support for this motion.

Alcohol caused significant ($p < .01$) increases in brake response times of 24 and 33 percent to central and peripheral lights, respectively. This effect is considerably stronger than that usually obtained in the laboratory, is similar in magnitude to that reported by Lovibond and Bird (1970), and contrasts sharply with McLellan's (1969) data.

Increased reaction time is perhaps the most meaningful indicator of alcohol-associated impairment to the layman, probably because the practical implications of such changes during driving emergencies are so obvious. However, certain ramifications of such increases may not be readily apparent, even though they have important effects. For example, as well as causing the expected increase in latency between signal detection and brake response, it can be expected that alcohol will influence the shape of brake-pressure curves and thus braking efficiency, since the appropriate modulation of brake pressure in emergency situations is to some extent dependent upon reactions to proprioceptive feedback. This notion was tested by Huntley, Perrine, and Kirk (1972) using "emergency" and gradual stops following a simulated passing maneuver.

Sixteen drivers were required to drive an instrumented car in a counterbalanced series of trials following consumption of a placebo on one evening, and after ingesting a dose of vodka on another. The alcohol dose produced a mean BAC of 90 mg% when averaged across subjects. Each driver was required to approach at 10 mph a barricade simulating the rear of a truck, pull out into the left lane, accelerate past the "truck" through a pylon-defined "crossroad," return to the right lane upon receiving a light signal flashed in the rearview mirror, and bring the car to a comfortable stop. On 50% of the trials, an abort signal was presented as the crossroad was approached. This signal appeared on top of either the front left or right fender and indicated that the car should be swerved to the left or right side of the road, respectively, and stopped quickly.

Relative to the counterbalanced placebo trials, alcohol was associated in the abort conditions, with increases in steering and brake response times of 6.4% and 8.7%, respectively, and in the completed-pass condition, with increases in braking response times of 2.5%. Analysis of variance revealed that, overall, the effect of alcohol upon response latency was significant ($p < .05$), but no significant differences among the four response conditions were found.

Brake-pressure curves recorded by means of a strain gauge mounted on the brake pedal had significantly ($p < .05$) faster rise times and tended to be of shorter duration after alcohol consumption. No effects on pressure amplitude were found.

The curves in the alcohol condition were interpreted as indicating a reduction in stopping smoothness and the sensitivity with which the brakes were applied.

As previously noted, when the magnitude of the alcohol effects upon reaction time obtained by McLellan (1969) and by Huntley, Kirk, and Perrine (1972) is compared with those of Lovibond and Bird (1970) and Huntley, Perrine, and Kirk (1973), the contrast is striking. The question then becomes: which data are most representative of the "true" alcohol response-latency relation? The work of Moskowitz and DePry (1968) on the effects of alcohol upon time-sharing indicates that a likely explanation of the discrepant results may be based upon procedural differences. Thus, one experiment obtaining large effects (Huntley, Kirk & Perrine, 1972) had a decided divided attention aspect, with the reaction-time task being the less important (according to instructions given the subject) of two tasks which had to be performed concurrently (the more important one being accurate speed maintenance). In the cases of McLellan (1969) and Huntley, Perrine, and Kirk (1973), there is little doubt that the higher priority task was to attend intensively to the light sources and respond as quickly as possible to their signals. Moskowitz and DePry (1968) suggest that in divided attention tasks, the least important component of tasks involving time-sharing is the most susceptible to alcohol effects, whereas the higher priority components may be nearly immune to such influences.

Unfortunately, Lovibond and Bird (1970) did not provide enough detail in their report to permit this type of procedural examination. Regardless, these ideas concerning the reasons for the different alcohol effects are only speculative and should be examined further in specific experiments designed for that purpose. Comparisons made between studies -- such as has been done here -- are hazardous, can only serve as the basis for tenuous conclusions, and are mainly of heuristic value.

Several important aspects of the influence of alcohol on control-use are apparent from studies employing instrumented cars. It has been shown that the magnitude, and perhaps direction, of alcohol-associated changes in control-use are dependent upon personality. It also seems clear that the particular controls subject to these effects depend to some extent on the driving task requirements. Furthermore, the driving literature indicates that "fatigue" (Platt, 1964) causes decreases in control-responses, an effect which is opposite that usually associated with alcohol and, therefore, one that could modify its influences. In order to examine this last possibility, Huntley and Centybear (1973) investigated the combined influences of alcohol and sleep deprivation upon control-use behavior using a simple serpentine driving course. The minimum distance between the pylon gates forming the course was 16 feet, considerably wider than the 8 feet employed in earlier gymkhana studies, and thus one which was simple to negotiate, intoxicated or not. Sixteen drivers negotiated this course after consumption of a placebo or alcohol beverage, and following a night of normal sleep or 24 hours of sleep deprivation. Each driver was tested in each of four combinations of these conditions in a counterbalanced factorial design.

Analyses of variance revealed that mean BACs of approximately 84 mg% caused significant ($p < .05$) increases in speed-change rate, coarse steer, fine steer, and accelerator reversals. Furthermore, significant ($p < .05$) alcohol-by-driver interactions were obtained on the steering measures. Spearman rank correlation coefficients calculated between Eysenck extraversion scores and the effects of alcohol upon coarse and fine steering reversal rates revealed significant ($p < .05$) positive correlations, indicating that the magnitude of the rate-increasing effects of alcohol became greater for both steering measures as extraversion increased.

In contrast to the effects of alcohol, sleep deprivation was generally associated with <u>reductions</u> in speed change and control-use rates, but the effects were not statistically significant ($p > .05$). However, an alcohol-by-sleep interaction ($p < .05$) was obtained such that alcohol caused increases in coarse-steering rates following normal sleep, but not after sleep deprivation.

It is apparent from this study and those cited above that alcohol and many other variables (such as personality, task requirements, and sleep loss) influence the rate with which automobile controls are used. However, the meaning of differences or changes in control-use rates is not clear, and so the meaning of alcohol-associated changes in control-use behavior can only be speculated upon. Greenshields and Platt (1967) have interpreted increases in control-use rates as indications of indecision and over-control. In support of this notion, they found that inexperienced drivers and persons with poor driving records generally make more control reversals than experienced drivers and those with good driving records. Similarly, it has been shown that increases in accelerator use are directly related to increases in driving difficulty (Jones & Potts, 1962). A logical extension of these relations is that decreases in control-use reflect increases in decisiveness and a reduction in control difficulty. However, an investigation of the influence of driving duration upon control-use (Platt, 1964) revealed that steering-reversal rates decreased as a function of driving time. Accordingly, it was suggested that low rates were indicative of a change in the accuracy criterion, such that drivers compensated for "fatigue" by accepting wider deviations from the ideal path before responding. The conflicting logic in these explanations is obvious and serves to demonstrate the need for research concerning the relation between control-use behavior and associated driving performance.

In the absence of such information, it can only be said that the effects of alcohol upon driving are complex, and that control-use behavior appears sensitive to a number of these complexities. Furthermore, the nature and extent of such complexities indicates a lability of driving behavior which discourages the use of simplistic models to explain alcohol-associated driving impairment.

4. SUMMARY

A review of alcohol-and-driving studies reported since 1950 has revealed work ranging broadly on the dimensions of adequacy of experimental design and sophistication of instrumentation. Some studies can be considered no more than demonstrational and in fact have been described as such by their authors; others provide a solid basis for much-needed additional work. Overall, however, there was a notable tendency for the experimental rigor and realism of studies to increase the more recently they were conducted, with the more recent work qualifying as scientific endeavors.

4.1 Tasks and Measurement

The studies were divided into two categories for review. The first included experiments which relied primarily upon direct human observation and judgment for performance assessment. The second category included those employing at least some instrumented measurement techniques, the work which was done in the most realistic situations, and consisted of the more recent experiments.

The tasks used in the earlier work were frequently low speed maneuvers, stressing driving precision in terms of accurate longitudinal and lateral placement of the automobile. They included driving in reverse, parallel parking, and parking within a rectangle of closely spaced stanchions or rubber pylons. Common performance measures were number of times the tire left the plank, number of pylons upset or hit, elapsed time; and the observer's judgment of driving smoothness based on wheelspin, gear clashes, sudden directional changes, etc.

Tasks employed in the more recent work often included those just described, as well as cornering at highway speeds (45 mph), detection of signal lights, highway driving, simulated passing maneuvers, and rapid turning and stopping. In these instances, variables observed included control-reversals, control-response times, driving speed, brake pressure, lateral acceleration, and eye movements.

4.2 Results and Discussion

Alcohol has been found to change driving behavior on almost all dimensions observed. It increases time to complete driving tasks, the number of pylons upset, velocity maintenance variation, the number of driving procedure errors, control-response times, and control-use rates. It decreases driving smoothness, stopping accuracy, the extent of the visual field explored, and cornering ability.

The magnitude of alcohol effects depends upon the driving tasks performed, the performance measures employed, the individuals tested, and the experimental paradigms used to measure such effects. It appears that the driving performance of experienced drivers and practiced drinkers is less influenced by alcohol than that of those without such experience or practice. It also seems that alcohol influences the control-use behavior and perhaps driving accuracy of high extraverts to a greater degree than that of lower extraverts; the meaning of these changes, however, is not clear.

BACs as low as 35 mg% have been suggested as adequate to cause driving impairment, but the experimental designs employed in making such determinations do not permit statements supporting this estimate. In fact, due to the lack of procedural attention to the test/retest reliability of individual performance, statements concerning specific levels of impairment for single drivers have rarely been supportable. When alcohol-associated changes in group performance have been evaluated, reliable demonstrations of impairment have been shown at BACs between 50 and 75 mg%. However, it cannot be assumed that all drivers are always impaired at this concentration, for it has also been shown that BACs as high as 130 mg% are not enough to impair the performance of some drivers in certain instances. Furthermore, the extent of impairment associated with alcohol and the nature of changes in driving behavior that have been shown cannot be separated from the specific tasks used for testing and the dependent variables observed. Therefore, without a great deal of qualification, the conclusions drawn from this research can only be very general. Thus, the literature indicates that BACs of 75 mg% or more reduce the ability of most drivers to performance maximally. Furthermore, the effects of alcohol are broad; they influence a number of performance aspects which are important to driving safety, and occur in the absence of apparent impairment on non-driving tasks -- a relationship which indicates the particular sensitivity of driving to alcohol.

4.3 Suggestions for Future Research

A review of the alcohol-and-driving literature leaves the impression that many studies have been more concerned with demonstrating that alcohol impairs driving performance in some way, rather than with trying to gain an understanding of the mechanisms through which such impairment occurs.

Granted, it is important to know that some low BAC reduces driving skill. However, an understanding of the process would be even more useful, in that it is more likely to indicate a means of guarding against alcohol effects. If such an understanding is to be achieved, alcohol research must become more systematic and intensive. Rather than looking at impairment only from the molar perspective of system output (e.g., in terms of tracking accuracy) as has often been done in the past, the relatively recent interest in the effects of alcohol on the psychological components (e.g., sensitivity to feed back, visual search, etc.) upon which system output is dependent should be encouraged and intensified.

Furthermore, the fact that the effects of alcohol are modified by individual differences, the nature of the driving task, and sleep deprivation emphasizes the complicated nature of the effects of alcohol upon behavior and indicates the need for additional research on the interactions of alcohol and other variables with which it is likely to be combined.

Considering the contribution of the particular driving task investigated to the aspects of driving effected by alcohol and the fact that the results of these studies must eventually be generalized to the real world, the importance of conducting the research in situations closely approximating real-world conditions and of studying behaviors directly related to actual driving performance must be emphasized. In view of the demonstrated sensitivity of control-use behavior to the physiological and attentional states of the driver, the logical relation of such activities to driving, and their unobtrusiveness, the continued use of such measures should be encouraged in driving research. However, until control-use patterns have been directly related to driving performance (e.g., tracking precision), their usefulness will not be fully realized.

Given validated measures, rigorous experimental procedures, realistic tasks, a commitment to understanding the effects of alcohol on driving, and time, it should be possible to obtain information which will be useful in modifying drinking-and-driving behavior and the driving environment to a degree which will substantially reduce the current annual rate of alcohol-associated driving fatalities.

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DISCUSSION

CARPENTER: Do you know just what constitutes good driving so that when you observe a change in control-use as a function of alcohol you know that driving has in fact been impaired?

HUNTLEY: This is a real problem. Although it can be reliably shown that in general alcohol causes increases in control-reversal rates, there are no experimental data relating such changes to decreases in driving performance, e.g., tracking accuracy. In our case, this problem is largely due to the limitations of our recording apparatus, e.g., we have no practical way of obtaining lateral placement information, and this limitation does detract from the usefulness of our data.

DRIESSEN: Regardless of the lack of established relation between reversal rates and driving performance, I think part of the value of research employing instrumented vehicles is the development of baselines of behavior against which comparisons of performance under alcohol, drugs, and a variety of other stressors can be made. From a long-range point of view, this type of data is exceptionally valuable.

BAKER: Along these same lines and towards application of your results, it would seem that this relation between blood alcohol and control-reversal rates could be translated into hardware which could be employed by police to detect driving behavior likely to be associated with unacceptable blood alcohol concentrations.

HUNTLEY: After seeing the data of our first study, we entertained a similar notion. However, subsequent experiments revealed that control-use rates were not only susceptible to alcohol, but to other influences as well, some of which negated the alcohol effects. Such interactions indicate that if a control-monitoring procedure is ever employed to detect impaired drivers, it will have to be a very sophisticated procedure indeed.

"GIVEN THAT CLOSED-COURSE STUDIES ARE CONTRIVED TO SOME EXTENT AND THEREFORE ARE THEMSELVES SIMULATIONS OF THE REAL WORLD, WHAT IS THE RATIONALE FOR USING THIS APPROACH TO STUDY DRINKING AND DRIVING RATHER THAN TAKING ADVANTAGE OF THE MORE READILY CONTROLLED LABORATORY SITUATION AND EMPLOYING DRIVING SIMULATORS IN YOUR STUDIES?"

HUNTLEY: The driving task as represented in fixed-based simulators is considerably further removed in realism from actual highway driving than is the closed-course driving experience. By definition, the simulator is an abstraction of the real world and so cannot include all of its features, but hopefully it includes the most important ones. However, since no complete model of automobile driving has been developed, it is difficult to determine what features of the task are critical and should be included in simulations. Perhaps consequently, validation studies have rarely found high correlations between simulator driving and real-world automobile driving. Since closed-course tasks are more similar to real-world driving, there is a greater chance that the elements in the real situation which are susceptible to the influences of alcohol have been included in the task. In fact, both face validity and operational validity of many closed-course tasks can be quite high. People who normally drive well usually do well in closed-course driving, an important relation if the results of closed-course experiments are to be generalized to real-world situations.

WALLER: In support of your approach, it also appears that the instrumented car has the added advantage of being able to consider specific environmental factors which may not be readily studied in the simulator or in basic laboratory research. This is an important advantage since, at least for the immediately foreseeable future, we are going to have a fair number of individuals on the road who are driving with impairing amounts of alcohol. In light of this, if we can determine aspects of the driving environment which tend to precipitate alcohol-related crashes, perhaps we can reduce the number of such crashes by modifying the driving environment.

MORTIMER: It seems that some kind of feeling is developing against simulation and perhaps this is justified when you look at what has usually been done with these devices. However, I think simulators have something to offer if properly used. In the first place, these devices are usually part-task simulators. A complete-task simulator could never be achieved within a reasonable cost. The correct approach to simulator development, and what has recently been done at UCLA with their TV display simulator, is to simulate a certain part of the task, e.g., lateral control in wind gusts, and then compare data obtained on the simulator with that obtained using a real car to see if performance looks the same. Through such comparisons and validation studies, a useful simulation of part of the driving task can be developed probably less expensively than the cost of instrumenting real cars to obtain the same kinds of information. Thus, when developed and used in an intelligent way, simulators have advantages and should not be discounted.

CARPENTER: Have you done any studies with poor drivers so that you know what they are like and the relative influence of alcohol upon their performance?

HUNTLEY: No, we haven't examined poor drivers as an independent group. However, we are conducting a study in which young, non-DWI drivers are compared with older ones who have been convicted of DWI. Although we expect driving skill is associated with age, we cannot examine driving skill as a separate factor because of the constraints imposed by our experimental design.

VOAS: I think the terms good and bad drivers are ambiguous and can include at least three characteristics of drivers. You can speak of skilled and unskilled, accident-involved and nonaccident-involved, and DWI and non-DWI drivers. Accident-involved drivers may or may not be skilled, since exposure and personality factors also have to be considered when determining the cause of accidents.

CARPENTER: To answer part of my own question, the alcohol-associated performance deterioration caused by alcohol might be in about the same proportion for each category of driver, the resulting level of the skilled driver without alcohol. Thus, it would seem that one solution to the alcohol-impaired driver problem is to make sure everyone is a skillful driver.

MOSKOWITZ: Steve (Huntley), I have some reservations about the usefulness of automobile control reversals as a dependent measure. This is primarily based on the difficulty in determining whether an increase or decrease in reversals is a sign of better car control or its converse. I suspect that whether an increase in control reversals indicates decreased control is a function of the specific strategy adopted by an individual driver or group of drivers. So while one might find, say, that alcohol increases reversals, does that necessarily mean for all drivers exhibiting that behavior that car control is decreasing? This is a problem in establishing what are the dependent variables associated with driving which are related to safety.

HUNTLEY: That is a good point, Herb. Individual differences have caused us some difficulty. However, some of the problems are solved by using the subject's non-alcohol performance as a baseline against which to compare performance after alcohol ingestion. Using this procedure, we generally find that alcohol causes increases in control-use rates regardless of the driver's base-level rate. I interpret this increase as indicating the application of additional attention to the driving task, most likely in compensation for the apparent impairing influences of alcohol. I think this is useful information, particularly when compared to the very different effects of other stressors, such as fatigue.

BUIKHUISEN: I just do not understand one point. If you have selected one personality variable to study, it means that you think it important to take into consideration individual differences as measured by personality tests. Why then have you chosen extraversion as the most important personality dimension and not gone beyond that?

HUNTLEY: Do you mean, why have we not expanded our study to cover other areas of personality?

BUIKHUISEN: As a possible relevant factor, yes. According to our studies, there are a number of other personality factors which are able to differentiate drunken drivers. A few easily remembered characteristics include self-control, socialization, and risk propensity. These can be measured using self-administered tests, and they all discriminate between drivers regarding drinking-and-driving habits. With these others available, I really do not understand why you have selected extraversion as the most important.

HUNTLEY: First, let me say that, although I agree that personality is an important area of alcohol research, it is not an area of particular interest to me and so I have not chosen it as an area of primary research emphasis. Secondly, we have not selected extraversion because we thought it was the most important personality dimension. Rather, based on past experience, it was selected as the variable most likely to account for unexplained variance in some of our data. In our first drinking-and-driving experiment, we found a significant interaction between alcohol and subjects with respect to driving accuracy. Since Drew, Colquhoun, and Long found that extraversion, as measured by Eysenck's test, was associated with the accuracy-decreasing effects of alcohol, we thought it might explain some of the variance we obtained, and it did; the greater the extraversion of our subject, the more alcohol was associated with reductions in driving accuracy.

Chapter 6

EPIDEMIOLOGICAL ASPECTS OF ALCOHOL IN DRIVER CRASHES AND CITATIONS[1]

Paul M. Hurst

ABSTRACT

In an amplification of previous work, a number of controlled studies of highway crashes and citations (with parallel roadblock samples) are treated in a consistent manner by a Bayesian technique, and relative probabilities of involvement derived as functions of blood alcohol concentrations (BAC) and of other important predictor variables. Relative "Effectiveness" estimates for hypothetical BAC limits are derived from the assumption of "perfect enforcement," i.e., universal acquiescence to a given BAC limit. Estimated "Effectiveness" is compared on the basis of differences in driver population characteristics and in the chosen criterion. These results are supplemented by comparisons with uncontrolled studies of alcohol in fatal crashes. The role of self-reported drinking habits is considered as a moderator of hazard-BAC relationships and of enforcement implications. Some tentative implications for control practices are drawn, with recommendations for research.

1. PERSPECTIVE

Laboratory studies, including those discussed here, have contributed a great deal of information about the effects of alcohol on the skills involved in driving. I have no desire to belabor the question of whether a particular task (e.g., simulator tracking) actually taps the skills involved in highway driving. Personally, I think many, perhaps most, of them do. However, I believe there is a more cogent reason to question whether laboratory results on the skills involved in driving are likely to bear any simple relationship to driving safety under given road and traffic conditions. One qualifying argument that has been raised repeatedly by proponents of stricter BAC limits is that "hazards present in normal driving, such as emergencies, require degrees of concentration, judgment and coordination, not demanded of the driver in our test situation... The influence of alcohol on the driver in normal driving situations may be greater than observed in these tests." (U.S. Dept. of Transportation, 1968; after Coldwell, 1957). Frequently, there is reference to the classical experiment of Cohen et al. (1958) in which expert bus drivers who had consumed moderate amounts of whisky showed a greater willingness to drive through gaps too small for the bus. Such effects on judgment might well be more pronounced under natural road conditions where the driver is not aware of being under the watchful eye of a research scientist. I

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would like to add, however, that there is another side to the same coin. In designing a laboratory study to test alcohol impairment, one is usually impelled to select a demanding task, such that any alcohol-produced deficiencies will be sensitively measured; in other words, one which is rather difficult for most volunteers to perform perfectly even when not impaired. This may be entirely appropriate. Nevertheless, the driving task is not ordinarily that demanding. Furthermore, it is possible for the driver (under some circumstances) to make his task a great deal less demanding. A rational person may drive slower after drinking, allow himself greater following headways, greater passing margins, etc. simply because he knows that his abilities and judgment may be impaired. In terms of net hazard, such a strategy could compensate for the reduced efficiency under emergency (demanding) conditions simply by making such high skill demands less likely to occur. There is no definitive evidence in this regard, but self-reports of driving habits have indicated that 63% of chronic alcoholics tend to drive more recklessly after drinking, whereas a substantial proportion of nonalcoholics (40%) drive more cautiously, with only 17% of the latter group reporting that they drive more recklessly (Selzer, 1961; Payne & Selzer, 1962; after Waller, 1964). Thirty percent of the nonalcoholic group said they had never driven while intoxicated.

The net thrust of this argument is that one cannot determine, from experimental findings, the BAC threshold at which most drivers will begin to drive less safely. We can determine the BAC at which 1% or 99% of our subjects show impairment of driving skills, but we can't really determine how many of them will actually drive less safely at such a level. We therefore turn to epidemiological findings, which will furnish more relevant estimates in terms of net hazard percentages. However, the latter cannot answer the questions of just how many drivers are impaired and by how much at any given BAC. All we really observe, even from the best of such studies, is the BAC at which significant differences in relative crash incidence occur. This rise in the curve does not tell us whether it resulted from a lot of slightly impaired persons or a few greatly impaired persons at the given BAC. To obtain a meaningful frequency distribution requires controlled, laboratory-type experiments on real highway driving (with randomly-assigned doses, etc.) of sufficient numerosity or duration to yield significant counts of real highway crashes. Such an experiment is unlikely to be attempted. Hence, we have on the one hand laboratory data which may be partially irrelevant, and on the other hand field data which do not reveal individual difference distributions except in the gross sense of differentiating demographical subgroups. As a last resort, we can "combine" the field and laboratory results and draw some tentative inferences. Since the laboratory studies usually show continuous or quasi-normal distributions of individual impairment levels, we may infer from field data that a substantial rise in crash incidence at a given BAC is the result of a fairly large number of individual impairments rather than just a few gross impairments with everyone else being unaffected. However, this introduces some tenuous propositions, and seems inadequate to answer the question of just what percent of a population drives less safely at a given BAC. It is even further from determining the BAC at which a particular individual may rationally be presumed to drive less safely, or presumed not to drive less safely. I would question the basis of laws that set levels for "presumed to be impaired" or "presumed not impaired." This does not imply that we should do away with chemical-test laws, but suggests a different approach from that based on presumed impairment thresholds. As an alternative, I would suggest an approach based explicitly on aggregate data, which lends itself to a sort of cost/benefit analysis. Here, the benefits (of changing the driver BAC distribution) may be estimated relatively precisely. The "costs" problem is far more elusive, and probably requires more data before even an educated guess can be made.

2. DATA BASE

Most of the data will be drawn from "controlled" studies of alcohol in highway crashes, with some supplementation by simple-incidence findings. By "controlled," I refer to the type of study where BAC is measured not only in highway crash victim victims, but also in uninvolved drivers randomly chosen in the vicinity of each crash site. Ideally, the latter should also represent those who were going in the same direction at exactly the same time the crash occurred. From the crash/control ratio within any interval of BAC, it is possible to calculate the relative hazard at that BAC; relative, that is, to the hazard encountered at zero BAC or at other selected levels. To permit such calculations, it is simplest to consider all crashed drivers without introducing assumptions as to blameworthiness. If total relative hazard is to be calculated, it is also appropriate to consider only those data sources in which all crashes are considered, regardless of type (i.e., single vs. multi-vehicular).

The available studies meeting these criteria are scant. All the strict sampling requirements imposed above have, of course, never been met in practice, but they have been approached (to varying degrees) in seven investigations:

1. Evanston Study (Holcomb, 1938)
2. Toronto Study (Lucas, Kalow, McColl, Griffith & Smith, 1955)
3. Manhattan Study (McCarrol & Haddon, 1962)
4. Bratislava Study (Vamosi, 1963)
5. Grand Rapids Study (Borkenstein, Crowther, Shumate, Ziel, & Zylman, 1964)
6. Vermont Study (Perrine, Waller, & Harris, 1971)
7. French Study (Biecheler, Rambach, Filou, Goffette, & Monseur, 1970)
   (Biecheler, Lefort, Rambach, Filou, Goffette & Monseur, 1971)

We have excluded the Bratislava Study here primarily because the "accident" sample included violations (without crashes). The Evanston Study suffers from a time-of-day bias, but the ancillary data from Holcomb's report permit calculation of a correction factor, and the corrected data will therefore be presented (the basis of correction is explained in Hurst, 1970). The French Study also introduced this problem, but in addition, their use of only one "closed" BAC interval (0.08 - 0.11%) makes it impossible to calculate relative hazard except in a very restricted sense. These results will be presented separately. It should be emphasized that these studies differed in other details, the most important of which was the type of crash victim being studied, with the Evanston data consisting of crash injury victims, the Manhattan and Vermont data being restricted to fatalities, and both Toronto and Grand Rapids being concerned with all reported or observed crashes. The Grand Rapids data were so voluminous that it was also possible to make separate calculations for the "serious or fatal" subgroup.

3. RELATIVE HAZARD

Calculated relative hazard from the six sources are charted in Figure 1, modified from Hurst (1970) to include the recent Vermont data. Details of the Bayesian calculation procedure are given in the above reference. Note that the end of the Manhattan trace had to be extrapolated, since the last class interval for which a calculation was possible was the 0.10% - 0.25% BAC range. A large number of their fatal crash victims (46% of the sample) were at "over 0.25%," but none of the control group were; hence, the relative hazard calculated from the case/control ratio would be infinite within this range, if were it possible to graph it.

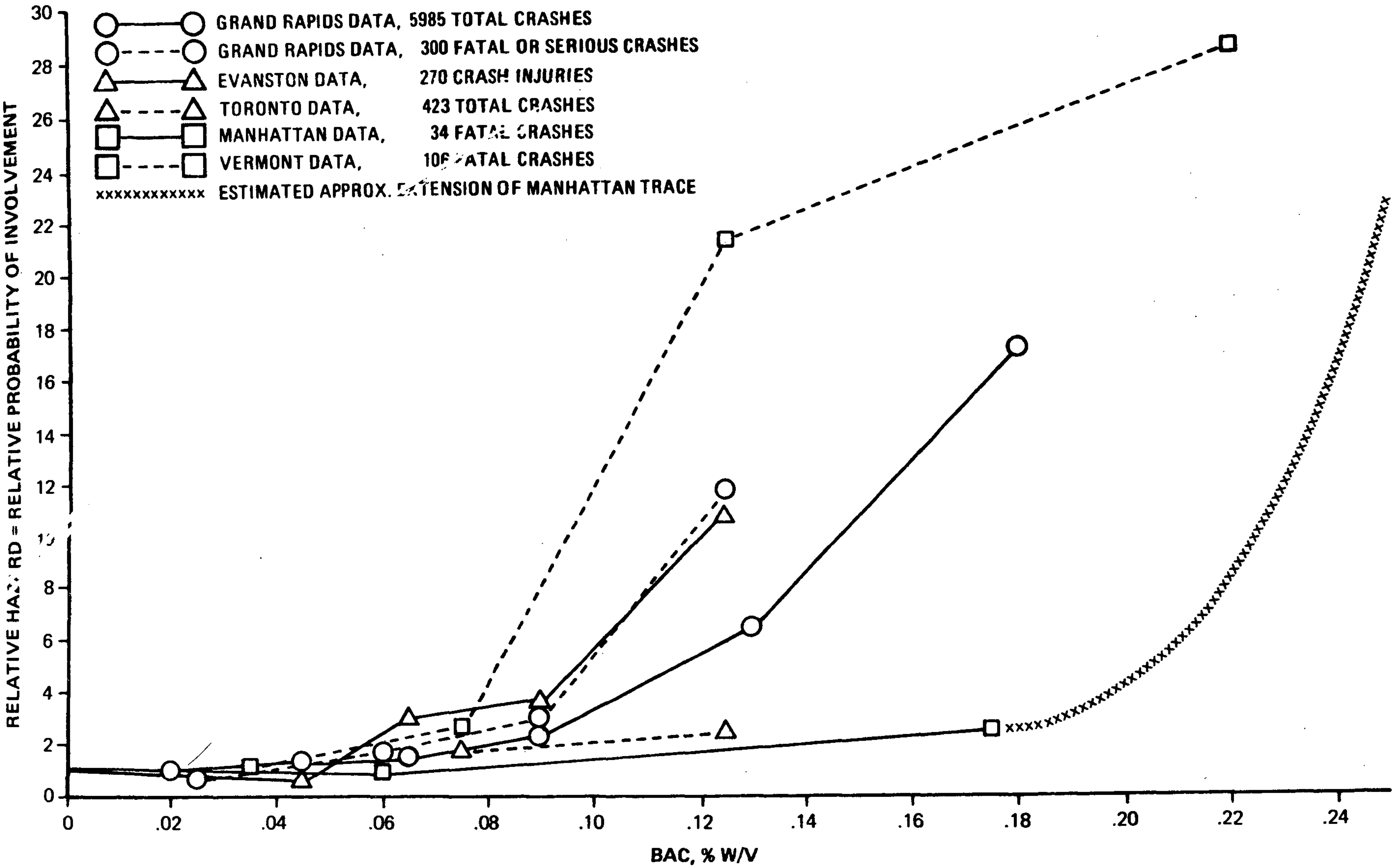

Figure 1. RELATIVE PROBABILITY OF CRASH INVOLVEMENT AS A FUNCTION OF BAC,

WHERE 1.0 = RELATIVE PROBABILITY AT ZERO ALCOHOL.

Several tentative inferences or hypotheses can be derived from these data. One is that relative hazard tends to be steeper for the more urbanized populations. This suggests a possible tolerance mechanism, conferred by heavier drinking habits. Some support for this is found in the comparative incidences of BACs above 0.10% in the control populations, which are: Manhattan 4.4%, Toronto 3.3%, Vermont 2.1%, Grand Rapids 1.9%, and Evanston 0.8%. Note that this ordering is consistent with the effects of small to intermediate amounts of alcohol. Another implication is present in the shape of the curves, particularly the right-hand segments. Although all the curves show crash incidence as an accelerated function of BAC, the incidence of more serious crashes has a greater acceleration than that of run-of-the-mine crashes. This greater acceleration seems to begin somewhere after the 0.09% point. Due to the confounding introduced by the first variable (site of sample), this is not easy to tease out. However, it seems to be there in the one comparison where the sampled population is held constant, namely, the Grand Rapids "fatal or serious" subset as opposed to the "total crashes" curve from the same study. Unfortunately, there were not enough fatal or serious crashes to permit comparisons with the extreme upper end of the "all crashes" curve.

Findings from the French study are not amenable to any detailed breakdown since the crash sample data (fatalities) are subdivided only into three BAC intervals: < 0.08%, 0.08 - 0.11%, and > 0.11%. The lowest of these includes a region of possibly increased hazard (relative to zero BAC), so one can only compute comparative figures relative to this elevated baseline. Likewise, the highest category (> 0.11%) yields little information for the relative hazard approach since it includes unknown numbers of samples in the wide region of values above 0.11% encountered on the highway. One can therefore only compute relative hazards in the rough composite sense, which cannot be meaningfully graphed. The original authors computed risk in two open-ended categories, > 0.08% and > 0.11% relative to the composite of drivers below this value. They reported a "risk factor" of about 3.2 for all drivers over 0.08% relative to all drivers under 0.08%, and a factor of about 5.4 for all drivers over 0.11% relative to all drivers under 0.11%. They did not determine the relative risk in the closed category (0.08 - 0.11%) relative to either of the open-ended extremes, but comparison of their summary figures from the Roadside Survey (Biecheler et al., 1970, p. 44) with their accident sample (Biecheler et al., 1971, p. 10) shows that relative risk is slightly increased (about 1.2) at 0.08% - 0.11% relative to < 0.08%.

However, these data contain visible bias. The control samples were obtained before the crash samples, so no matching was done for time of day, day of week, crash site, etc. I have re-calculated their data correcting for the most obvious bias by deleting all crash samples between 23:00 and 06:30 hours, since no control data were tabulated for this interval (table on p. 44, Biecheler et al., 1971). I have also adjusted these control data by weighting the time-interval percentages at various BACs according to the relative frequencies of crash samples obtained in these respective time intervals, so that the effect is that of having control sample sizes proportionate to crash sample sizes in particular time intervals. I then re-calculated hazard for 0.08% - 0.11% relative to < 0.08%. (As explained above, the > 0.11% category is useless for the present purpose.) The result, surprisingly, is a relative probability of 0.69, i.e., those at 0.08% - 0.11% BAC had only 0.69 times as many fatal crashes as those at < 0.08% when exposure was adjusted for time of day. Whether or not this represents another "Grand Rapids Dip," occurring in a much higher BAC region, is hard to say. The time-of-day adjustment corrected for what seemed the most serious mismatch, but there are many other sampling differences, and it appears impossible to match on all at once. The "Grand Rapids Dip" will be further discussed below.

In the more recent studies (Manhattan, Grand Rapids, and Vermont), the crash data are subdivided so that BAC-interval tallies are available not only for "all crashes," but also for the separate subsample in which the crashed driver is presumed to be "at fault." This includes all single-vehicle crashes and also those multi-vehicular collisions in which blame could quite plausibly be assigned to one of the drivers, without necessarily exculpating the other driver(s) involved. It is possible to base relative hazard calculation on these subsets instead of the entire sets of crashed drivers.

In my original calculations of relative hazard as shown in Figure 1, I used "total crash" data for the following reasons. First, I wanted to make a rough comparison among various data sources, not all of which included a "driver-at-fault" subsample. Second, I wanted to estimate "effectiveness" of BAC-limit enforcement in terms of total savings. Now, it is a common finding that even among drivers not identifiable as "at fault," alcohol levels tend to be higher than in uninvolved control samples. Thus, there appears to be a "contributory negligence" component that reveals iteself in mass statistics even though it may not be clearly identifiable in a given specific incident. I wanted the "total effectiveness" calculation to include this component. Since estimated total effectiveness is based, in part, on relative hazard, I was obliged to use the appropriate relative hazard term for this calculation: namely, total or overall relative hazard, as estimated from crash/control ratios without regard to culpability.

It may nevertheless be instructive to compare relative hazard functions derived from subsamples of crashed drivers presumed to be at fault and those not so presumed. (No corresponding "effectiveness" functions will be derived since even though stronger in terms of slope, the "at-fault" function would understate the potential saving from BAC-enforcement because it ignored the "contributory negligence" component due to alcohol.) The presumed at-fault subsamples from Manhattan, Grand Rapids, and Vermont are charted in Figure 2. The not-at-fault subsamples are too small for meaningful analyses except for the Grand Rapids data, which are included in Figure 2. Even the at-fault and total samples from Manhattan are quite small for this sort of analysis, and the BAC-interval hazard estimates must be considered as rough approximations to the probable parametric values.

Note that all three data sources for "at-fault" drivers show steep, accelerated relative hazard functions as was to be expected, with the Manhattan fatalities function showing a greater similarity to the Vermont function than when "all fatal crashes" were compared. Note, also the rather interesting flatness of the Grand Rapids not-at-fault function, which was derived by subtracting the tallies in their "estimated accident causing driver group" (Table 43) from the total crash data (Table 17). Intuitively, one might have expected the unidentified "contributory negligence" factor to be a positive and accelerated function of BAC, albeit a weaker one than that based on "accident causing" drivers. Yet within the probable limits of sampling error, the not-at-fault involvement function is flat, showing a value of around 1.6 - 1.7 throughout most of its range. Thus, the chance of being involved in a crash, but not being identifiable as the culpable party seems to increase by about 60% from drinking, regardless of amount consumed. This does not seem to make sense. One possibility may be mentioned, strictly as a conjecture. Recall that the not-at-fault function was derived by subtraction of "accident-causing" from "total crash" data. It is conceivable that a bias may have somehow been unwittingly introduced by a tendency to consider more of the high-BAC crashed drivers as "accident causing," and hence leaving fewer in the "not presumed at fault" group. This seems unlikely in view of the rather objective rules used in assigning culpability, but the "not-at-fault" hazard curve is so puzzling that one is impelled to speculation.

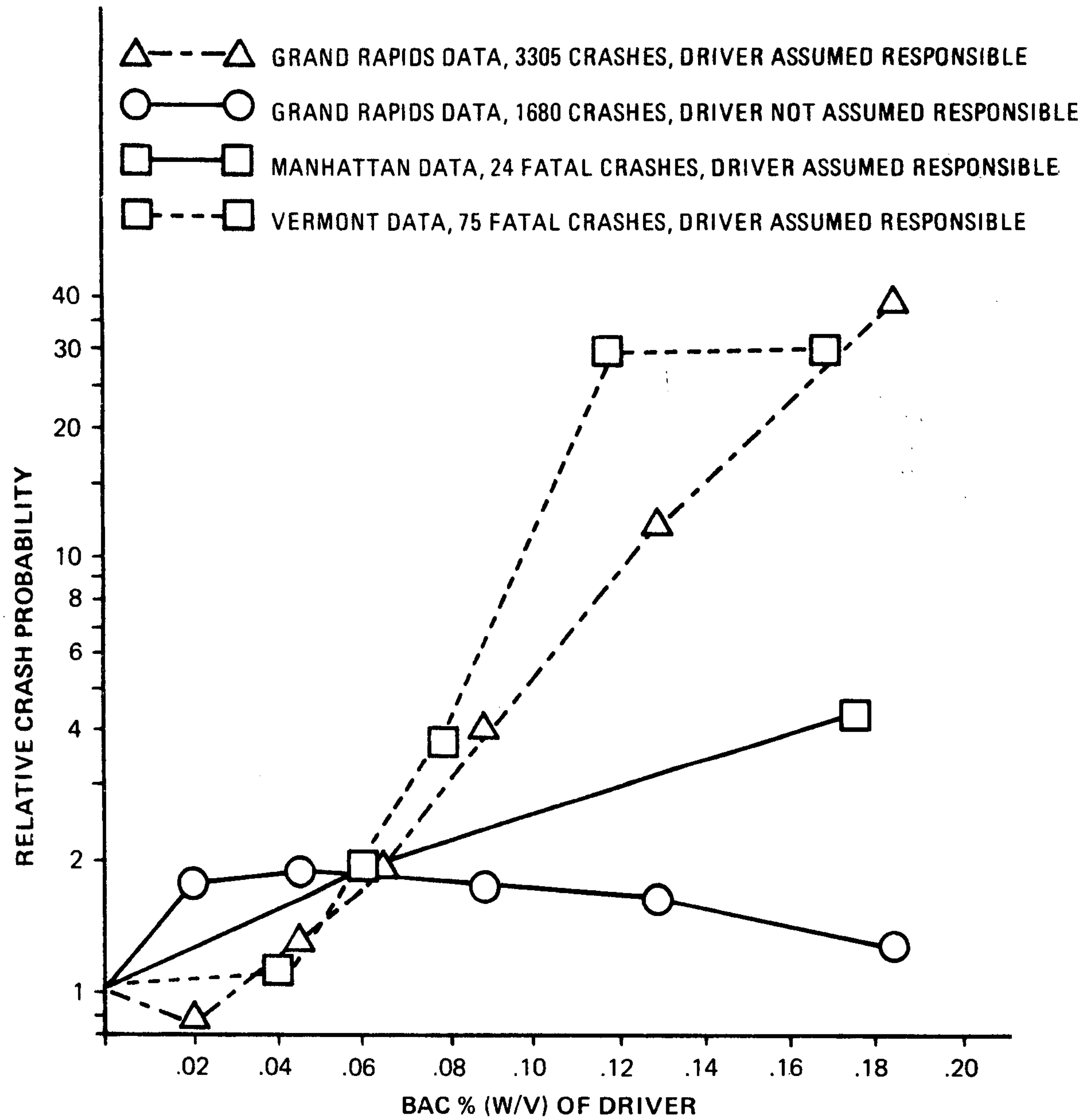

Figure 2. RELATIVE CRASH PROBABILITY FOR DRIVERS ASSUMED RESPONSIBLE AND THOSE NOT ASSUMED RESPONSIBLE AS A FUNCTION OF BAC, WHERE 1.0 = RELATIVE PROBABILITY AT ZERO ALCOHOL.

The voluminous Grand Rapids data lend themselves to many other interesting analyses. One concerns the celebrated "Grand Rapids Dip," referring to the slight departure below the zero-alcohol baseline that is observed with the aggregate data in the 0.01% - 0.04% BAC range. This has aroused a controversy out of all proportion to its realistic significance, or, alternatively, its statistical non-significance, as was pointed out by the original authors. Although numerous explanations have been rendered, based on possible sampling biases or differntial absorption-elimination lags between crash occurrence and BAC testing, the simples appears to be that of Allsop (1966), who inveighed against the fallacy of comparing "two ill-matched groups of individuals" in this context. Allsop was referring to the different kinds of driver that one is likely to find on the road at different BACs. In Table 41 of Borkenstein et al. (1964), one finds tabulations of cases and controls at various BAC ranges that are broken down by self-reported drinking habits, which is the strongest of the potentially discriminating variables referred to by Allsop. When these data are converted to relative hazard functions for the separate drinking-habit subgroups, the Grand Rapids Dip vanishes!. (The monotonic increase within each subgroup was mentioned by the original authors, but its implications seem to have been unnoticed by most discussants of the Grand Rapids study.)

At first glance, these data appear unreal; and I was impelled to recheck my calculations, having not yet seen Allsop's mathematical demonstration. How can a composite, which is essentially an average, have a trend that <u>reverses the trend</u> shown by every one of its components?

Closer examination resolves the paradox. First, note that drinking frequency (DF) has a strong inverse relationship to relative hazard within any given BAC interval. Now, recall that the higher DF groups were more heavily represented in the positive BAC samples (Borkenstein et al., 1964); as might be expected, those who drink more often are more likely to drive after drinking. Hence, the "Grand Rapids Dip": the low but positive BAC sample may have had a better record because it was loaded with these "frequent drinkers," i.e., with individuals who, for whatever reason, tended to be safer drivers. Apparently, they were safer drivers despite, not because of, their more frequent combining of driving with drinking. They did better yet when cold sober. Expressed in statistical terms, the unweighted mean hazard of combined DF subgroups is lowest at zero alcohol, but the weighted mean is not. A mathematical proof of this possibility was presented by Allsop (1966).

I have extended these curves beyond the "dip" region referred to by Allsop, and a remarkably orderly pattern emerges, as shown in Figure 3. This is to be compared with the aggregate Grand Rapids data (Figure 4), which are converted to the logarithmic scale used in Figure 3 to facilitate comparison. Note the near-perfect ordering of hazard curves in Figure 3 as a function of self-reported drinking frequency, and also the well-ordered progressive divergence of these curves as BAC increases over the ranges for which adequate samples were available for the various separate groups. Although such self-reports can never be accepted at face falue, the orderliness of the data is compelling. Three major lessons are implied. The first is that the average self-reported daily drinker is, for whatever reason, almost as safe as a driver at a BAC of 0.09% as the average abstainer or near-abstainer is when he is cold sober. The second is that the daily drinker is not, at any positive BAC, as safe a driver as he is when <u>he</u> has not been drinking. Thirdly, the infrequent drinker is very seriously impaired at a level (0.06%) quite close to that at which many state laws presume that nobody is impaired.

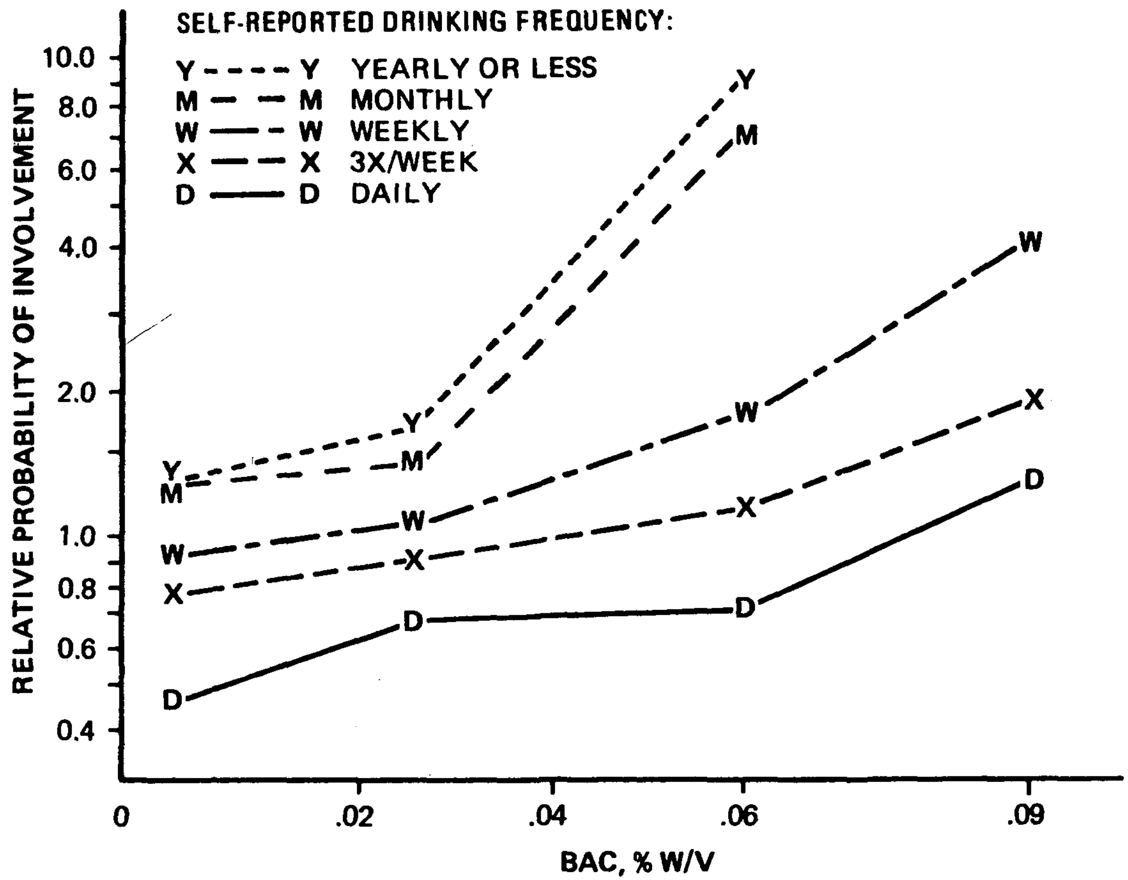

Figure 3. RELATIVE PROBABILITY OF CRASH INVOLVEMENT (BY DRINKING FREQUENCY SUBGROUPS) AS A FUNCTION OF BAC, WHERE 1.0 = RELATIVE PROBABILITY OF COMPOSITE GROUP AT ZERO ALCOHOL.

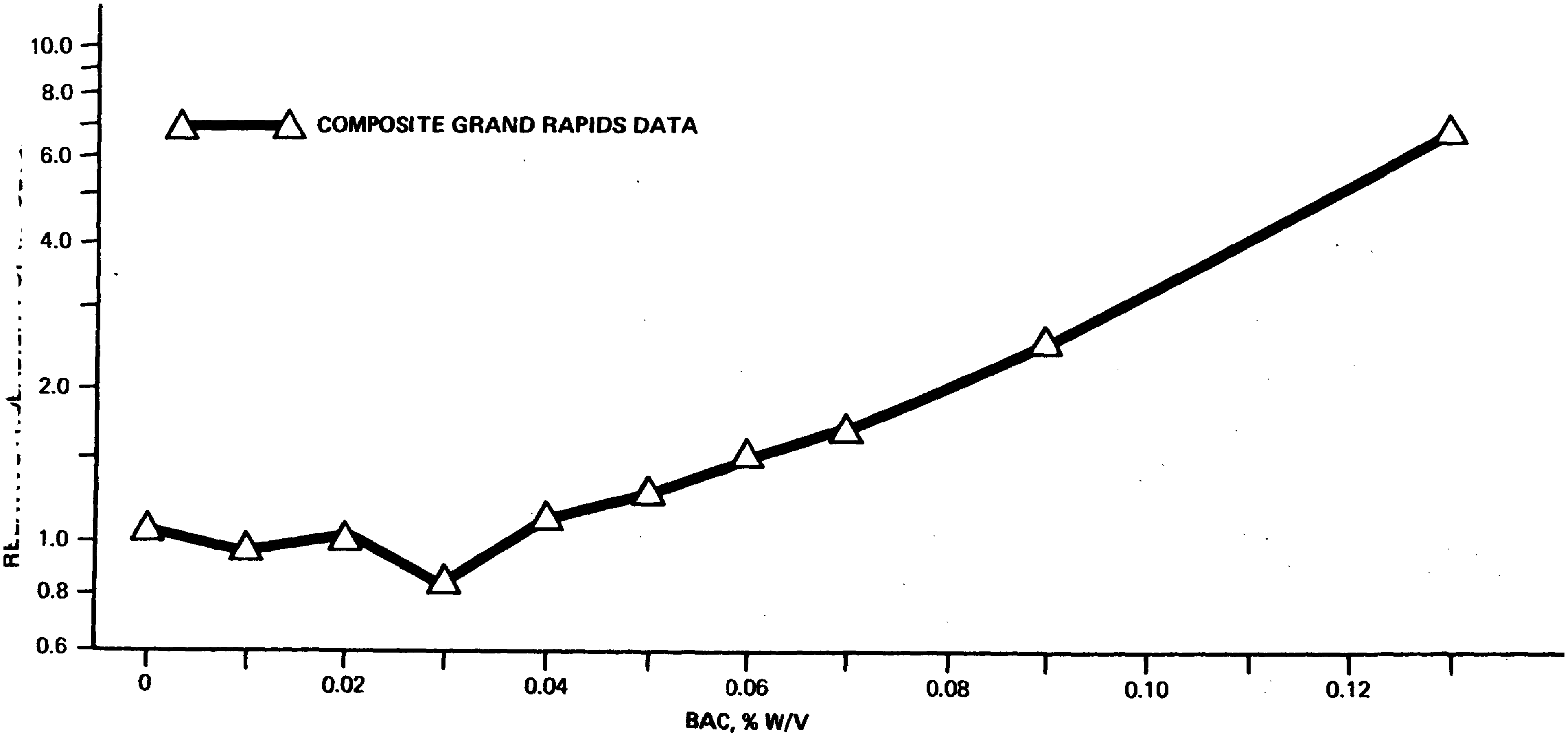

Figure 4. RELATIVE PROBABILITY OF CRASH INVOLVEMENT AS A FUNCTION OF BAC, WHERE 1.0 = RELATIVE PROBABILITY AT ZERO ALCOHOL

Finally, this comparison suggests that the average relative hazard at higher BACs derived from composite data is a serious underestimate when applied to the average driver. It applies only to the average of those who drive at such BACs. Hence, it is invalid in the customary dose/response sense.

The Vermont data also include a somewhat similar breakdown based on self-reported frequencies and quantities of "preferred beverage" (not total alcohol). Being limited to 56 crashed-driver cases where such data were available (28 fatalities and 28 hospitalized cases), they cannot be subdivided without seriously shrinking subsample sizes. Nevertheless, the scantiness of these kinds of controlled data is such as to merit some comparison. Relative hazard was therefore compared for self-reported daily, weekly, and monthly drinkers. These categories roughly correspond to those used in Grand Rapids, since they refer strictly to frequency of drinking occasions without regard to amount consumed. The total number of cases was too small to cross-categorize by actual BAC, as was done for Grand Rapids. Therefore, the computed relative hazards are based on BACs for the three groups as they happened to be distributed in the samples. Thus, the differences in relative hazard reflect not only "vulnerability," but also the probable differences in actual BACs, the more frequent drinkers tending more often to be found with positive blood alcohol. These same 56 cases were then also compared according to reported average amount consumed per drinking occasion, without regard to frequency of occasions, again without cross-categorizing on the basis of alcohol concentration present when tested.

Results from these comparisons cannot be expressed relative to the composite baseline since there is insufficient overlap in the sample compositions. They can only be compared relative to one another. Setting relative hazard for the monthly drinkers at 1.0, one computes values of 0.75 for the daily drinkers and 0.43 for the weekly drinkers. These differences are only trends, since the frequencies on which they are based yield a chi-square of 3.81 (d.f. = 2, $< 0.10 < p < 0.20$). Comparable composite data from Grand Rapids (Borkenstein et al., 1964, Table 41) shows considerably greater relative hazard for the weekly than the daily group, when "relative hazard" is computed from overall case/control ratios with test BAC ignored. However, the difference is less when we combine the Daily and 3 x/week Grand Rapids samples to approximate the Vermont "Daily" group. Composite Grand Rapids data, without adjustment for differences in actual BAC, yield the following indices of relative hazard (overall differences significant, Borkenstein et al., 1964, p. 161):

Yearly or less (set at 1.00)
Monthly (once a month or less) 1.06
Weekly (more than once a month, but no more than once a week) 0.88
Three times per week 0.72
Daily (more than 3 times a week) 0.51

When the Vermont data are analyzed according to average amount consumed per occasion (without regard to use frequency), the composite data yield the expected monotonically-increasing relationship with relative hazard. Relative to "light" drinkers (set at 1.00), the "medium amount" drinkers have a relative hazard of 1.45 and the "heavy amount" drinkers a relative hazard of 2.48 (chi-square = 6.73, d.f. = 2, $0.02 < p < 0.05$). It should be emphasized that these ratios do not reflect relative vulnerability to alcohol and (since BAC was not held constant) are probably in large part a reflection of the greater probability of heavier drinkers to have higher BACs when driving. Not only do the heavier drinkers drink more, but they also report themselves as more often driving after they do drink (Perrine et al., 1971, Table 4-11).

4. TRAFFIC CITATIONS

Data from the Vermont study are also available for frequency of traffic citations by BAC, and by frequency and amount of drinking per occasion. Citation frequencies can be compared with incidences in roadblock controls for any self-reported drinking habit category. These data are tabulated by BAC and by numerous demographic variables.

I have derived "relative hazard" indices for the variables of greatest interest for comparison with the foregoing data from Vermont and other sources. Table 1 shows the relative probability of DWI citations in comparison with "all fatalities," with BAC as the common independent variable. Table 2 shows the relative probabilities of DWI citations, non-DWI citations, and of all citations as functions of self-reported drinking habits.

With respect to DWI citations, the strongest contrast is observed with respect to the weighted quantity-frequency index (QFI) employed by Perrine et al. (1971) when analyzing the Vermont data. Consider the two extremes from the four categories (light, light-medium, medium, heavy). The probability of DWI, in terms of ratios to roadblock controls, is 95 times as high for "heavy" as for "light" drinkers. This contrasts sharply with the corresponding ratio for "serious plus fatal crashes," which was only 2.5 as great for "heavy" as for "light" drinkers.

However, one should expect a stronger contrast with DWI than with crash incidences, since the former always involved alcohol and the latter did not. It would be more interesting to compare the "heavy" and "light" drinkers on alcohol-involved crashes. Unfortunately, the data are scant. In Table 6-12, Perrine et al. (1971) present a tabulation of 23 fatal crashes by QFI levels, cross-indexed by BAC (less than 0.02% vs. over 0.10%). In terms of alcohol-involved fatal crashes (over 0.10% BAC, N = 15), the "heavy" QFI drivers have about 9.4 times the case/control ratio of the "light" QFI group. Despite the small sample sizes, the 9.4/1 ratio is still so much lower than the 95/1 ratio for DWI that one is tempted to speculate about what caused the discrepancy.

Looking at their data from a different standpoint, Perrine et al. (1971) have remarked on some of the DWI group's dissimilarities from the serious crash group. From the above comparisons, one might infer that some behavioral tolerance mechanism is offering partial protection from crash involvement in the more practiced drinkers or drinking drivers, but that it is relatively ineffective in protecting them from DWI arrest. The police, in other words, are responding to alcohol rather than to serious-crash hazard. This seems plausible in one sense, considering that a breath sample is usually involved. True, it is usually taken post-arrest; yet perhaps charges may be dropped when it is negative, or the charge changed to reckless driving, etc., etc. Thus, the use of breath tests might be expected to focus arrests on alcoholic content rather than alcoholic impairment.

Nevertheless, one must still consider whether behavioral impairment is not indeed of consequence in DWI arrests. Why did the officer detain the driver in the first place? And how many breath tests of suspects fall below the legal limit? In numerous published studies, these are very few, because the suspect's detention/arrest is generally occasioned by rather grossly deviant driving behavior. And is this not, then, the sort of driving behavior that also occasions serious or fatal crashes?

One of my colleagues, R. S. Hostetter (personal communication) has an intriguing suggestion in this respect. Suppose that the more frequent and heavier drinkers do indeed "compensate" when driving and that the compensatory behavior

TABLE 6-1

Relative Probability of Fatal Crash vs. DWI Citation as
Common Functions of BAC in the Vermont Study
(106 fatal crashes and 41 DWI citations; data from Perrine et al., 1971)

BAC	Relative probability	
	Fatal crash	DWI citation
.10-.149%	Set at 1.0	Set at 1.0
.15-.199%	1.34	1.14
.20-.249%	3.72	5.11
≥ .25%	∞	∞

Note. - Data from upper BAC range only due to no citations being observed at < 0.10%. Calculated relative probabilities from zero-BAC baseline would all be ∞. Therefore, relative probabilities at 0.10 - 0.145% are used as the 1.0 baselines. Actually, the "1.0" baseline for fatal crashes at 0.10 - 0.149% would be 21.3 if derived by using the 0 - .02% BAC data as <u>its</u> baseline, as seen in Figure 1.

TABLE 6-2

Relative Probabilities of Citations According to Self-Reported Drinking Habits in Vermont (48 DWI citations and 34 non-DWI citations; data from Perrine et al., 1971)

Reporting group	Citation		
	Non-DWI	DWI	All citations
Composite	Set at 1.0	Set at 1.0	Set at 1.0
Frequency[a]			
Monthly (or less)	0.98	0.28	0.57
Weekly (more than once a month, but no more than once a week)	1.16	1.37	1.29
Daily (more than once a week)	0.88	1.26	1.10
Quantity[b]			
Light (1-2 drinks)	0.50	0.13	0.29
Medium (3-4 drinks)	1.60	1.31	1.43
Heavy (≥ 5 drinks)	2.47	5.06	3.99

[a] Arranged by frequency without regard to quantity per occasion.

[b] Arranged by quantity per occasion without regard to frequency.

is one that reduces crash-injury hazard to a greater extent than it reduces the chance of DWI citation. For example, a "compensating" driver at high BAC might drive slowly, but erratically. This seems not too implausible. As we have seen in our earlier discussion of alcohol and risk taking, we aren't really very sure about this relationship, especially under field conditions. It is entirely possible that an experienced drinker, or a fortiori an experienced drinking driver, may be sufficiently aware of his impairment to take this simple defensive action (cf Selzer, 1961; Payne & Selzer, 1962; after Waller, 1964). He drives slower, and may therefore be less likely to be killed or seriously injured under light traffic conditions. (These are likely to prevail in a rural setting, i.e., Vermont, during the high-BAC time of night.) However, his ability is still impaired, so that he cannot simultaneously maintain stability of lateral placement and speed; he may also make mistakes, as by missing traffic signals or (often) actually having a non-fatal crash (Perrine et al., 1971, Tables 5-6). Thus, he is still quite likely to be noticed by the police. He has materially reduced his chance of serious or fatal injury, but perhaps has not materially reduced his chance of being arrested. Such behavior patterns, if found in fact to be highly prevalent, could be helpful in explaining the different characteristics of the DWI and the "serious + fatal" groups of drinking drivers, and may have some interesting implications for countermeasure strategies.

One further inference can be made from these self-report results: They strengthen the reader's opinion that the interviewees were telling relatively accurate stories about their drinking habits, or at least that the bias was not such as to render these data meaningless. Otherwise, it appears unlikely that such strong contrasts would be observed on the DWI incidences. In the face of such overwhelmingly strong relationships, alternatives to the "face value" interpretation might seem as far fetched as those attributing a non-causal relationship between cigarette smoking and lung cancer.

Since the non-DWI citations are rather few in number, the smaller differences in relative frequency should probably be ignored. However, the case/control contrast between "heavy" and "light" drinkers is nearly a factor of five, and therefore suggests a real relationship. This could be due to heavy drinkers being basically less law-abiding types with or without alcohol. However, when one considers the factors yielded by the DWI contrasts, it seems more likely that the non-DWI contrast reflects the role of alcohol in predisposing toward traffic offenses, even when BAC is not high enough for a DWI arrest to be made. According to self-reports, the heavier drinkers not only drink more, but also drive far more often after they do drink (Perrine et al., 1971, Table 4-11).

5. ESTIMATION OF EFFECTIVENESS OF BAC-LIMIT ENFORCEMENT

The values of relative hazard estimated from the foregoing data sources were used to estimate the effectiveness of various hypothetical legal limits for blood alcohol, according to the procedure described by Hurst (1970). This involves two fundamental assumptions:

1. An hypothesized BAC limit will be enforced so effectively as to create a total deterrent to drinking more than the limit before driving, but will have no other effects on driver behavior. (This is essentially a "speed limit" concept, in which drivers who would ordinarily exceed the limit will drive at the limit, but those who would ordinarily drive at some level below the limit will continue to drive at this same level.)

2. The relative crash probability at varying BACs reflects only the causal influence of the alcohol involved.

Of course, neither of these assumptions is expected to hold strictly in actual practice. The first assumption is something that might be approached by stringent enforcement and intensive education. The second assumption probably introduces some systematic distortion on the side of conservatism. My procedure (Hurst, 1970) essentially converts the incidence encountered at, e.g., 0.20% BAC into the expected crash incidence at, e.g., 0.10% BAC, by multiplying the incidence at the higher level by the ratio of the two relative hazards. It then expresses the difference between the obtained incidence and the new expected incidence as a "savings" or effectiveness score. This assumes that those who now drive at 0.20% BAC would, if driving at 0.10% BAC, have the same relative crash incidence as is observed among those now driving at 0.10% BAC. The foregoing analysis by drinking-habit subgroups suggests that the "savings" would be greater than this, so that the estimated "effectiveness" value at any point appears likely to be a conservative one.

Estimated effectiveness functions are charted in Figure 5. These values reflect, in part, the relative hazard functions shown earlier. However, they are also strongly influenced by the observed absolute crash incidences at various BACs. In other words, the expected savings ("Estimated Effectiveness") at a given BAC limit depends not only upon the relative hazard encountered at that level, as opposed to higher levels, but also upon how many drivers would be affected. (In Manhattan, the high incidence of crash victims above 0.25%, where the relative hazard is extreme, together with the low relative hazard at intermediate BACs combine to produce a nearly flat effectiveness function.)

Due to limitations in matching crashed and control samples, the French data were not included in the effectiveness calculations. It is easy to see, however, that an hypothetical enforced limit of 0.11% would be calculated to save more lives than one of 0.08%. This follows directly from the calculation, based on adjusted time-of-day exposure matching, that the 0.08% - 0.11% sample actually encountered lower relative hazard than the < 0.08% sample. Due to the inferential problems of interpreting the "French Dip," I shall not pursue this further, other than to say that their data, as available, do not support a conclusion that a 0.08% limit will save more lives than a 0.11% limit.

6. IMPLICATIONS AND RECOMMENDATIONS

From the "Estimated Effectiveness" functions, one can draw some tentative conclusions. If one wishes to reduce total crash incidence to an important degree, one must evidently choose a rather stringent BAC limit. Although the estimates are probably conservative, as explained above, there seems little to be gained by enforcing a liberal limit. An enforced (complied with) limit of 0.15% would be only 1/5 to 1/3 as effective as a 0.05% limit in reducing total crashes (Grand Rapids and Toronto data); a 0.10% limit would be about 1/2 to 2/3 as effective as a 0.05% limit. A limit of 0.08% would be nearly twice as effective as a 0.10% limit in reducing total alcohol-involved crashes, according to the Grand Rapids data, amounting to a total crash reduction (from all causes) of 6% as opposed to slightly over 3%. The Toronto data suggest much less relative difference in alcohol-involved crashes, but a similar total crash reduction: 12% for the 0.08% limit, as opposed to 10% for the 0.10% limit.

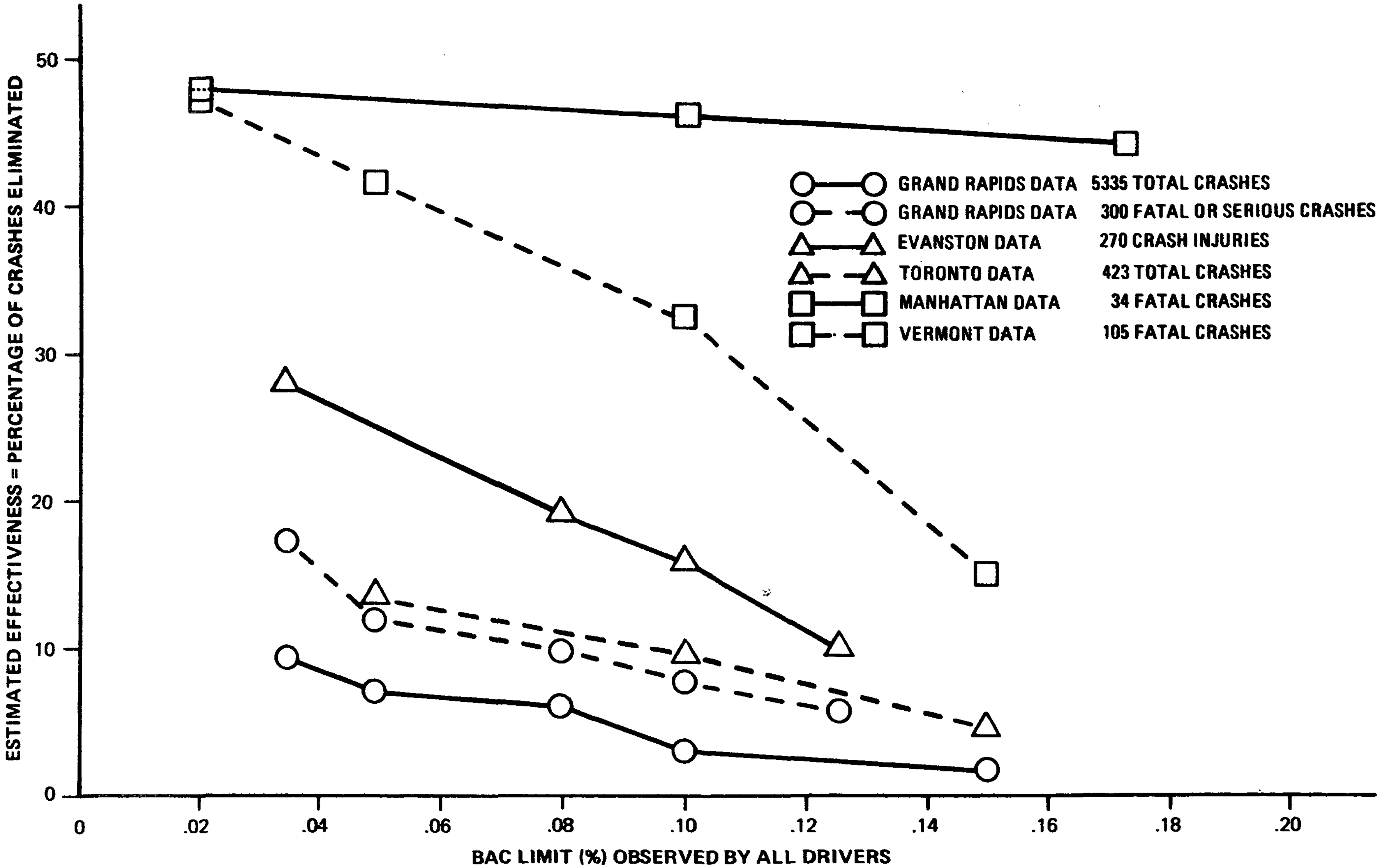

Figure 5. EFFECTIVENESS OF BAC LIMITS.

Turning to the "fatalities" data, one estimates much greater Effectiveness from BAC-limit compliance, as was to be expected. In Manhattan, it would appear that reducing the very high BACs even to the relative sobriety of 0.15% would be very nearly as effective as the most stringent limit conceivable. Vermont's Effectiveness function shows considerably greater sensitivity. Here, the estimated potential savings in total fatal crashes from BAC-limit compliance are 42% for a 0.05% limit, 36% for a 0.08% limit, and 33% for a 0.10% limit. The savings in total fatalities from a 0.15% limit would be only 15%.

Thus, it appears that the effectiveness of a BAC limit is strongly dependent on how you assess it: total crashes, fatal crashes, or some intermediate criterion. There are two reasons why an alcohol-safety program might well focus on the fatalities criterion: first, because of their much higher social cost, and second, because alcohol seems to play a much greater role in them. Alcohol countermeasures can do a lot more about total highway fatalities than they can about total highway crashes. According to this premise, we may approach the cost/effectiveness determination in terms of fatality reduction.

As would be expected, the Effectiveness data generally imply that the lower the limit, the greater Effectiveness. Yet, one must bear in mind the potential impact on public acceptance of too severe a limit: As Borkenstein et al. (1963) have warned, we must get the normal, non-pathological drinker on our side. This brings us to the nebulous "cost" side of our cost/effectiveness determination; e.g., is the increased savings from a 0.08% limit, as opposed to a 0.10% limit, worth the problems it might create? In terms of perfect compliance, the difference in Vermont would represent a 36% reduction in total highway driver fatalities, as opposed to a 33% reduction. The Manhattan data, though based on a smaller sample, suggest an even smaller difference. So do the French data. What we must consider is that these calculations are based on perfect compliance and the extent to which this ideal is approached might be strongly contingent on public acceptance. Most current enforcement practices are surely falling far short of this ideal, and the foregoing data indicate that improved compliance is likely to pay off far more than more stringent limits.

Lest this report appear to lean too heavily on the controlled data sources, which are admittedly scant, it may be appropriate to add a final bit of supplementation from straight body-count data. In a summary of four U.S. studies of fatally injured drivers who had been drinking, the U.S. Department of Transportation (1968) reported incidences of BACs in excess of 0.10% for 72% to 83% of the driver-victims. This leaves only 17% to 28% of the alcohol-connected fatalities associated with BACs under 0.10%. Of these, a sizeable fraction would probably have died anyway since the relative hazard curves for fatal crashes tend to be much lower in this region. Although these studies did not contain "control" observations, one may apply the figure from the Grand Rapids study as an approximate guess of overall incidence. According to this source, drivers at over 0.10% BAC represent only about 5% of all drinking drivers on the road at the times when highway crashes occur. The Vermont data yield a higher fraction, being based on the BAC distributions of controls at times and sites of fatal or serious crashes: 16% of drinking controls over 0.10%. Hence, we may infer that about 80% of the fatal crashes caused by alcohol involve only a small minority (1/20 of all drinking drivers, 1/6 of drinking drivers on the road when serious or fatal crashes occur). A select target group appears to be primarily indicated. We may well be convinced that most drivers are impaired at much lower BACs, but the payoff question does not depend on impairment thresholds. It seems adequately answered by these simple epidemiological statistics.

In conclusion, I would offer the opinion that an absolute BAC limit is mandated, since it should greatly facilitate enforcement. It should not be based on the presumption that "everyone is less safe" at this level, since no such presumption can be supported either by laboratory or epidemiological data. Rather, it should be based simply on aggregate relative hazard statistics: When population BACs exceed certain values, bad things begin to happen. These should be more than a sufficient warrant for such a law. We are presently subject to all kinds of traffic laws that have far less evidence to support them. For example, absolute speed limits do not take into account individual differences in driving ability, but are generally accepted by the public.) The alternatives (behavioral tests; chemical tests that are rebuttable by behavioral observations) lead only to a morass of conflicting testimonies from the usual parade of adversarial witnesses. They do not absolutely protect the innocent, and they surely allow many grossly impaired drivers to be acquitted or not prosecuted.

As to the level at which the absolute limit should be set, I think the evidence suggests we could accomplish a great deal of our goal (at least in the U.S.A.) by adequate enforcement of the presently-recommended DOT maximum of a 0.10% limit. There may well be a warrant for reducing this limit in certain jurisdictions, or for younger drivers. There are insufficient epidemiological data on the effects of alcohol on young drivers for highly reliable hazard calculations, due to paucity of positive BACs in control samples of young drivers. However, one might be justified in presuming that they lack both drinking and driving experience, and therefore have steep relative hazard functions, since both of these variables are strongly related to exposure-adjusted hazard. In a recent publication, Carlson (1972) reported that only 2% of night-time drivers in his control sample of BACs over 0.05% were in the 16-20 age group. However, 18% of the "alcohol-related" single-vehicle crashes (police reports) involved drinking drivers in this age group. If we assume that most police reports citing alcohol involvement were associated with BACs over 0.05%, this implies that the 16-20 year age group had 9 times the relative hazard of the population-at-large at BACs over 0.05%. Since this age group as a whole (drinking plus non-drinking) had a relative hazard of only 1.5, these figures suggest that increased vulnerability to alcohol, rather than poor driving per se was the important contributor to the 9:1 factor. Of course, it is possible to cite the alternative possibility that the drinking-crashed drivers in the 16-20 age group had more to drink than the drinking-crashed drivers in the other age groups. This, however, would be in marked conflict to results where BAC was actually measured in crashed drivers of varying age groups, as in the Grand Rapids and Vermont studies (cf. Zylman, 1972). It is also possible that increased education, and hence better popular acceptance, may later permit lowering the national standard. At the present time, I am inclined to the view that the incremental savings from 0.08% over 0.10% are insufficient to risk jeopardizing some badly needed enforcement innovations.

It might be argued that we have had a 0.10% limit in many jurisdictions for some time now; and since no great hue and cry has been raised, it is time to start inching it downward. In a statutory sense, this is true; but have we really had a 0.10% limit? Such reports as I have read still indicate that more arrests occur at far higher BACs where the symptoms give rise to grossly deviant behaviors. Have we had a chance to study the social impact in the U.S.A. of a real (enforced) 0.10% law? I think the answer is clearly "No." Were such a practice to occur practically anywhere in this country, there should be such a dramatic reduction in highway fatalities that we could not fail to observe it. Conversely, failure to observe such an event suggests that no de facto 0.10% limit does, in fact, exist.

To an extent, the British have "really" had a BAC limit of 0.08% since 1967. During the first full year of its enforcement, total highway deaths dropped 17% below the extrapolated trend based on the previous four-years' experience (Newby, 1971). Even there, however, one cannot quite say that a de facto limit of 0.08% or any other value was being strictly observed by drivers: In 1968, 17,955 drivers were prosecuted at BACs over 0.08%, and over half of them were over 0.15% (Home Office, 1970, after Newby, 1971). In later years, the estimated fatalities reduction slipped to about half its initial level.

In summary, then, I would suggest that even the British enforcement standard, including "test on suspicion," is far from achieving total enforcement effectiveness. As a last resort, one might need even more unpalatable measures. As to what these should be, there is need for some research as outlined below.

7. RESEARCH NEEDS

According to the implication drawn herein, the more serious alcohol-involved crashes are attributable to a very small proportion of all drinking drivers on the road at a given time: those with BACs indicative of serious impairment. I have gone so far as to recommend that enforcement practices be focussed on these drivers, and that rather than lowering BAC limits from present values (such as 0.10%), one should facilitate enforcement of present limits by: (1) enacting per se BAC-limit laws; and (2) increasing detection, invoking "test on suspicion" practices, but perhaps going yet further in the "1984" direction, as by use of random roadblock checks. The latter, however, are only conjectures about seemingly plausible ways to effect loss reduction. For more definitive guidelines, the following questions should be addressed:

7.1 Is it necessary to identify problem drivers?

Our major focus seemingly should be the seriously impaired driver. (I will depart from current custom and call him the drunk driver.) The question is what to do about him. I have implicitly assumed that it is necessary, though not sufficient, that we first identify him: hence, the emphasis on improved detection methods. But perhaps even this assumption should be tested.

7.1.1 Is it possible, through improved public enlightment via breath-testers in bars, informational campaigns, etc., to change drinking-driving habits without invoking punitive or coercive sanctions? If so, then one need not identify, as individuals, those we are to punish or coerce.

7.1.2 Is it indeed fruitless to concentrate on the small fraction of "drunk" drivers? Smart and Schmidt (1970) have shown that the distribution of BAC in randomly checked drivers tends to be of the same shape (log-normal) in populations of varying mean levels of BAC. Their implication is that if there are P_1% of drivers in the 0.02% - 0.05% range, there will generally be about P_2% of drivers in the 0.10% - 0.15% range, P_3% in the 0.15% - 0.20% range, etc. While the properties of the two-parameter log-normal distribution allow for fluctuations in P_2 or P_3 relative to P_1 (cf. O'Neill & Wells, 1971), one can still address the problem in terms of more restrictive assumptions, as follows: If the values of P_2 and P_3 are closely tied to some measure of average BAC, it would appear most fruitful to concentrate efforts on reducing the average BAC of drivers. Conversely, efforts aimed to reduce P_2 and P_3 would, if successful, inevitably be reflected in lowered average BACs.

But might not the answer to this question depend on what means are employed to reduce driver BACs? If one manipulates the price of intoxicants, for example, one might well find that average BAC, P_1, P_2, and P_3 all co-vary strongly. However, if one aims his program specifically at high-BAC drivers, might not the shape of the BAC distribution change? The answer is not to be found in the results of campaigns whose effect is to put the fear of God into all drinking drivers, or, like the British experiment, result in general fear coupled with confusion about how much one can drink and remain safe from prosecution. I have recollections (undocumented) from British newspaper articles published before and after the 0.08% law went into effect. When passage of the law was being urged, it appeared that the 0.08% level was a liberal limit: Would you like to have someone on your road who had drunk 8 or 9 whiskies? After passage, it was then explained by the press that you had better not have more than 2 or 3 drinks or you might lose your license. Considering total ranges of bodyweight absorption conditions, and Widmark "constants" in a national population, and choosing a set of extreme values on each, one can support either interpretation. Nevertheless, one could scarcely expect the law with its attendant publicity to produce a driver BAC distribution that was sharply truncated above the 0.08% level. What seems to have happened is that the moderate drinkers were scared more than the heavier ones, or at least responded accordingly: Intermediate BAC incidences were reduced more than high BAC incidences. Nevertheless, the immediate results were more encouraging in terms of fatality reduction. The long-term trend thus far is somewhat more difficult to evaluate, depending on extrapolations from pre-0.08% years that become more tenuous as they get longer. Ultimately, however, the degree of success would seem to depend on the answers to several further questions:

7.2 How will the British public react?

Will they succeed in pulling the law's teeth (enforcement practices)? Will they learn how much they can drink to stay below 0.08%, and so change the BAC distribution? Will they continue to drink generally less at all levels and still produce a favorable result, even while not knowing how much it takes to reach 0.08%? Will the moderate drinker thus accept the inconvenience, bowing to authority; i.e., is public understanding/acceptance an essential condition for the law to work? Will acceptance of a poorly understood, but anxiety-arousing deterrent be achieved in Great Britain? Would it be more, or less accepted in another particular culture?

These questions can be answered only through a combined approach, based on experimental education (propaganda) techniques, skilled public opinion sampling, and (most rigorously) by trial programs initiated in different jurisdictions. Ideally, controlled experiments should be performed with different treatments applied to different jurisdictions in randomized-blocks designs. This requirement also applies to some other suggested research areas and will be further elaborated below.

7.3 If we decide that it is necessary to identify problem drivers and succeed in doing so, what should we do with (to) them?

Assuming that improved detection methods are successful in apprehending many of the "drunken" fraction of drinking drivers, what should we do when we catch them?

The consensus of research literature seems to implicate three primary target groups, though with some minor disagreements:

7.3.1 Problem drinkers who drink too much whatever they are doing, and also happen to be drivers.

7.3.2 "Social" drinkers who occasionally drink too much before driving.

7.3.3 Young (or inexperienced) drivers who do not necessarily drive at high BACs, but who have low impairment thresholds.

In addition, one might add inexperienced drinkers (see Figure 3, above), who are badly impaired at BACs in the 0.05% - 0.10% range, and sociopathic types who are bad drivers to begin with and worse with any amount of alcohol. Unfortunately, the last two classes seem hard to do much about by legislative means, so I shall discuss mainly the first three categories.

Most experts seem to agree that different measures should be taken with the various different target groups. The prevalent legal sanctions (fine and revoke license), applied without discrimination, seem to be unsatisfactory in deterring the un-apprehended and even in deterring the convicted DWIs from further driving after suspension or revocation (Coppin & Van Oldenbeek, 1965). And what do you do with DWIs who are caught driving after revocation? Give them long prison terms, and precipitate high-speed chases of drunk drivers? While having a superficial face validity ("cut the fingers off pickpockets", "castrate sex offenders"), license revocation is a most inequitable practice in terms of the hardship it inflicts; and it is not hard to see why drivers may be unwilling to accept it. The legal justification for administrative license-revocation ("protect the public") is whimsical, since the public is protected for a relatively short time, if at all. License withdrawal is a punishment, and it should be evaluated on like grounds with other punishments: Is it a good deterrent; and is it fair? (An exception to this principle is when the license is withdrawn pending correction of a hazardous condition, e.g., alcoholism, and restored when and only when, there is evidence that correction has been effected. This, in my opinion, is a true "protect-the-public" function, but calls for research on the adequacy of rehabilitation programs. In this connection, some programs that should be critically evaluated are: (a) coerced rehabilitation for alcoholic DWIs, and (b) coerced "re-training" for non-alcoholic DWIs.)

A further possibility to be considered, used in other countries, is a fine based on percentage of annual income. Short prison sentences should also not be dismissed *a priori*. But the treatment should be rational and based on experimental evidence rather than reformer zeal or specious notions of letting-the-punishment-fit-the-crime. Pilot projects, such as ASAP, are an essential first step to determine feasibility of alternatives in a "can-this-actually-be-done?" sense. Subsequently, however, we should have controlled tests between jurisdictions on the randomized-blocks model, with more than one jurisdiction per treatment and with the separate jurisdictions being non-interacting and thus representing independent observations. Regardless of how many drivers are sampled and treated in a given jurisdiction, it is the number of separate jurisdictions within-treatments that constitutes the number of degrees of freedom for treatment comparisons. This is a necessary condition, not only for applying statistical models (such as analysis of variance), but also for a useful degree of generalization of results. (If one compares teaching methods applied by different teachers, the appropriate "N" is not the total number of students involved, but the total number of teachers-classes.) The problem is an important one and seems likely to remain so for some time. Rather than be satisfied with limited, possibly idiosyncratic results, we should strive for the politically unpalatable alternative of random treatment assignment among matched blocks of independent jurisdictions. When one of the comparison treatments involves license withdrawal, we also need follow-up data on how many continue to drive anyway, if we are to make useful criterion comparisons on accident or citation counts.

7.4 Are there other possible countermeasures that are not being seriously considered?

Perhaps we have unduly restricted our thinking by implicitly defining our goal as preventing drivers from drinking--or from drinking too much.

7.4.1 In addition, there is the possibility that we could prevent drinkers from driving too much. Of course, this is implicit in the notion of license withdrawals, designing cars that drunks can't drive, etc. There are in fact possible ways that either of these practices can be made to work, even though the former seems not to work very well at present and the latter is still in the experimental stage. However, both of these sanctions--the suspended/revoked license and the gimmicked ignition switch--are intended primarily for those who have already been caught and convicted of DWI. They are intended to keep drunk drivers from driving at all. At least on prior logical grounds, it is also possible to reduce losses by reducing the miles driven and/or hazardous traffic encountered by those who have not been convicted of DWI, but who nevertheless contribute to the problem by driving with BACs at which some impairment is present. To begin with, a systematic logistical study should be made of where they were going to drive while in this condition. Is there sufficient warrant, for example, for prohibiting the sale of alcoholic beverages at establishments whose clientele, for the most part, depart by private automobile for lengthy and/or hazardous journeys? Or, if it is politically unfeasible to close down such establishments, might various economic sanctions be applied? Liquor license fees could be set by zones. This would tend to raise prices of drinks in the more hazardous locations, and should divert some of the traffic to less hazardous ones, such as neighborhood bars. The concept here is the same as that of levying taxes on factories situated on public waterways, proportionate to their individual contributions to the overall degradation of water quality, as is done in some European countries. Changing the opening and closing times of "pubs" has also been shown to affect the BAC distribution by hours of the day. In fact, the apparent "safety" measure of advancing the closing times of some Australian pubs produced results suggestive of increased hazard, by turning drunk drivers loose in heavier traffic. For such reasons, a thorough logistic study should be made over numerous jurisdictions to determine whether existing liquor laws should be changed.

7.4.2 As another possibility that may seem far fetched, we should consider the possible savings from acute tolerance (short-range accommodation, acute adaptation, or the "Mellanby Effect"). Since this review was restricted to epidemiological findings, I did not mention some recent laboratory data (Jones & Vega, 1972; Hurst & Bagley, 1972) that support the existence of this long-controversial phenomenon. At least for some behavioral measures, impairment seems to be less during the falling phase of BAC than it is during the rising phase, when BAC itself, as well as practice, fatigue, etc., are equated. It would be difficult to translate such findings into modifications of chemical test statutes, if indeed they are applicable to real driving situations. However, there is a potential educational value. A brief period of abstinence (1/2 to 1 hour) after the last drink at a party might pay off in considerably reduced driving hazard, even if not in the ability to pass a Breathalyzer test. I would advocate, as a first step, some simulation and/or test track studies to determine whether the laboratory results are applicable to the skills involved in driving, and whether they interact with practice and fatigue. It is also possible that "carryover" exists, as originally suggested by Jellinek (1960) and supported by Kalant et al. (1971). This refers to an interaction between chronic tolerance and acute tolerance. Relative to the light drinker, the habitually heavier drinker may have slightly greater tolerance shortly after alcohol ingestion, but much greater tolerance an hour or two afterward. Thus, a brief period of abstinence before driving could be particularly valuable for those who putatively contribute the most to the DWI problem. Furthermore, such a brief abstinence (while drinking coffee, eating, etc.) might be voluntarily acceptable, even though nobody is likely to sit around abstemiously for long enough to effect a material reduction in BAC.

8. SUMMARY

To elucidate the role of alcohol in highway crashes and citations, it is necessary to turn to "controlled" studies. In a naturalistic situation, one does not have "control" in the rigorous sense of randomized assignment to comparison treatments. However, it is possible to achieve a sort of inverse control by comparing samples of crashed or arrested drivers with roadblock samples, provided that the latter have been selected in a manner that does not bias the relative representation of blood alcohol concentrations (BAC) and other comparison features.

To varying degrees, such controls have been achieved in several naturalistic highway studies. Although these studies differ in many salient features, they remain our best -- perhaps our only -- valid source of epidemiological data. Differences in foci (e.g., fatal crashes, vs. crash injuries, vs. all crashes) will inevitably lead to differences in results, but need not be treated as "biasing" influences, since they address different questions. Inadequacies in control procedures (basis of matching roadblock samples) can produce biases, but there is little one can do about these except to attempt gross adjustments on the basis of known influences, such as time of day or day of week. Ethnographic differences in populations studied are virtually impossible to control. These need not bias a particular calculation of relative hazard with regard to BAC, but they must be kept in mind as one of several sources of differences when comparing one study with another.

There is one other thing that can be done in the attempt to integrate these disparate findings, and that is to treat each data base in a mathematically consistent manner. The present review is an expansion of an earlier attempt to do this. The mathematics are simple, but have not been consistently applied in the past.

I have calculated relative probabilities of involvement in various types of crashes or citations as functions of BAC. Relative hazard appears as a monotonically increasing, upwardly concave function of BAC regardless of data source. However, both slope and acceleration vary between studies. Insofar as between-studies comparisons are valid, the acceleration in the upper region of the curve appears greater for more serious crashes. There also appear to be strong moderator roles for age (data from young drivers suggesting considerably greater hazard slopes) and for self-reported drinking habits (with self-reported drinking frequency being negatively related to hazard at any given BAC, and this relationship progressively strengthening as BAC increases). Self-reported "amount per occasion" is positively related to overall crash or DWI citation hazard, but the direction or degree of this relationship could not be determined within any given BAC class-interval. The overall relationship is very much stronger for DWI citations than for serious + fatal crashes, suggesting that practiced drinking drivers may compensate by driving slower at high BACs, and thus materially reduce serious injury hazard in light traffic, but cannot prevent tell-tale give-aways from erratic maneuvers or non-fatal collisions.

From the relative hazard calculations, it was possible to estimate the relative "Effectiveness" in terms of loss reduction to be expected from total compliance to a given BAC limit. Subject to limitations of inter-study comparisons, it appears that the potential contribution of BAC "deterrence" is much greater when considering the more serious crashes, where alcohol is more over-represented, especially when considering the high BACs. In terms of expected fatality reduction, enforced compliance to a relatively liberal limit could potentially eliminate most of the incremental loss associated with alcohol. In terms of expected property damage, not only is the incremental loss associated with alcohol much less, but the relative effectiveness of any non-zero limit is also greatly reduced.

Based on data at hand, it would seem advisable to concentrate upon enforcement rigor, rather than attempting to enact more stringent BAC limits. Research recommendations center on public acceptance factors and the logistics of drinking and driving.

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DISCUSSION

PERRINE: Are there submitted questions? If so, please raise the cards, and we will pick them up. As we did yesterday, I will read the question and the speaker will have the first option of responding. Some of the questions are directed specifically to the speaker. Then we will open up the discussion on the topic of the particular question which is at hand.

"PRESUMABLY THE MANHATTAN STUDY AND THE VERMONT STUDY ARE MOST SIMILAR, BUT APPEAR TO BE MOST DIFFERENT. WHY?"

HURST: That is a tough one. There are possibilities for differences in the method of post-mortem analysis and this is one possibility that I am not qualified to speak on. I would direct you to one aspect of Figure 5, though, showing that the Vermont and Manhattan curves intercept at virtually the same point, which is around 48%. This is the effectiveness calculation of what could be done by absolute enforcement of a particular blood-alcohol limit. In other words, 48% of all fatal crashes could presumably be eliminated if you enforce a 0.02% limit absolutely, in a speed-limit sense, that people would drink up to that but no more, which in that case means scarcely drinking at all. At this value, you see the curves come together. This is not so for the intermediate values: at .10%, for example, you would not have achieved nearly all the potential effectiveness in Vermont, whereas you would have done about as well in Manhattan as you would with a 0.02% limit. I can attribute this in part to the drinking habits of the population. Manhattan seems to have been populated with a lot of heavier drinkers who have had a greater tolerance. I submit that as a partial explanation, though probably not a complete one. The other one is that the Manhattan data base was fairly small.

GOLDSTEIN: My memory is that the Manhattan groups studied for alcohol were somewhat unique in that there were ethnic differences between them. I would expect them, as a group, to have very different kinds of people from the Vermont sample. Also, you have the metropolitan environment, contrasted with rural environment of the Vermonters.

WALLER: I think there may have been ethnic biases in the pedestrian study, but undoubtedly there were in the driver study.

HURST: Manhattan was a rather small sample and could well come out a little different than what it did. It is also true that the controls in the Manhattan study did show heavier drinking, although perhaps not as dramatically as you would have expected to account for the seemingly high impairment threshold.

HARRIS: I don't think enough has been said about the terrific difference in the environmental effect in the two studies. Seeing these cases at the scene, one is always impressed with the effect of the terrain, and the reasons for the victims being out on the road and driving in the first place. I am sure that the populations are dissimilar not only in terms of the persons involved -- I am sure there must be ethnic differences as well to some degree -- but also in environmental influences, and that such differences cannot be underestimated.

ZYLMAN: While we are talking about the differences in the populations studied, I must take exception to the whole idea of making a composite of these studies as represented in Dr. Hurst's paper. It must be recognized that there were very wide differences in the studies themselves; that is, in the methodologies used and in the populations studied. For those of you who are not directly involved in this field, I will give a brief description of those studies.

The Holcomb study in 1938 was not even a controlled study. Although Holcomb was the first to express the need for a profile of the population-at-risk to be used as a control against which to compare collision-involved drivers and that study was the progenitor of these other studies, it should be cited for historical purposes only. By today's standards, the results of that study cannot be accepted as valid.

Holcomb, with the cooperation of the staff of St. Francis Hospital in Evanston, was able to obtain the results of urinalysis from 270 drivers involved in injury collisions over a period of 3 years. There was no methodology, no system; they took the tests if and when they could or when the spirit moved them. Whether or not a urinalysis was made frequently depended on who was on duty in the hospital. Dr. Holcomb then perceived the need for a profile of the "normal" population, as he called it, to be used for a control.

With a $500 grant and the cooperation of Dr. Heise, Dr. Harger, Dr. Muehlberger and others, they equipped a van with Drunkometers and then selected 4 sites in Evanston (which was a dry town) where they thought they would find a large number of drinking drivers coming in from surrounding communities and 4 sites in Evanston where they thought they would find fewer drinking drivers. (As it turned out, there was no significant difference between the sites.) In addition, they stressed the nighttime and weekend heavy drinking hours. This portion of the study, involving about 1,750 drivers, was done in 8 days.

Without in any way denigrating the excellent work of Holcomb and his colleagues 35 years ago, I think we can agree that that study cannot be accepted as scientifically valid today.

The Toronto study by Lucas and his colleagues has limitations of another sort. That was a study of evening collisions between the hours of 6:30 p.m. and 10:30 p.m. They stopped vehicles at the same time, at the same location, and going in the same direction as those involved in the studied collisions. If they had included collisions and controls for the late night and early morning hours, the results would have been skewed much heavier toward alcohol-involvement. If they had included daytime traffic, the proportion with positive alcohol concentrations would have been much lower. In addition, having limited the selection of the control to the vintage of auto that was involved in the collision, they quite likely, although inadvertently, skewed the selection of the control toward drivers most likely to be involved in collisions. That study should only be compared with other studies of collisions between 6:30 and 10:30 p.m., from Mondays through Saturdays, in urban areas and limited to the vintage of autos most likely to be involved in collisions.

Vamosi's study in Czechoslovakia was not limited to collisions, but included all police contacts, such as traffic violations and criminal offences. The study was done mainly during daylight hours. In addition, the control sites were selected on the basis of convenience rather than at the exact time and location of crashes. For example, in the city of Bratislava with a population of 250,000, they tested 70 drivers as they returned to a government motor pool; all of them were driving government-owned vehicles and 11% were found with BACs of .11% or more. Considering the characteristics of that study and the very different cultural drinking patterns, it is unlikely that the results of that study should be combined or compared with those in Evanston, Toronto, New York, or Grand Rapids.

The McCarroll and Haddon study in New York included 43 fatalities and a control of 258. That study was heavily concentrated on the nighttime and early morning hours and weekends and in non-business areas. That study should be compared or combined only with other studies with the same or similar limitations.

The Grand Rapids study (Borkenstein et al.) is the only study that included all collisions of all degrees of severity and at all hours of the day. It was in continuous operation for one year around the clock. Breath tests were completed on 7,590 control drivers and 5,985 collision-involved drivers. The results of that study are the only results that are applicable to all collisions, but even the implications of that study are limited to conditions as they existed in Grand Rapids in 1962-1963.

Considering these wide variations in methodologies and in populations studied, I fail to see the validity of a composite as represented in Dr. Hurst's paper.

It is doubtful that a valid curve for the probability of collision-involvement at given alcohol levels can be established. It must be recognized that such a curve would not be constant; it would change over time of day and would be different for different age groups, drinking or driving experience, education levels, etc. For example, the curve from the Grand Rapids study shows that drivers with BACs below .05% appeared in collisions less often than in the control. A later treatment of the data showed that this was just an average. After midnight, even the drivers with BACs of .07% appeared in collisions less often than in the control, but during the day, even the low BACs appeared in collisions more often in the control.

There are two explanations for this phenomena: (1) it is possible that experienced drinkers who are also experienced drivers can recognize and compensate for the early stages of impairment, but this is possible only during hours of sparse traffic when demands on one's faculties and the likelihood of conflict in traffic are at a minimum; this would explain why drivers, even with a BAC as high as .07% can appear in collisions less often than in the control during the hours after midnight. On the other hand, as traffic density increases, even the low BACs appeared in collisions more often than in the control. (2) The second reason why BACs below .05% appeared in collisions less often than in the control is because a preponderance of drivers with those low BACs were from the better driving categories, e.g., between 25 and 55 years old, drove more than 15,000 miles per year, were better educated, etc. Conversely, the drivers from the poorer categories, e.g., the very young, the very old, those who drive less than 5000 miles per year, and the poorly educated were more likely to be found with a 0.00% BAC. This appears to be a real-life manifestation of Carpenter's laboratory findings that someone experienced at a given task can perform better after having a considerable amount to drink than a neophyte who had nothing to drink.

A third explanation for the dip in the Grand Rapids curve might be added; the most experienced drinker-drivers also represent a greater portion of the traffic during the hours when it is easiest to compensate.

HURST: Let me speak to that. I should first emphasize that the roadblock sample data are not in any sense comparable from one study to another because they do not in any case represent a random sample of drivers on the road. In all studies but Evanston, they were chosen to match the crash victims, so that relative hazard could be calculated. As explained in my paper, this matching was accomplished with varying degrees of precision. But the roadblock data, by necessity, are different with respect to time of day, day of week, etc., because the crashes they were to be compared with were clustered differently in the various data sources. And this is as it should be. If you find a high proportion of older vehicles in a crash sample, then you should include a high proportion of older vehicles in your control sample; that is, if you are trying to study the role of alcohol instead of vehicle age.

So the data sources are, indeed, heterogeneous. But since comparisons of these apples and oranges studies are inevitable, and are frequently made at least in an implicit sense (or, when talking about the nationwide role of alcohol in crashes), I felt that someone should at least calculate relative hazard, from the various studies, in a mathematically consistent manner. Then you can at least look at meaningful comparative figures and are free to speculate about what produced the differences.

PERRINE: Are there other comments to this point before we go onto the next question? It concerns selecting the criterion for the selection of the site for sampling, whether on the basis of a previously reported crash or on a random basis.

"SELECTION OF CRASH SITES FOR COLLECTION OF SO-CALLED CONTROL DATA MEANS THAT A HIGHER LEVEL OF ALCOHOL IS OBTAINED, IN EXPOSED-BUT-NOT-INVOLVED DRIVERS THAN IF A PURELY RANDOM SITE IS SELECTED: ABOUT .86% PER RANDOM VERSUS 2% FOR CRASH SITES. HOW DID THIS AFFECT FIGURE 5?"

HURST: Figure 5 is derived from the relative hazard figures, and I think for the relative hazard figures, you do have to use the same site and time of day for your control sample as you do for your crash sample. Otherwise, for example, supposing that you took your control sample from the daylight hours and you got your crash samples mostly from the nighttime hours, and in your crash sample, there are 50% of the people that had been drinking and in the control sample, you found that only 1% of the people had been drinking. Well, this showed a tremendous role for alcohol, but if you looked at night at the same time you picked up the crash sample, you might have found a much higher percent had been drinking. I do think it is appropriate to use the same site and the same time of day for the relative hazard and therefore for the calculation of effectiveness which comes right off the relative hazard.

PERRINE: Any comments on this? Would the questioner wish to identify himself so we can ask where the information comes from.

VOAS: The .86 figure, I believe, comes from the Howard County study. -- Would you like to comment on that, Bob?

BORKENSTEIN: Yes, I did a few calculations a week or so ago, and I find that in Grand Rapids, we have found something like 78 drivers in 10,000 (.78%) at 0.10% BAC. In Howard County, Indiana, using as completely random a sample as possible, the figure was 74 drivers in 10,000. Apparently there was randomness in the crashes in Grand Rapids. We apparently didn't bias the sample very heavily by selecting crash sites. In Howard County, we took our sample in only what we considered the high alcohol period. This didn't seem to change the figure very much. However, Howard County is a rural area containing one major industrial, educational community of 83,000, whereas Grand Rapids is an urban community of 200,000. For this reason, they are not directly comparable.

PERRINE: Any further comments on this particular point? If not, the next question is:

"WHY ARE MORE FREQUENT DRINKERS INVOLVED IN FEWER COLLISIONS?"

This question gets to the issues of drinking frequency, and blood-alcohol concentration plotted against crash rates.

HURST: The question comes from Dick Zylman, and I think he knows a lot of the answers already. The more frequent drinker has a lot of things going for him: He tends to be not extremely young, he tends to be not extremely old, he tends to come from upper socio-economic and educational levels, and he tends to have a high annual mileage. And remember these are the exposure-adjusted figures I am giving here. Nevertheless, self-reported drinking frequency is the best single predictor from all the demographic variables in the Grand Rapids study.

EDWARDS: Suppose that one of the things that controls your driving behavior is your perception of your own capability. Suppose further that in evaluating your own capability, you average over both drunk and sober states. If so, then a driver who is more frequently in a state of reduced capability has a better opportunity to learn about his reduced average capability and will adjust his behavior accordingly. This interpretation would be consistent with the finding that the more often you drive while drunk, the better you drive while sober.

HURST: You notice, too, the progressive diversion of the curves at the greater BACs.

WALLER: Besides frequency of drinking, I think you need to control for age, because if we look particularly at the young male driver in his early twenties, there not only is frequent drinking, but heavy drinking. Among older drivers, however, there may be frequent drinking, but commonly of more modest amounts. This is why we used a quantity/frequency index (QFI) to measure drinking behavior, and we also looked at QFI by age. I think if you look at the sample again -- according to age -- you might find you could divide it into two different curves.

HURST: At two points here, I did look at the Vermont data separately by quantity and frequency, as well as by your combined QFI index. Quantity per occasion did show the expected relationship; there was no question about that. The drivers who reported drinking more per occasion had the heavier involvement indexes in both accidents and citations, whereas the frequency without regard to quantity showed a much more ambiguous relationship in the Vermont data. As far as age is concerned, I ran into a problem. Unfortunately, most of the studies, even though some are tremendously voluminous -- say thousands of cases -- still do not have enough entries in the sub-cell of those 16-18 or 18-20 years of age who are between .00 and .05%, .05 and .10%, and so forth, to get any kind of dose-response curve. But there are fairly strong indications that younger people have lower impairment thresholds, since the major studies all show similar trends.

PERRINE: These quantity and frequency relations have interested me greatly. On the basis of Cahalan's work, as well as our own work in Vermont, we must consider not only the quantity of alcohol consumed in addition to frequency and in combination with frequency, we must also consider the most preferred and most frequently consumed beverage. I say this on the basis of our analyses of drinking patterns which differentiated the DWIs from the deceased drivers and in turn from the comparison drivers tested at roadblocks. We found great differences between the DWIs and all other samples when we looked only at quantity of alcohol usually consumed. The DWI sample had significantly higher proportions of individuals who reported heavy consumption of beer, of liquor, and of preferred beverage. However, when we looked only at frequency of consumption, the deceased drivers' data and the DWIs' data were essentially the same with both samples showing significantly higher proportions of daily drinkers of beer and of preferred beverage than the other samples. But with liquor, all groups were esentially the same, showing relatively low proportions of daily liquor drinkers. What does all this mean? It implies that we must take drinking patterns into consideration. More specifically, we analyzed the two most disparate groups (DWIs and clear-record drivers) on the basis of the variables we considered to have high predictive or discriminative ability. We used discriminant function analyses, and found four variables significant at the .05 level: the number of lifetime citations, occupation, frequency of beer consumption, and quantity of liquor consumption. DWIs have an enormous number of traffic citations, and are typically from the lower part of the socio-economic spectrum. With the liquor variable, we found significant differentiation not in terms of frequency, but in terms of quantity. Therefore, I strongly suspect that in Paul's Figure 3, we may be getting misleading results by looking only at frequency of alcohol consumption.

HURST: The Grand Rapids data had only drinking frequency, not quantity, so I had no choice with Figure 3. With the Vermont data, the problem lies with trying to subdivide too far according to beer, wine, liquor, and then according to quantities, frequency, etc. When you are only considering fatalities, or even fatalities plus hospitalizations, the subcell N's just get awfully small after a while. So the Vermont data on crashes don't tell us anything definitive about the combinational relationship between frequency and quantity per occasion. With the Vermont DWI data, it is a different story since the N's are much larger, and one can make some firm inferences about quantity, QFI, type of beverage, etc.

PERRINE: Just to help clarify the results, let me put them in a simple 2 x 2 table, even if it means grossly oversimplifying them. Let's make frequency of beverage and quantity of beverage the two column headings, and liquor and beer the two row headings. The three significant differentiators are found in both quantity cells, regardless of beverage, as well as frequency of beer. Since quantity alone differentiated the DWIs from the rest of the drivers, the quantity of preferred beverage was the best single differentiator, as we might expect. In addition, frequency of beer was associated with the socio-economic variable of occupation, at least in Vermont; that is, 50% of DWIs were laborers and they typically drink beer.

ROSS: In holding constant socio-economic status, does the frequency of beer still distinguish?

PERRINE: We didn't have a sufficiently large sample to do that sort of analysis, but it would be very interesting to do.

ZYLMAN: Have to hold age constant, too.

PERRINE: Yes.

KELLER: Did I gather that you are assuming that the quantity and frequency of beer as the beverage of the DWIs is related to socio-economic status? Do I gather that you will imply that it is because beer is cheaper?

PERRINE: There are several variables apparently operating here, Mark: availability, convenience, and economy. Beer surpasses liquor on all three. First, beer is more readily available in Vermont since it can be purchased by almost anyone in virtually any grocery store seven days a week until about 10:00 p.m. By contrast, the distilled spirits are more rigorously controlled in the system of State Liquor Stores, both in terms of who may buy and when they may buy. Secondly, beer is convenient; it comes in disposable bottles and is ready to drink directly from the bottle; no glass or ice or mix is necessary. These factors doubtless contribute to its mobility; a lot of beer is consumed while driving. In fact, the beer bottle is known as the State of Vermont's spring flower, because when the snows melt, the winter accumulation of hidden beer bottles suddenly emerges along the roadsides. Finally, beer is cheaper than spirits, and can be purchased in smaller units. Regarding use, the patterns shifted with the change from the 21-year old to the 18-year old majority. Prior studies showed that beer was the implicated beverage for the fatally injured young driver; those under 21 could not buy liquor legally in the State Stores because of the rigorous controls, but they could very easily obtain beer from any of the many grocery stores. Furthermore, many of these young drivers were coded as "laborers" because such jobs are frequently available to highschool drop-outs and terminal students. In any case, we did analyze with age held constant, by cutting at 25, yet we still found that beer quantity and beer frequency were the best single predictors for differentiating these groups.

KELLER: I was wondering whether there still survives this social factor that "beer is the working-man's drink"; whether that has anything to do with it; whether that counts in the kind of result you get there.

WALLER: We can best summarize this with the picture of an individual half-ejected from his car, with a sweatshirt that said "Beer, the breakfast of champions."

HARRIS: I have the same guy on the autopsy data.

PERRINE: Just one more thing to your point Mark. We did an analysis that was not beverage-specific; we examined the frequency and the typical quantity of the respondent's preferred beverage and we found the same cross-over, differentiating the DWIs. We also did the same for the Quantity-Frequency Index, and we got the same cross-over for DWIs. I don't want to take any more time now, but these data are available in a report, and I just happen to have one copy with me if you want to see it.[1]

BUIKHUISEN: Could I give a brief comment on this. Yesterday, I made some references to studies we have carried out in the Netherlands. In those studies, we could establish significant differences between DWI and control groups of non-DWIs. The chairman of this meeting then suggested that those differences might be explained by selective police arrests. Now I am very happy to see that you are bringing in some data that suggests that indeed those two populations are different and, as you did not make any references about selectivity of police arrests, I assume that you have controlled for them. Now what surprises me is that if you do find with regard to some items differences between DWIs and non-DWIs, why is this not a reason to look for other differences? What I mean to say is that as a European, it strikes me that in the U.S.A., little attention is paid to what is characteristic of people convicted for drunken driving. In the Netherlands we have

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[1]The report referred to was: 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 & FH-11-6899), U. S. Dept. of Transportation, 1971.

carried out many such investigations. Differences between DWIs and non-DWIs could be established with regard to factors like: personality, job history, family life, leisure activities, drinking patterns, etc. We believe that especially from the point of view of prevention and treatment, it is important to know more about these characteristics of drunken drivers.

PERRINE: I am glad you have raised this issue. Excellent work has actually been done already, leading for example to the so-called Mortimer Test, for which the various personality dimensions were surveyed and analyzed. We have also done rather extensive work ourselves, and still have enormous amounts of unanalyzed data on a variety of biographical and personality dimensions from our DWI drivers (and the DWIs in comparison with drivers in the other samples). We have just looked at the top of the iceberg so far. But the differences on the significant discriminator variables have already been used as the basis for constructing the Vermont Driver Profile questionnaire which is currently being used as a supplement to Motor Vehicle Department's licensing examination. These data are being recorded and stored for all those individuals who are so tested; we plan to track them for one or two or three years depending upon when they were tested. Then, at the end of the project, we will have both baseline data and driving record during the interim which will permit us to study the psychological-biographical differences between all those who had crashes and/or citations and those who did not. Naturally, we will be especially interested in any differences between these groups concerning use and abuse of alcohol.

WALLER: I have a very important recommendation. Paul has mentioned the problem of studies that have attempted to collect massive data on a large number of individuals, and yet when one attempts to break the data into cells, the sample size really is whittled away rather quickly. I think that an attempt has been made to develop a standard format for the road blocks. One of the recommendations that should come out of this meeting is not only that we need additional studies, but that as these studies are done in a number of places, exactly the same criteria should be used, so that we are in position to pool several studies. Thus, we could avoid Paul's problem of trying to compare several studies and then having someone very rightly get up and say that they can't be compared.

PERRINE: Of course, just this kind of coordination has been tried in the Alcohol Safety Action Programs currently being conducted by the U. S. Department of Transportation. Active efforts are also being made to achieve international coordination of studies, so that for example, a French or Dutch study of the future will be consistent with a future Vermont study or a future Michigan study. These kinds and levels of coordination are being tried, and I think will certainly be a good thing.

SMART: I am very worried about quantity and frequency data concerning alcohol abuse. If one does a good survey of the general population, asking if they drink and how often, and if you multiply the numbers, you can never account for more than 60 or 65% of the total alcohol sold. In France, they can account for about 90% of the alcohol sold. But in North America, reported quantity/frequency for alcohol is very poor. But I think it is not as consistent in that heavy drinkers under-report more than moderate or light drinkers. In Ontario, it used to be that in order to buy a bottle of alcohol, you had to sign your name and address. These slips with names and addresses were all held together for a period of time so that total use by individuals could be identified. We interviewed a few dozen heavy drinkers in a household survey. A great majority of these people reported themselves as very moderate drinkers (many less than normal).

PERRINE: Cahalan and his colleagues have worked on this under-reporting problem and I think have reduced its magnitude through getting people to respond more honestly by expanding the scale to include responses for those who would drink three times daily, two times daily, just daily, etc., etc. The notion is that a person who is a very frequent drinker will be more willing to check a response which is not at the extreme anchor point of the scale.

SMART: The California drinking practices say they still can't account for any more than at the most 60%.

KELLER: I think you may be overlooking the fact that there is a good proportion of the sales which shouldn't be accounted for in these surveys, because they are surveying the drinking by a resident population, but a great deal of the drinking in California, and in a lot of other places I know of, is done by tourists, or by people who buy liquor to take home across a state line because it's more expensive in their own state or they live in a local-option dry town. So you should not expect to account for 100%, and I don't know what percentage should be accounted for.

HURST: I wanted to comment again on the younger driver question. I did have one publication that many of you may be familiar with by Carlson (in the Journal of Safety Research, 1972) who used nighttime drivers and therefore was able to get some fairly respectable subcell N's even though it wasn't as big a study as Grand Rapids. He found 2% of the nighttime drivers in his control samples with BACs over .05% were in the 16-20 age group; however, according to police reports, 18% of the so-called alcohol-related single vehicle crashes involved drinking drivers in this age group. I will give you this for what it is worth. If we assume that most police reports citing alcohol involvement were associated with BACs over .05%, this implies that the 16-20 year age group has nine times the relative hazard for the population at large at BACs over .05. Since this age group as a whole, drinking plus non-drinking, has a relative hazard of only 1.5 times the population at large, these data suggest an increased vulnerability to alcohol rather than poor driving *per se* was the important contributor to the 9 to 1 age factor.

ZYLMAN: In anticipation of this discussion, I drew the chart on the board. The information I am about to present comes from the Grand Rapids Study; it was first reported by Hyman in 1968 and again in my paper on Youth Alcohol and Collision Involvement in 1972. The numbers along the bottom represent the BAC and the numbers up the side represent the Collision-Involvement ratio. (Editor's note: It was decided jointly with Dick Zylman to include the relevant portions of Hyman's original table, rather than the figure which was drawn on the blackboard.)

It can be seen that 16 and 17 year old drivers have the worst collision-involvement ratio even without alcohol; they appear in collisions two and one half times more often than in the control. Drivers who are 75 years or older have the second worst experience, followed by those who were 70 to 74 and 18 or 19 years. In each case, their collision involvement is worse without alcohol than that of drivers from 25 to 64 years old who had BACs as high as 50 mg% to 90 mg%. This further illustrates what was said earlier, e.g., that experienced drinkers who are experienced drivers can indulge in moderate amounts of alcohol and still function better than inexperienced drivers with no alcohol. It should also be noted that when these drivers who already have the worst collision experience without alcohol take almost any amount of alcohol and then drive, the likelihood of collision-involvement rises abruptly.

TABLE 6-3

Percentage of Accident-Vulnerability Ratios (A-VR) for Males in Each Age-BAC Category[a]

Age	Blood alcohol concentration			
	.00%	.01-.04%	.05-.09%	.10%+
< 18	2.38	7.33	b	b
18-19	1.55	2.29	4.17	b
20-24	1.12	1.12	1.78	9.38
25-34	0.81	0.94	1.61	6.75
35-44	0.68	0.71	1.14	5.56
45-54	0.63	0.57	0.91	4.50
55-64	0.76	0.56	1.17	15.00
65-69	0.83	0.56	1.25	13.00
70-74	1.88	2.50	2.33	b
75+	1.88	5.00		

[a] Abridged from Table 4 in Hyman, M. M. Accident vulnerability and blood alcohol concentrations of drivers by demographic characteristics. Quarterly Journal of Studies on Alcohol. 1968, 4, p. 39.

[b] "The ratio cannot be calculated since there are no controls."

There is an important message here. We have heard much discussion about "information processing" and decrements in relation to .03, .04, or .05%. Almost all of these studies are done on young healthy persons over the age of 21. There may be greater payoff if more attention were given to drivers at the extreme ends of the age spectrum.

PERRINE: One limitation to some of these studies is that individuals are typically asked about their usual frequency of drinking and their usual quantity of drinking, but are not asked how much they usually drink before they drive, the assumption being that most people would not give an honest answer to that question. Thus, many assumptions are made about the respondent's drinking patterns as they relate to his driving after drinking, but this may be too large an inferential jump.

WALLER: You can get that out of the Vermont data too because we asked about how they were combined; in the subsequent data from Project CRASH, we have also asked about how much they drink when they have more than their usual amount and how often is that. We are able to look at that component as well.

HURST: It is true, though, if the daily drinker is indeed more frequently represented on the road at the higher blood alcohols, then the data in Figure 5 emerged despite this, rather than because of it. This category of persons was less represented in terms of case/control ratio as he was seen on the highway, even though he was more likely to be there at positive BAC.

VOAS: In terms of the development of effective countermeasures, I think it is important to distinguish between two factors which contribute to the over-representation of a given type of drivers in crashes. Statistics which do not control for exposure will show that young drivers are greatly over-represented in fatalities of all types. When exposure is taken into account, as when a baseline of at-risk drivers is created by roadside surveys such as those reported by Dr. Hurst, the extent of this over-representation is reduced. Thus, young drivers are over-represented in crashes in part because on a risk-per-mile basis, they are more likely to have an accident, and in part because they are more exposed; that is, they do more driving, particularly at high risk times, such as during nighttime hours. In terms of countermeasures, one can hope to improve the risk-per-mile problem by providing training. However, the greater exposure problem can only be handled by restricting the driving of young drivers.

GOLDSTEIN: If I remember correctly, the age groupings were fairly gross.

VOAS: If you are speaking of this, this was 16-18 as I recall, but please correct me.

GOLDSTEIN: The combining of ages obscures very important information, particularly at that lower range.

VOAS: You mean a finer breakdown should be done -- 16, 17? Yes.

PERRINE: I quite agree; having that large a class interval from 16-20 years is obscuring some extremely important changes that occur within it. For example, Pelz has reported a post-high school graduation peak, that is, a sharp increase in crashes, citations, and warnings at 18.

GOLDSTEIN: Even a five-year span in that age range is very important.

ZYLMAN: The same thing is true at the other end of the age spectrum. Some very important changes start at the age of 65.

BUIKHUISEN: Could I have some information? When you asked for drinking spectrums of subjects, did you ask for drinking spectrums in general or drinking spectrums related to driving. Many people admit to be heavy drinkers, but they do not participate in traffic after drinking. They are not of much concern to us. We are mainly interested in frequent drinkers who continue to drive their cars. Could you in your study differentiate between these two categories?

WALLER: I can answer that, at least as far as the Vermont data are concerned. One question we asked was about usual frequency and quantity of alcohol consumed for each of the three types of beverages. The second question was, "On those occasions when you have consumed alcohol, how often do you drive within a short period afterwards?" I don't remember our exact categories, but it was something like "less than half the time", "about half the time", "more than half the time", or "almost always". The fit isn't perfect, but is reasonably good, so you can get ball-park figures of what sorts of relative exposures individuals with different quantity/frequency indices are having.

You may notice that I keep on slipping up and talking about frequency/quantity index. We first had done our analysis based on frequency/quantity, and then felt that the quantity was more important, so we now talk about quantity/frequency index. What we have been doing in some of the later work with Project CRASH -- and this was after discussion with Robin Room and Don Cahalan -- is to ask not only the information about usual drinking patterns, but also about more than usual drinking and how often that occurs.

That brings up a very interesting age-related difference. Even the occasional light drinker in the teenage group is very likely to have times when he gets himself into the heavy drinking category, although this occurs only rarely among older persons. So when we talk about the young population, if we get their usual drinking pattern, we don't really get a complete picture of the likelihood of being on the road with an impairing amount of alcohol, a very impairing amount.

BUIKHUISEN: Did you also ask for information about the time of day they drink these amounts?

WALLER: We have asked in the Project CRASH work another question, "When is the last time when you had five or more drinks in a period of one hour or two?" It again varies with age. I should mention that we had two reports here, one of which compared male drivers in Vermont whom we stopped at roadblocks and the other was given to all of the members of the Vermont Department of Public Safety, all the state police, and we have some very interesting differences, especially on that particular question.

PERRINE: Speaking of questions, I would like to conclude this morning's session with one submitted question of particular relevance and give perhaps five minutes to it. The topic also relates to the last session this afternoon.

"WOULD YOU COMMENT ON THE IMPLICATIONS FOR ALCOHOL COUNTERMEASURES FOUND IN FIGURES 3 AND 5?"

ABERNETHY: A higher frequency of young people drink and drive and get killed, and we talked about adapting to driving while intoxicated. You are talking about two ends of the scale. How much of an effect does this have on the thing we are looking at in terms of adaptability.

PERRINE: In other words, what is the Darwinian correction factor as a function of increase in age? Good question, does anyone have any data?

VOAS: The probability of a fatal crash and being killed in a fatal crash is very small relative to the total number of times you are on the road. The same issue came up on cancer and smoking. Do you count the dead or do you count the living?

BAKER: Some specific figures on that point are that if you take a thousand 15-year-old males and follow them for 10 years, 13 of them will have died of some sort of injuries before they reach age 25. That includes a few suicides and homicides and non-highway injuries. Highway deaths claim about 8 of the 1000. In other words, almost 1% of all males are lost through highway-related injuries between the ages 15 and 25. If you looked just at heavy drinkers, I'm sure the percentage would be much higher.

SMART: It couldn't be very much at death rates only 0.3%/year at that age.

PERRINE: If it is relatively negligible in a statistical sense, let's move on to countermeasures and this very important question relating to Figures 3 and 5 and the implications for alcohol countermeasures. Who would like to speak?

HURST: I have some more data here from State body-count statistics from the Department of Transportation in their survey of 1968 related to some on-the-road statistics, some other sources that of course are not completely matched, and so forth. It seems if you are talking about run-of-the-mine accidents that you want to reduce, then you better set a stringent limit because you are involved with a lot of people who are a little bit impaired. If you are talking about fatalities, it does look as if most of them are being caused by relatively few people who are very much impaired. To what extent these are the same few people from one weekend to the next is uncertain, but one would expect some consistency. Even if you look at the Vermont data in Figure 5 which are less spectacular in that respect than the Manhattan data, you find that you are still getting rid of 2/3 of your fatality problem if you could even enforce a .10% limit.

ZYLMAN: We found that drinking frequency is very closely related to other variables, the principle ones of which were age and driving experience; the very young and very old and drivers who drive less than 5000 miles a year were least likely to be frequent drinkers. (Low mileage is quite likely a reflection of age.) It was also true that drivers of higher education level and of high socio-economic status were more likely to be frequent drinkers.

You will note that in each case the low frequency drinkers could be identified as those sub-groups most likely to be involved in collisions and, conversely, the frequent drinkers were most likely to be among those subgroups least likely to be involved in collisions. When we took a first look at this, we were a little surprised to find that those who drank most often were involved in fewest collisions. However, when we recognized the interaction of these other variables, we realized that we were not measuring the effects of drinking frequency, but of those other variables (Page 135, Grand Rapids Study). This gets back to explaining the dip in the Grand Rapids curve; those drivers found most often with a low BAC were most often from the middle age, greater driving experience, greater drinking experience, better educated groups who, even though slightly impaired, appeared in collisions less often than the very young, very old, low mileage drivers who had nothing to drink. On the other hand, the high drinking frequency drivers were also most likely to be the heavy drinking-high BAC drivers. I think these findings have implications for countermeasures.

HURST: Let me amend my statement very briefly, speaking of the .10% general limit that there is a strong case for a lower limit for younger drivers which could probably be forced upon them, but while there may be a similar case for the older ones, it would seem to be a lot harder to force a lower limit on them.

WALLER: I was about to make the same point as Paul. New York has gone to a lower presumptive limit for teenagers. I should preface this by saying that I think that the question has two components -- one is a scientific component, but the more important component here is the administrative decision component and a political decision component. I don't see much problem from my point of view in going to a lesser limit for impairment for the young driver or in dealing with a "limit per se" rather than presumptive limit. I think we also have to recognize that everything we are talking about is based on the very inaccurate assumption that we can achieve 100% effectiveness in removing impaired drivers. I think the answer ultimately comes down to doing this, plus making the appropriate environmental changes to that people aren't as likely to get into trouble or that if they do get into trouble, they are not likely to have serious consequences.

KELLER: From everything that was said here about the drunken driver, and also at previous sessions, I got the impression that people who are likely to be identified or labeled as "drunken drivers" -- and I am going to make an assumption that police bias is not an important factor in this -- that they are people with special characteristics which we know, which we can identify. They are people who get into trouble when they are young. They have all kinds of personality and social and background characteristics that we can ascertain. Therefore, it seems to me that if we consider countermeasures, we should be thinking of measures which would be effective with this population, with this especially vulnerable population, rather than scatter-shot measures directed at total populations or at all drinkers. In other words, I would like to see less wasting of the countermeasures effort on very general attempts, and more direction at the vulnerable populations.

PERRINE: We have a session on countermeasures this afternoon. Therefore, are there any more comments on the particular implications of these kinds of data for countermeasures, rather than on countermeasures themselves?

Chapter 7

USE OF PSYCHOACTIVE AND HALLUCINOGENIC DRUGS IN RELATION TO DRIVING RISK

Reginald G. Smart

ABSTRACT

Reviewed were investigations of prevalence of drug use in different populations (including the driving population), drug use among persons involved in accidents, and accident rates among drug using/abusing populations. A review of the available literature on drug involvement in vehicular accidents suggests that few definite conclusions can be made. It appears that 35 to 50% of the general population take the risk of driving after drug use at least once per year. Much of the known drug use problem occurs among drinking drivers. It is uncertain whether narcotics and hallucinogenic drug users had elevated accident rates and whether their accidents are due to their drug use. Such drugs cannot easily be analysed in body fluids at present. It appears that the known contribution of drugs to accidents is small, compared to say, alcohol. However, better studies on more frequent drug use in the population may necessitate a revision of this conclusion. At present, there appears to be no need for greater legal countermeasures against drug use and driving.

1. INTRODUCTION

Evidence accumulates to suggest that the use of psychotropic or mood-modifying drugs is increasing (Berg, 1970; Smart & Fejer, 1971). For the most part, these drugs are not replacing the older, socially acceptable drugs, such as alcohol and tobacco. Naturally, current increases in drug use of all types lead to an interest in the driving risks they might represent. Research in this area has been of several types: (1) laboratory and simulator studies of the impairing effects of various drugs or drug combinations; (2) surveys of the prevalence of drug use in different populations, including driving populations; (3) studies of drug use among various persons involved in accidents; and (4) studies of accident rates among drug using or drug abusing populations. In general, research in these areas is much less adequately developed for mood-modifying drugs than for alcohol. Some of the reasons relate to the large numbers of drugs involved, the lack of easy methods for their detection in body fluids, and the generally held view (Nichols, 1971) that drugs represent a less important factor in accidents than alcohol.

The aims of this paper are to: (1) review research in each of the areas listed above, with the exception of laboratory and simulator studies of impairment; (2) suggest what research remains to be done in assigning driving risk; (3) assess the present importance of drugs to driving risk relative to other factors; and (4) suggest some possible countermeasures related to drug use and driving. Previous reviews in this area (Kibrick & Smart, 1970; Milner, 1972; Nichols, 1971) have tended to emphasize psychoactive drugs rather than hallucinogenic or opiate drugs, but the present review attempts to consider all three.

The definition of psychotropic or "mood-modifying" drug can be problematic. Nearly all drugs in some doses could modify some users moods. For our purposes, psychotropics or mood-modifiers will be drugs taken specifically to modify moods. This will include primarily 5 classes of compounds: the barbiturate and non-barbiturate sedatives-hypnotics, anti-depressants, and stimulants (i.e., psychoactive drugs); the hallucinogenics (chiefly cannabis and LSD); and the narcotics (chiefly heroin and methadone). Of course, this ignores many drugs not used for mood-alteration (e.g., antihistamines, anti-motion sickness preparations, etc.) which can have side-effects, such as sleepiness and altered judgement. A truly comprehensive study of drugs and driving would have to include more than the drugs listed above. However, the most relevant research on driving risk has been done with those listed and less often with other primarily medicinal agents.

Numerous laboratory studies (Chelton & Whisnant, 1966; Crancer & Quiring, 1968; Forney & Hughes, 1964; Hurst, Weidner & Radlow, 1967; Hurst, 1962; Murray, 1962; Steinberg, 1964; Wagner, 1963) have shown that many psychoactive drugs can impair mental and motor performance, although some studies of tranquilizers have not shown impairment (Miller & Uhr, 1960). Unfortunately, most of the experimental procedures employed are not parallel to actual driving situations, and prediction of drug effects in traffic is still uncertain at best (Kielholz & Poldinger, 1967; Wagner, 1963).

There are other complicating factors in assessing the effects of drugs on driving performance. One is the question of drug interaction. A bewildering number of drugs interact with one another or with alcohol; consequently, assessing the effects of each possible combination is a difficult task. Research on some of these combinations has begun, but not all combinations have been tested (Bernstein, Hughes & Forney, 1967; Burger, 1963; Hughes & Forney, 1964; Hughes, Forney & Cates, 1963; Lawton & Cahn, 1963; Wagner, 1962; Zirkle, King, McAtee & Van Dyke, 1959).

Regarding barbiturates and alcohol, there is general accord that their effects on behaviour are additive or potentiative (Brown, Hughes, Forney & Richards, 1965; Chelton & Whisnant, 1966; Gupta & Kofoed, 1966; Hoffer, 1962; Manno, Kiplinger, Scholz & Forney, 1971) and that their use should not precede driving. With the two other major drug groups, namely the tranquilizers and stimulants, the literature is still unclear. Some researchers have found evidence of synergism with alcohol-tranquilizer combinations (Forney & Hughes, 1964; Goldberg, 1965; Poldinger, 1964; Zirkle, McAtee, King & Van Dyke, 1960), and unpredictable effects upon judgement, mood, and psychomotor performance with alcohol-stimulant combinations (Brown et al., 1965; Forney & Hughes, 1965; Hughes & Forney, 1964; Hurst et al., 1967; Landauer, Milner & Patman, 1969; Newman & Newman, 1956; Zirkle et al., 1960). Others have not had similar results (Hoffer, 1962; Marquis, Kelly, Miller, Gerard & Rapaport, 1957).

Studies of the effects of hallucinogenic and narcotic drugs have been reviewed elsewhere, and such reviews will not be attempted here (Ban, 1969;

Efron, 1968; Le Dain, 1972). The hallucinogen most often studied in relation to driving risk would be cannabis, whereas narcotics and LSD have rarely been studied. In general, studies of cannabis are inconsistent in showing impairment in pursuit tasks (Le Dain, 1972) and driver simulators, but more consistent in showing impaired hand and body steadiness. Results in several of these studies have been questioned, and it is probable that boredom and inattention also contribute to the impairments. It is also clear that impairment is greatest for naive cannabis users and least -- or even non-existent -- for experienced users (Mayor's Committee on Marihuana, 1944). Additive detrimental effects of alcohol and cannabis have been found for some complex tracking behaviours, but not for simple ones (Manno et al., 1971) where low doses of alcohol are used (BAC = .03%). These additive effects could be important when it is realized that marihuana is often taken with alcohol. Low BACs in drivers may suggest less behavioural or driving impairment than actually exists.

Soehring and Wolters (1968) have reviewed the considerable literature on relationships between blood (or urine) levels of drugs and driving performance. They state (in translation) that: "(1) The ideal conditions prevailing in ethanol decomposition to carbon dioxide and water, distributing in an organ corresponding to water content in the tissues, etc., cannot be transferred to drugs; (2) In general, it appears that the 'blood level' cannot be regarded as a reliable criterion for the effect of different drugs ...; (3) Many active drugs can only be separated with difficulty from their inactivated decomposed forms ...; (4) Some drugs in therapeutic doses can be found in the urine many days after ingestion ...; (5) Retrogressive calculation that can be done with ethanol cannot be done with most drugs, as their decomposition rates are affected with chronic use of certain drugs and by other factors." Aside from methodological problems, low correlations have been found between drug blood levels and various changes in mood and behaviour (Hollister, 1962; Hollister & Clyde, 1968). With the opiate and hallucinogenic drugs, especially cannabis, there are also problems of achieving rapid body fluid analyses which will allow even a positive-negative judgement.

Despite the above difficulties in methodology and analysis, assessment of the hazards of some types of psychotropic drugs is slowly being made. This review deals mainly with studies of the use of mood-modifying drugs in general populations, in samples of drivers in general and accident drivers, in particular, plus studies of accident rates among drug users. The general aims are to describe the involvement of drug-influenced persons in driving and driving accidents. Further reviews should assess the laboratory findings concerning the effects of drugs on psychomotor and behavioural variables related to driving.

2. SURVEYS OF DRUG USE IN GENERAL AND IN DRIVING POPULATIONS

2.1 Psychoactive Drugs

Studies of the incidence of psychoactive drugs in non-fatal and fatal vehicular accident populations are still few in number, while those for hallucinogenic and narcotic drugs are non-existent. Given this lack of studies of the frequency of drug use in general populations and in various driving populations, the few existing ones are useful as a rough indicator of the probability of driving hazard from the use of that drug. Clearly, if a drug is rarely used, its contribution to accident risk cannot be very great.

The most general figures of all are cited in an editorial in Traffic Laws Commentary (1965). It contains an estimate prepared for that journal by Smith, Kline, and French in 1963. It states that at any one time, 10-20% of the "U.S. driving population" (more than 16 years of age) is using a prescribed drug. There is also an estimate by the U.S. Department of Health, Education, and Welfare that the percentage of people taking over-the-counter drugs at any one time is 1½ times those taking prescribed drugs. It has been estimated by Cooperstock and Sims (1969) that about 24% of the prescribed drugs are psychoactive. These estimates do not include such modifiers as caffeine (in coffee), nicotine, and alcohol, or any illegally procured drugs. The U.S. Food and Drug Administration estimated in 1964 that about half of the amphetamine and barbiturate doses produced annually got into illegal channels. Thus, the above figures may under-estimate the percentage of people using drugs at any one time. These data suggest that a substantial proportion of the population is exposed to driving after drug use at least some time during the year.

Parry (1968) has reported on two surveys of the incidence of psychoactive drug use by U.S. adults, and both indicate that "about one-fourth of the U.S. adult population currently use one or another of the legal psychotropic drugs -- sedatives, tranquilizers and stimulants". By "currently" is meant use of a drug within the 12-month period preceding the questionnaire. Forty-eight percent of the people answering the questionnaires had taken a drug at some time preceding the test day. A survey of adults in California (Manheimer, Mellinger & Balter, 1968) showed that frequent use was reported by 17% of adults.

Parry (1968) divides the psychoactive drugs into sedatives, tranquilizers, and stimulants. Unfortunately, the breakdown is not carried further; sedatives include both the prescribed and potent compounds, such as the barbiturates and mild over-the-counter preparations like "Sleep-eze"; tranquilizers include both meprobamate and "Compoz"; stimulants include both amphetamine and "No-Doz". Even with these large categories, Parry found that women use more psychoactives than men, and that older people tend to use proportionately more sedatives, while younger people use more stimulants. Accident problems involving drugs may therefore be age-related.

A study by Fejer and Smart (1972) of 1,200 adults in Toronto during 1971 showed that 24% had at least one prescription for psychoactives in the past year. Tranquilizers were most commonly used (13% of sample), followed by barbiturates (8.6%), and stimulants (3.6%). There was considerable multi-drug use, in that 4 or 5 times as many tranquilizer users took barbiturates or stimulants than did non-users. Tranquilizer and barbiturate users tended more often to be older females, whereas stimulant users were more often young persons (less than 25) of both sexes.

Some studies (Chelton & Whisnant, 1966) have demonstrated a discrepancy in the incidence of drug use found between the answers obtained by questioning (9% use) and by actual analyses (38% use). Chelton and Whisnant's study (1966) involved 100 alcoholics who were asked about barbiturate and tranquilizer usage, and who then submitted to urinanalysis for these drugs. This study indicates a need for verification, whenever possible, of answers obtained solely by questioning. However, a study by Parry, Balter, and Cisin (1970) suggested that 75 to 80% of all prescriptions could be reported on questionnaires, especially if detailed questions were asked. Various studies of the validity and reliability of questionnaire estimates of illicit drug use have been made by Whitehead and Smart (1972). In general, they suggest that such estimates of illegal drug use are fairly accurate for youthful populations.

Studies of psychoactive drug use in special driving populations have been made by Rees (1966), Milner (1969), and Adams et al. (1966). Rees (1966) had access to the medical records of most (77%) of the drivers licenced to drive in a rural area of Wales. The percentage of people taking psychoactive drugs would seem to be less than Parry's (1968) figure, although an exact comparison cannot be made. Parry's incidence of 25% refers to all psychoactive drug use within the preceding 12 months, while Rees' 3.4% refers to people taking only prescribed psychoactives for more than 3 months within the preceding 5 years. In addition, Rees' population is from rural Wales; Parry's is an urban and rural cross-section of the United States. Adams et al. (1966) found that 4% of a general-practice-population, many of whom were probably licenced, were taking a barbiturate at any one time. About 80% of this population were female, with a peak in the ages 40 to 49.

Milner's study in west Australia (1969) gives the only estimate of the percentage of a population-at-risk of drinking-driving while on psychoactive medication. In a sample containing 4,020 general practice patients and 564 psychiatric patients, 8.4% of the general and 73.5% of the psychiatric patients were prescribed psychoactive drugs. The combined sample gives an incidence of 16%. Of these patients on medication, Milner calculated that 57% of the men and 35% of the women were running the risk of drinking and driving while on psychoactives. About 7.1% of the total population questioned ran the risk of drinking and driving while on psychoactives. One valuable aspect of Milner's study is that the information about psychoactive drugs was obtained from medical records, while many studies rely totally on questionnaires. However, it tells us nothing about risks of driving under self-medication or illicit drugs.

2.2 Hallucinogens and Narcotics

Of all hallucinogens and narcotics, cannabis appears to be the most frequently used. Its use is sufficiently frequent in young people to be certain that it must be used before or during driving. Surveys by Berg (1970) for the United States and Smart and Fejer (1971) for Canada show that cannabis is used by more high school and college students than any other drugs but alcohol and tobacco. Usage rates vary from place to place. About 18-25% of high school students and 27-50% of college students have used cannabis, the majority at least 7 times in the past 6 months. Usage rates are much higher for selected sub-samples, e.g., hippies (100%), heroin addicts (100%), soldiers in Viet Nam (68%), etc. (see Mercer & Smart (1972) for a review). However, rates are much lower for adults, with about 6-13% using cannabis (Mercer & Smart, 1972).

Rates of use of LSD in student and adult populations vary enormously, but are typically only 15 to 20% of those for cannabis (Mercer & Smart, 1972). Rates of use of opiates are much lower (1 to 2% of high school populations), with estimates of upwards of 300,000 heroin addicts in the U.S. population.

There appears to be no estimate of how often users drive under the influence of LSD or narcotics, although some estimate can be made for cannabis. Studies by Haines and Green (1970) and by the Le Dain Commission (1972) indicate that at least half of young cannabis users have driven under its influence. Many users claim that they can easily compensate for the impairing effects of cannabis, but nearly equal numbers refuse to drive until a "high" is well past (Haines & Green, 1970). In Haines and Green's study, those who do not drive after marihuana use tend more often to be females and to be less experienced users.

Klein et al. (1971) made an interesting study of driving and cannabis use among college students. They found, as have others (Smart & Fejer, 1971), that non-users of cannabis were less often users of all other drugs (including alcohol). In their study, 18% of infrequent users and 53% of heavy users had been stopped by police while under the influence of marihuana, but being "high" may not be the reason they were stopped. They also found that chronic users less often reported impairing effects on driving tests than did infrequent or former users. Infrequent users and non-users typically recommended that people should not be allowed to fly airplanes or drive cars while "high", and both groups would feel less adequate in being able to do so themselves, but frequent users were more permissive in their attitudes. Klein et al. (1971) also presented sufficient case history material relating cannabis use to accidents to suggest the need for further research.

Other problems of cannabis use related to driving impairment concern: (1) recurrent experiences or flashbacks which can occur weeks or months after the last drug experience; (2) the possibility that some illegally sold marihuana may be impregnated with other drugs, such as LSD or opiates; (3) the possibility, although apparently rare, of psychotic or panic reactions; and (4) the mixing of different drugs with cannabis by the user himself (see Le Dain (1972) for a review of these effects). Any of these events could create additional driving hazards and accidents for users, although little evidence is available to show how frequently or infrequently they do. The rarity of flashbacks, impairing drug impurities, and psychotic episodes makes it unlikely that they are very important, but this same rarity also makes it difficult to establish just how trivial they might be. If cannabis use were eventually to involve all or most of the population, these events might well become important contributors to accidents.

3. SURVEYS OF DRUG USE AMONG PERSONS INVOLVED IN ACCIDENTS

3.1 Non-Fatal Vehicular Accidents (including erratic driving arrests, etc.)

Various studies have been made of psychoactive drug use among various persons involved in non-fatal accidents. Finkle et al. (1968) investigated the "incidence and significance of drugs encountered in 3,409 routine drinking driver cases", in Santa Clara, California. They found records of 705 people (21%) who admitted to an arresting officer that they had ingested a drug within a "short time prior to arrest". There were 107 drugs which fell into 20 groups, including prescribed and over-the-counter compounds. It will be recalled that the HEW estimate for over-the-counter drug use (Traffic Laws Commentary, 1965) at any one time, gave a range of 25 to 50%. Finkle's 21% falls at the lower end of these figures, but this may be due in part to the lack of adequate questioning procedures.

In the 3,409 cases (Finkle et al., 1968), there were 246 psychoactive drugs mentioned, namely, stimulants and anti-depressants, tranquilizers, barbiturate and non-barbiturate sedatives and hypnotics. The actual incidence of people who took at least one psychotrope would be slightly less than 7.2%, owing to several cases of multiple drug use (713 occurrences of psychoactive drugs in 705 people). In each of the three drug groups, a substantial proportion (50% of tranquilizers, 50% of stimulants, and 35% of sedative hypnotics) were not named, but listed as "unspecified". This makes it impossible to calculate the actual proportions of prescribed and over-the-counter drugs in each drug category.

As a result, a comparison of Finkle's data with Milner's on prescribed psychoactives cannot be made. The proportions of the three main classes of psychoactives are similar in both studies, but because so many of Finkle's psychoactives were unspecified, the comparison should be tentative. Nevertheless, the similarities are striking. In Finkle's study, 26% of the drugs were stimulants, 54% were tranquilizers, and 21% were sedative-hypnotics. In Milner's study, 19% of the psychoactives prescribed were stimulants and anti-depressants, 49% were tranquilizers, and 26% were sedative-hypnotics (6% were for "other" psychoactives). The striking similarity between Finkle's actual findings of incidence of psychotropic drugs in a drinking driver population (7.2%) and Milner's estimation of the percent of people at risk of drinking and driving while on psychoactives (7.1%) should be carefully qualified.

A further difficulty concerns the veracity of the drivers' answers to questioning. In 180 of Finkle's cases, where the BAC was at least .15% and there were signs of "overt intoxication", blood analyses for drugs were carried out. Thirty-eight cases (21% of 180) of drugs were found, 11 of which were not indicated upon questioning. In other words, about 30% of people whose blood and urine showed the presence of drugs did not admit to them on questioning. Finkle added these 11 cases found by analysis to the 705 cases found by questioning, and arrived at a total of 716 drug cases. Because so many drug cases were found that were not indicated by questioning, suspicion is cast on the actual incidence of drug use in the 3,409 drivers.

A last problem concerns those drugs which would not be detected by Finkle's analytical procedures. In the tranquilizer groups, these drugs included Librium, Valium, Vesperine, and the phenothiazine derivatives, but in his results, two cases of Librium were detected. However, the discrepancy is not explained.

Another class of compounds which could not be detected were the amphetamines. They have a real potential for creating traffic hazards as they may affect judgement (Hollister & Clyde, 1968) and estimation of risk (Hurst, 1962), as well as result in reactive fatigue when the effects have begun to wear off. Finkle et al. (1968) reported 14 cases in which the driver exhibited gross signs of intoxication, no drugs were indicated upon questioning, BAC was less than .15%, and no drugs were found upon analysis. Possibly, the intoxication was due to the effects of one of the undetectable drugs. Finkle also found subjects who exhibited signs of intoxication normally associated with high BACs (< .24), who had BACs < .15, and evidence of a drug upon analyses. There were only 11 such cases, but more may have appeared if a sampling had been made of people admitting or not admitting to drug use and having some alcohol in their blood. In 13 cases, the BACs were negative, but there were gross signs of intoxication and at least one drug was present upon analysis. Their findings indicate the need to investigate the deleterious effects of drugs as well as alcohol on driving.

A later study by Finkle (1969) involved samples from 10,436 suspected drinking drivers in California. Almost 25% had a drug involvement and 13% involved "dangerous" drugs which are given on prescription. Only 6% of the drug positives were negative for alcohol, and most were males in their 20's to 40's. It is of interest in this study that most drug positives were not indicated by police questioning.

Several other studies, for example, by Reinartz (1962), Wagner (1962), and Wangel (1962) involved motorists being questioned about their drug use.[1] They

[1] An additional study by Wagner (1963) contains very little information on the drugs used by some 5,000 drivers who were questioned.

found rates of drug use of 15.2%, 11%, and 15%, respectively, even though Wagner's study involved impaired drivers, and those by Reinartz and Wangel involved accident drivers. All three studies are European (the first two from Germany, the last from Denmark), and they show remarkably similar rates of drug use. Unfortunately, none of the investigations attempted to verify their results by laboratory drug analyses.

Both Reinartz (1962) and Wagner (1962) found an increase in rates of drug use with age: Reinartz, from 0% in 14 to 18 year olds, to 46% in the over 65 year group; Wagner, from 1.1% in the 14 to 18 year olds to 19.1 in the over 60 year group. Since older people involved in accidents have the highest incidence of drug use, some older persons should be tested as subjects in experiments assessing impairing effects of various drugs. Such experiments typically use only college-age students.

The study by Reinartz (1962) was concerned with 500 drivers who admitted to having taken a variety of drugs within the preceding 24 hours. Reinartz concluded that "it may be assumed that of these, driving ability was impaired in 4 to 5%," but the basis for this conclusion is not made clear. The potential hazards of drug combinations have, on the whole, not been assessed and may present a greater hazard than that estimated by Reinartz.

Wagner's (1962) population consisted of drivers who had been involved in traffic accidents (67%), or had been driving conspicuously (33%). The sample was selected so that: (1) all drivers had a measurable BAC, and (2) "neither the extent of injury nor the degree of intoxication was severe enough to make normal questioning impossible." Wagner found the prevalence of various classes of drugs to be age-dependent; sedatives were used most frequently by people between 25-40 years (27.3%), and 40-60 years (50%). An interesting finding in Wagner's report is that sedative users had a higher percentage of accidents (77%) than did the total group (67%), but this was not found for other drug categories.

Wangel's (1962) study also involved accident drivers. Some 6,067 people involved in traffic accidents were questioned about their drug use. They were divided into acute users who took one or two doses in the preceding 24 hours to relieve acute symptoms, and chronic users who took drugs for a longer period than the preceding 24 hours. These cases were divided into alcohol and alcohol-free groups. BACs were measured, however, and no non-alcoholic drug analyses were done.

Wangel's (1962) general aim was to see if "drivers who consume ordinary therapeutic doses of drugs get more intoxicated by alcohol than other drivers with the same concentration of alcohol in the blood but without drugs." He found, on the average, that chronic drug users had the same average BAC as the non-drug users, and concluded, therefore, that synergism was not involved. With acute drug users, he found lower average BACs in three drug groups: (1) analgesics and antipyretics, (2) psycho-pharmacological drugs like meprobamate, and (3) miscellaneous drugs, e.g., antibiotics and hormones. He proposed that "these people had a lower blood alcohol level because of an acute state of bad health which demanded use of these drugs." Although this may be the case for Groups 1 and 3, it seems less likely for Group 2.

Wangel (1962) also examined the concept of synergism with respect to meprobamate usage. Of 63 chronic meprobamate consumers "slightly under the influence of alcohol," 18 fell into the age range of 31 to 45 years. This group of 18 is compared with a "control" group of 109 "consecutive cases of drug-free people" age 31 to 45 who were slightly under the influence of alcohol. As both groups had similar BACs (0.146% and 0.149%, respectively), he concludes: "Thus, the consumption of meprobamate has not potentiated the effect of alcohol in this group as far as driving ability is concerned".

An interesting study by Gupta and Kofoed (1966) was concerned with official data on barbiturate and tranquilizer use in relation to accidents. They presented data on the number of drivers charged for driving under the influence of alcohol who had tranquilizers or barbiturates in their systems, but not alcohol. The number of such cases in Ontario showed an increase from one in 1958 to 25 by 1964. Unfortunately, it is not certain how the reporting system changed during these years. Much of the apparent increase may be due to increasing use of analytical methods for the non-alcoholic drugs. Some such studies where reporting artifacts have been removed would be of considerable value.

An excellent study by Berg et al. (1971) investigated the relationship between licit and illicit drug use among college students involved in accidents as drivers and a comparative group not so involved. Blood tests and questionnaire estimates were made for many psychoactive and narcotic drugs in students seen at a university health center for accident involvement and no accident involvement (controls). None of the data indicate any connection between drug use and accidents; however, the sample of accident drivers was rather small (N = 24).

3.2 Fatal Vehicular Accidents

To date, there have been several studies of drug use in fatal accidents. Blood determination studies are, of course, more easily performed where a fatality exists because official rights to body fluids are created by the need for their investigation.

One of the largest studies of drugs and fatalities was done in California in 1967 (State of California Highway Patrol, 1967). This study showed that 13% of persons involved in fatal single-vehicle accidents had some drug in their blood. Unfortunately, all psychoactives were not screened; blood analyses were made for barbiturates, tranquilizers, caffeine, Dilantin, anti-diabetic agents, and anti-infectants. However, no screening was made for amphetamines or opiates, as these drugs were not detectable by the method used.

The figure of 13% falls within the range of the Smith, Kline, and French estimates (10 to 20%) of U.S. adults taking prescribed drugs at any one time. This figure is probably an underestimate of psychotropic drug use because, of the 772 fatalities, 10% had psychoactive drugs in their blood. Unfortunately, this cannot be compared with Parry's (1968) figure for a general population, as he asked people about their drug use within the past 12 months.

In the California study, 70 of the 102 drug cases had a measurable concentration of alcohol in their blood (at least 0.01%). Thirty-eight percent of the 102 drivers were "excessively impaired" (i.e., BAC of 0.20% or higher). The percentage of people with drugs who had a BAC of .10% (60.8%) is only slightly smaller than the proportion of the total population with a BAC of .10% (66.8%). There were 9 cases of multiple drug use in addition to alcohol, and the authors concluded that "there is little hesitation by many people to mix drugs with alcohol".

There were 121 drug occurrences in the 102 cases; this involved 94 psychoactive drugs and 27 drugs of other types. Of the 94 psychoactive drug occurrences, 60% were for barbiturates, 10% were for tranquilizers, and 31% were for stimulants (namely caffeine). This distribution of psychotropes is far different from Milner's (1969) or Finkle et al. (1968) in that here, the most prevalent psychotropes were in the barbiturate class. There may be some connection between a seemingly disproportionate number of barbiturate occurrences and fatal vehicular accidents. Since the California investigation only partially screened for non-barbiturate sedative-hypnotics and tranquilizers, and did not screen for amphetamines, the distribution of the three classes of psychoactives could, in reality, be very different.

Although the California study is the largest, several other studies (Davis & Fisk, 1966; Waller & Turkel, 1966) have dealt with drug use among fatally injured drivers. However, all searched for a limited number of drugs, and a few are difficult to interpret. For example, Braunstein (1968) and his colleagues screened 188 fatally injured drivers for "the total spectrum of drugs which could impair driving." He found very few drug cases (2 cases of barbiturates and one of Dilantin), and concluded that "drugs play a minor role in fatal accident causation." A report by Konkle (1969) creates similar difficulties in that both the persons and drugs sampled are difficult to determine, but only 1.4% of fatalities were reported as having used psychoactive drugs (chiefly barbiturates and stimulants). As few details are given of the actual research procedures, evaluation of these data is difficult. Tranquilizers were apparently not analyzed for in the samples done and these may account for the low rate of drug use found.

A study of road fatalities among U.S. forces drivers (U.S. Department of the Army, 1967) investigated a wide range of psychoactive drugs (narcotics, barbiturates, tranquilizers, antihistamines, and amphetamines). Drug analyses were done for 90 of the 164 driver fatalities and no drugs above the "therapeutic level" were found.

Briglia's (1966) study of 95 fatal auto and cycle accidents screened only for barbiturates and alcohol. This study found 3 drivers with barbiturate levels and 47 with blood alcohol concentrations. However, as the author says, the screening program "only scratched the surface."

The report by Kaye (1970) on 179 accident fatalities in Puerto Rico is one of the few to analyze for narcotics. It is a little difficult to determine exactly how many of the cases had drug determinations made, but about 790 appear to involve a psychoactive drug (from blood samples). Half of these cases involved narcotics.

Davis and Fisk (1966) examined samples from 179 drivers who were killed "immediately" in single vehicle accidents. They screened for carbon monoxide, alcohol, amphetamines, and drugs detectable by routine ultraviolet screening. They found evidence of drugs in 4.5% of the drivers. Some of their comments are pertinent to many of the accident studies listed: "Without doubt, a more careful scene and background investigation followed by additional chemical tests would reveal a greater incidence of drugs ..."; and "as a general rule, post-medical history of drug use, and even the presence of medicinal containers within the wreckage of the vehicle, may be expected to be overlooked at the time of the scene investigation." In a later study with a larger sample (N = 306), Davis found evidence of psychoactive drugs in 5.6% of "immediately killed" drivers. In 50% of these, alcohol was also detected.

Sunshine et al. (1968) described blood and urine analyses from postmortem samples on persons dying within 12 hours of the accident. They found a low incidence of drug use (they do not give the total number of persons studied, but comment on their barbiturate incidence being lower than 4%). They obtained very few urine specimens (to be screened for phenothiazines and amphetamines). The long lapse allowed until time of death may have partly contributed to the low incidence.

A similarly low incidence of drugs was found in a study by Perrine et al. (1970) of 46 fatalities, where only 11% had taken any drugs at all and only 1 of the samples was a dangerous drug (barbiturate). This study illustrates the problems of trying to find rare events in a small sample, but a variety of similar studies have used samples less than 100.

3.3 Hallucinogenic and Opiate Drugs in Accident Studies

Anecdotal reports and case history material which tie hallucinogenic and opiate drug use to accidents have already been cited. Given the probably impairing effects of some doses of drugs such as cannabis and heroin and their current use, they should be involved in some accidents. To date, no accident investigation studies have inquired about their use among drivers or victims. Consequently, there is a blank in knowing what proportion of drivers or victims of any description took a hallucinogenic or opiate drug prior to their accident. Only one study (Finkle et al., 1968) investigated drug use in any accident drivers seen at a university health center. Sophisticated analyses would be more difficult than with alcohol in that blood and urine samples would be required for opiate and hallucinogenic drugs.

With cannabis it is doubtful whether urine or blood samples would help in this research since "a simple and efficient method has not been developed for the detection and quantification of unlabelled cannabinoids in the body" (Le Dain, 1972, p. 36). However, cannabis can often be detected in saliva samples or skin swabs hours after use (Le Dain, 1972). A study of accidents where drivers and/or victims were asked to report recent non-prescription drug use and to provide saliva samples would substantially reduce our ignorance about cannabis and driving. This, of course, should involve a comparable group of controls not involved in accidents, e.g., passing the scene of a prior accident.

4. STUDIES OF ACCIDENT RATES AMONG DRUG USING AND DRUG ABUSING POPULATIONS

Numerous studies have been made of accident and violation rates among alcoholic drivers (e.g., Schmidt & Smart, 1959; Waller & Turkel, 1966), but this research approach has less often been taken with hallucinogenic and psychoactive drugs. Only a few studies have apparently been made of the driving records of psychoactive drug users. Smart, Schmidt, and Bateman (1969) studied the records of 30 patients addicted to or dependent upon sedatives, tranquilizers, or stimulants (some were also alcoholics). It was found that these patients had accident rates about twice as high as expected for their age and sex, and exposure (miles driven). Most of the excess accidents could probably be attributed to amphetamine users who often admitted use prior to their accident. Accident rates for barbiturate and tranquilizer users were lower than expected. This study involved a small sample size, especially for the subgroups, and the model could profitably be applied to larger groups of youthful speed users and adult drug users, especially of stimulants. Murray (1962) reported that 68 drivers taking

Librium over a 90-day period had 10 minor and 6 major accidents, a rate 10 times as high as expected.

Somewhat greater interest has been taken in the driving experience of cannabis and heroin users. However, the results are rather contradictory. One of the first studies in this series was by Waller (1965). For it, records of 231 drivers convicted for illegal possession or use of "addicting" drugs were searched. This sample probably contained mainly heroin and cannabis users and few prescription drug users. Accident and violation rates corrected for exposure were calculated. It was found that the drug users had only the expected accident rate, but 1.8 times the violation rate. In a later paper, Waller (1971) stated that in this sample, there was no direct association of marihuana use with accidents in that their accident records were known to the police before drug use. Waller and Goo (1969) also showed that the accidents and violations of the drug users were similar to those of younger drivers in general, and not peculiar to drug users. However, drug users accidents seemed more often to involve fault for the drivers, excessive speed, more errors, weaving, and inattention. Similar results to Waller's were found by McGlothlin et al. (1970) in a study of adult cannabis users who volunteered for LSD, and by Haines and Green (1970), none of whose cannabis users who drove when high reported accidents when "stoned".

Different results for accident rates among cannabis and heroin users have been reported in several studies. Crancer and Quiring (1968) compared accident and violation rates for matched samples of users (of heroin, barbiturates, LSD, and marihuana) and non-users. The users had substantially more accidents and violations than non-users -- marihuana and heroin users had 29% more accidents, and users of depressants and stimulants 57% more than the non-users. Drug users had especially high violation rates for reckless driving, hit-and-run, and defective equipment. A study of 1,245 registered opiate users in New York also found much higher than expected rates of accidents and violations (Babst, 1969), although these two types of problems were not differentiated. A somewhat similar study of 1,889 arrestees by Moser et al. (1972) failed to find that drug users (chiefly heroin addicts) had higher rates of accidents or convictions than did non-users. This suggests that when social class and other non-drug use factors are controlled, heroin addicts may not be expected to have poor driving records.

Klein et al. (1971) found that cannabis users (especially heavy users) admitted more violations and licence revocations than non-users, but it is not known whether the driving errors occurred while "high." A study of high school students in Virginia (Ferguson & Howard, 1971) also reported that 2.93% of students admitted involvement in an accident as a driver or victim in which marihuana "may have been a cause."

Although interesting and suggestive, these studies do not provide unambiguous information about the role of drugs in accident causation. Except indirectly for Moser et al. (1972), such studies fail to control for personality and social class characteristics, which may be associated with drug use (especially heroin) and accident rates as well. It should also be noted that a WHO report (1965) estimated that only 1% of heroin addicts in New York hold licences, fewer than expected for their age and sex, although a study of registered addicts found 20% (Hughes, Cramer & Knight, 1967). The contribution to accident rates by heroin addicts may be minor because fewer are licenced. Also, few studies demonstrate that the accidents or violations occur while the user is under the effect of the drug. Drug users are typically multi-drug users, and assigning their accident experience to the effects of a particular drug is often difficult to do. Lastly, no study has looked in detail at accident rates both before and after drug use began; consequently drug use may be only tangentially related to high accident involvement.

5. CONCLUSIONS ON THE BASIS OF PRESENT RESEARCH

This review of data on drug involvement in vehicular accidents indicates that few propositions have been clearly established and no studies have been replicated.

Various studies have been made of drug use in the general population, but they are not directly relevant to accident risk rates. An assortment of figures on "drug" incidence in accident and non-accident drivers is available, but few investigators have inquired about the same drugs. Still fewer have made laboratory screenings for them. Also, no two investigators have used similar criteria for selecting their cases, and thus different populations are described. Many "procedures" for data collection do not seem to be reliable nor can they be reproduced by others for comparative purposes.

Even with these qualifications, it can still be stated that much psychoactive and hallucinogenic drug usage is potentially hazardous to drivers. The following conclusions can be supported, at least tentatively:

5.1 Studies of rates of psychoactive drug use show that 35 to 50% of the general population run the risk of driving after drug use at least once per year. About 7% of the general population are exposed to risk of drinking and driving while on psychoactives.

5.2 The extent of use of amphetamines by accident and non-accidents drivers is especially uncertain as few relevant studies have utilized laboratory analyses for these drugs. Most studies have been concerned with barbiturates or selected tranquilizers.

5.3 There is a substantial problem of psychoactive drug use among drinking drivers. At least 7% of drinking drivers have a psychoactive drug in their system and this estimate is almost certainly very low. Perhaps a more important observation is that at least 50% of fatally injured drivers with drugs in their system have also been drinking. Of course, this makes the attribution of impairment to alcohol or drugs impossible. However, it also suggests that drugs and driving may be much the same problem as drinking and driving. The psychoactives often do not represent a substitute for alcohol, but an additional element to be combined with each other or with alcohol.

5.4 The veracity of drivers' statements to police about drug use is low, and drug use estimates derived from questioning are probably conservative. Studies based on analyses, however, report varying results with 0 to 13% of fatal accident drivers having taken a psychotropic drug prior to their accident. The rates vary so markedly from one study to another that a meaningful choice amongst them is almost impossible.

5.5 At least some psychomotor impairment in drivers with low or non-existent blood alcohol concentrations is due to their use of psychoactive drugs. It follows that some highly impaired drivers will be missed by alcohol screening procedures.

5.6 Few studies have analyzed for narcotics, but those which have suggest that narcotics may constitute a large proportion of the total positive analyses for accident drivers and victims in some areas.

5.7 Barbiturates are the psychoactive drugs most commonly found among accident and non-accident drivers.

5.8 More mysteries would appear to surround the contribution of opiates and hallucinogens to driving risk than in the case of prescription drugs. Difficulties in easy road-side or laboratory analysis are at least partly to blame, especially where marihuana is concerned.

5.9 To date, there has been no determined effort to associate the use of psychoactive 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 psychoactive drugs would actually be more dangerous on the road without them than with them.

5.10 Hallucinogenic drugs, such as cannabis and LSD, have not been analyzed for their frequency in fatal accident drivers. Few analytic or questionnaire studies have been made of how many drivers were using these drugs alone or with alcohol before their accident.

5.11 Studies of cannabis users are inconsistent as to whether such users have higher than average rates of accidents. Studies with excess accident rates among cannabis users have not demonstrated that their accidents can be attributed to cannabis use rather than to social, demographic, or personality characteristics.

5.12 It would appear that some heavy users of drugs, especially heroin addicts, do have elevated accident and/or violation rates. However, it is not clear whether their accidents and violations are mainly due to their drug use or to other associated social and psychopathologies. An important question is whether one wishes to identify high risk drivers or the reason (drug use?) for their high risk.

5.13 The percentage of drivers not involved in accidents (e.g., those passing the scene of an accident, but not involved), with particular drugs in their system has not been determined, except for alcohol.

5.14 Nothing is known of the contribution of drug use to pedestrian accidents.

6. IMPORTANCE OF DRUGS RELATIVE TO OTHER DRIVING PROBLEMS AND CURRENT RESEARCH NEEDS

It may seem difficult to consider the importance of drugs and driving problems and the current research needs of the field at the same time. However, the view taken here is that the first cannot be adequately decided without the second being discussed. Nichols (1971) in his major review of the relevant literature concluded that "drug use (other than alcohol) is not a major factor contributing to highway crashes and fatalities." A similar conclusion was reached by the Le Dain Commission regarding cannabis (Le Dain, 1972), but they cautioned that "continuing changes in the frequency and patterns of use of cannabis ... in addition to improved research techniques may substantially alter the epidemiological picture in the future." Milner (1972), however, concluded that the contribution of drugs to driving risk is a substantial one requiring treatment, prevention, legislation, and education programs. It should be noted that Milner was considering mainly prescription drugs in his analysis.

At present, the largest gaps in knowledge concern the role of hallucinogens, narcotics, and -- to a lesser extent -- amphetamines in driving risk. The difficulties of securing body fluids and analyzing for these drugs mean that they have rarely been examined for a role in traffic accidents. It is possible to agree with Nichols that drugs appear to represent a small problem with regard to driving risk. However, it should be strongly emphasized that this could be more a feature of the state of the art and current research inadequacies than a representation of reality. Further, increases in the youthful use of cannabis and other drugs as well as psychoactive drugs by adults may mean that the problem will become both greater and more easily studied.

Relative to some driving risks, drugs would appear to be a small problem -- based on existing evidence. The possible reduction in accidents and fatalities represented by eliminating known drug use before driving could not be more than 10% at the outside. It probably would be much less because it is not known that all drug using drivers were at fault or that their "fault" resulted mainly from their drug use. Elimination of drinking before driving or of excessive speeding, and the provision of passive restraint for passengers or certain highway modifications would likely result in far greater reductions in accidents and fatalities. It is possible, though, that the study of cannabis use could account for some proportion of accidents among young persons or that psychoactive and narcotic drugs could account for accidents among heavy using adults, alcoholics, or multi-drug users.

Current research needs would seem to center around two major areas: (1) establishing whether hallucinogenic and narcotic drugs appear more frequently in accident drivers than expected, and whether these accidents were a result of drug use; and (2) establishing for psychoactive drugs, whether accident drivers with these drugs in their system were under drug impairments which resulted in their accident. Without claiming it to be an exhaustive list, one can suggest the following sorts of studies:

6.1 Studies of cannabis and opiate use among large samples of drivers, together with estimates of how often they drive after taking cannabis alone and with other drugs.

6.2 Studies of urine taken from accident drivers and analyzed for a variety of drugs (particularly the metabolites of opiates, anti-depressants, and stimulants) would still be useful, especially if samples were obtained from non-accident drivers as comparable controls. Interviews about the use of such drugs prior to accident should also be conducted.

6.3 Assessments of cannabis use among accident drivers, utilizing both interviews and analyses of saliva or skin swabs.

6.4 Studies of the use of cannabis and other hallucinogens with alcohol among accident and non-accident drivers.

6.5 Investigation of sufficiently large samples of opiate and cannabis users to determine whether their accident rates correlate more closely to social and psychopathologies than to drug use.

6.6 Investigations of accident responsibility for all drug-involved accident drivers.

7. COUNTERMEASURES FOR THE DRUGS AND DRIVING PROBLEM

From the analysis and conclusions presented so far, the whole topic of countermeasures may seem premature. Without solid, replicable evidence that drugs other than alcohol contribute heavily to accident involvement, any suggestion of countermeasures must be presented in a most cautious manner. In fact, few writers or researchers have presented detailed proposals for countermeasures for the drugs and driving hazard and methods of reducing the contribution of drugs to driving risk via legal changes, treatment for heavy users, or drug education programs. Two exceptions to the general neglect of countermeasures are Nichols (1971) and Milner (1972). Neither suggest anything like a comprehensive program of countermeasures at this time, and both put more confidence in further research, although Nichols places particular stress on this aspect.

Nichols (1971), after an extensive and important review of the field, concludes that more legal countermeasures are not indicated due to the small size of the problem, the ineffectiveness of legal controls, and the like. He also surmises that concentration on drug countermeasures at this time could de-emphasize alcohol countermeasures programs which are far more necessary. It could well be that further concentration on alcohol and driving countermeasures could reduce the psychoactive drug and driving problem since so many drug using accident drivers had also been drinking. The dissemination of information about abuse of drugs is discussed as a countermeasure without receiving recommendation or condemnation from Nichols.

McAtee (1963) and others, but especially Milner (1972) have suggested that certain improvements in physician prescribing habits would be effective countermeasures. Among these improvements suggested by Milner would be: (1) warnings by physicians about driving after drug use; (2) not prescribing drugs for patients who are likely to drink and drive or because of personality or social characteristics to be high accident drivers; (3) prescribing psychoactive drugs for patients who must drive only if they have a low impairment potential; (4) prescribing shorter courses of therapy with drugs such as barbiturates. He is equally as pessimistic as Nichols about providing heavier legal penalties for drinking and driving.

The major problem with suggesting any educational or legal countermeasures program is, of course, that one does not know the maximum possible benefit. Most jurisdictions in North America have some laws prohibiting drug use and driving (Nichols, 1971). It is unlikely that additional legal countermeasures could be defended because of present scientific uncertainty about risks prevented and the lack of simple assay procedures such as breath tests for identifying transgressors. Without such evidence, both public and legal support for the laws would be impossible. At present, the likelihood of significant impact makes further legal measures unnecessary and undesirable.

With regard to educational countermeasures, the situation would be different. Disseminating information about drugs and drug impairment related to driving does not have the same problem as do legal changes. No criminalization or misidentification of users takes place. Further, the addition of information about drugs and driving to existing education programs would probably not be an onerous task. The training of physicians to recognize drug impairment of driving has already been suggested by Milner (1972), as has the need for physicians to caution patients receiving psychoactives. Furthermore, many high school students are currently receiving drug education programs. Content analysis of many of these programs indicates that very few include a discussion of driving risks. Such programs could be expanded to cover this aspect more adequately, but a sanquine view of the efficacy of this approach should be maintained. For example, it has been shown by Appleton and Chien (1967) that physicians knowledge of the effects of psychoactive drugs bore no relationship to how often they prescribed them. Smart and Fejer (1972) also showed that illicit drug users knew more facts about drugs than did non-users. This would suggest that although facts may set you free, they do not necessarily result in more judicious behaviour. Just how having the facts about drug impairment would affect the driving of drug users remains to be seen.

8. SUMMARY

This review of data on drug involvement in vehicular accidents indicates that few propositions have been clearly established and no studies have been replicated. An assortment of figures on "drug" incidence in accident and non-accident drivers is available, but few investigators have inquired about the same drugs. Still fewer have made laboratory screenings for them. Also, no two investigators have used similar criteria for selecting their cases, and thus different populations are described. Many "procedures" for data collection do not seem to be reliable nor can they be reproduced by others for comparative purposes.

The following conclusions can be supported:

(1) Studies of rates of psychoactive drug use show that 35 to 50% of the general population run the risk of driving after drug use at least once per year. About 7% of the general population are exposed to risk of drinking and driving while on psychoactives.

(2) The extent of use of amphetamines by accident and non-accident drivers is especially uncertain as few relevant studies have utilized laboratory analyses for these drugs. Most studies have been concerned with barbiturates or selected tranquilizers.

(3) There is a substantial problem of psychoactive drug use among drinking drivers. At least 7% of drinking drivers have a psychoactive drug in their system, and 50% of fatally injured drivers with drugs in their system have also been drinking. This suggests that drugs and driving may be much the same problem as drinking and driving.

(4) At least some psychomotor impairment in drivers with low or non-existent blood alcohol concentrations is due to their use of psychoactive drugs. It follows that some highly impaired drivers will be missed by alcohol screening procedures. Few studies have

analyzed for narcotics, but those which have suggest that they may constitute a large proportion of the total positive analyses for accident drivers and victims in some areas. Barbiturates are the psychoactive drugs most commonly found among accident and non-accident drivers.

(5) Less is known of the contribution of opiates and hallucinogens to driving risk than of prescription drugs. Difficulties in easy roadside or laboratory analysis are at least partly to blame, especially where marihuana is concerned. There has been no determined effort to associate the use of psychoactive drugs by drivers with specific driving errors or with responsibility for accidents. Further, it is not known whether drivers who need psychoactive drugs, would actually be more dangerous on the road without them than with them.

(6) Hallucinogenic drugs such as cannabis and LSD have not been analyzed for their frequency in fatal accident drivers. Few analytic or questionnaire studies have been made of how many drivers were using these drugs alone or with alcohol before their accident.

(7) Studies of cannabis users are inconsistent as to whether such users have higher than average rates of accidents, and their accidents can not be attributed to cannabis use rather than to social, demographic, or personality characteristics. However, some heavy users of drugs, especially heroin addicts, do have elevated accident and/or violation rates. However, it is not clear whether their accidents and violations are mainly due to their drug use or to other associated social and psychopathologies.

At present, the largest gaps in knowledge concern the role of hallucinogens, narcotics, and to a lesser extent amphetamines in driving risk. The difficulties of securing body fluids and analyzing for these drugs mean that they have rarely been examined for a role in traffic accidents.

Relative to some driving risks (e.g., drinking), drugs would appear to be a small problem -- based on existing evidence. It should be strongly emphasized that this could be more a feature of the state of the art and current research inadequacies than a representation of reality. The possible reduction in accidents and fatalities represented by eliminating known drug use before driving could not be more than 10% at the outside. It probably would be much less because it is not known that all drug using drivers were at fault or that their "fault" resulted mainly from their drug use.

Extensive work on countermeasures against drugs and driving is not indicated currently. Education, in terms of fair, unbiased information given to physicians and young people is recommended for the present. The most valuable countermeasure may, however, be suggested from some of the further research on drugs and driving, especially the narcotic and hallucinogenic drugs. Serious application of countermeasures will, of course, depend on the outcome of this research and on the establishment of drugs as a priority investigation and social policy area.

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DISCUSSION

PERRINE: One question has already been submitted.

"ON THE STUDIES OF ARRESTS FOR DWI ANALYZED FOR BLOOD ALCOHOL CONCENTRATION IN THE PRESENCE OR ABSENCE OF DRUGS, YOU NOTE THAT THE AVERAGE BLOOD ALCOHOL CONCENTRATION OF THOSE ARRESTED IS NEARLY THE SAME WHETHER OR NOT DRUGS WERE ALSO PRESENT, YET YOU FEEL PRETTY SURE THAT MANY OF THESE DRUGS, FOR EXAMPLE BARBITURATES, ARE AT LEAST ADDITIVE WITH ALCOHOL REGARDING IMPAIRMENT. ONE MIGHT THEREFORE EXPECT TO FIND A LOWER MEAN BLOOD ALCOHOL CONCENTRATION IN THOSE ARRESTED FOR DWI WHO ALSO HAD DRUGS PRESENT. DO YOU HAVE AN EXPLANATION? I HAVE AN HYPOTHESIS." (Hurst)

SMART: I wonder whether we know if when they were arrested, their impairment was at the same level as for people who were DWIs with alcohol only. There are findings showing that a number of arrested people with rather low blood alcohol levels had severe behavioral impairments. It looked as if they ought to have a much higher blood alcohol level. When analyses were done, it was found that a very large portion of them did have some non-alcoholic drug in their system. However, the total number of cases like that is not very great.

MOSKOWITZ: What is not clear to me is the supposition that blood alcohol levels should be different. Are you supposing that the police should have picked them up sooner? I don't understand the initial assumption that you would expect their blood alcohol level distribution would be different.

HURST: What I was assuming was that the police have some sort of a behavioral threshold; the police would pick somebody up for some sort of conspicuous action that they would see. If there is indeed, as we have strongly suspected, an additivity between barbiturates and alcohol, then people would attract police attention at maybe .10% blood alcohol if they also had some barbs in them, but they would not drive this erratically until maybe .20% alcohol if they did not also have the barbs in them at the time.

SMART: It could be accounted for if the police doing the arresting thought that the people with alcohol and drugs were more impaired than the ones with alcohol only at a given blood alcohol level. I don't know whether we have that kind of information.

HURST: I have an hypothesis that this difference could well occur because the total statistics get watered down by the fact that people with the barbs in them tend to be barbiturate users and they therefore tend to have a tolerance to barbiturates and consequently a cross-tolerance to alcohol. Because they are probably heavier-than-usual alcohol users, they tend to have a direct tolerance to alcohol as well. These tend to wipe out the differential impairment effect they get from having the barbs on top of the alcohol and that is why you don't get that much more difference in the blood alcohol.

WALLER: I would like to suggest two other things that may be going on here. First, regarding methodologic information that we don't have and could use is that we do not have information about dose-effect relationships with drugs other than alcohol that we have with alcohol. Also, we don't have information in cases where there is combined use of alcohol plus another drug -- whether these drugs that actually were obtained were on prescription or not. In looking at the types of drugs that are found in conjunction with large amounts of alcohol, my impression is that, by and large, they are the sorts of drugs that are being used for the treatment of emotional disorders, including drinking problems. I don't know how plausible it is, but there is one hypothesis that if the individual does have a serious emotional problem, he is a little better off with the drug which is providing some sort of help for him even with the alcohol than he is with just the alcohol alone. As I said, it is a "way-out" hypothesis.

PERRINE: There is evidence for the notion that the person who needs some sort of sedating effect -- whether tranquillizer, alcohol, or what have you -- needs it for emotional reasons. So, he is going to get it one way or another -- sometimes both ways, as you point out. And the question is, whether he is a higher risk if he has neither the tranquillizer nor the alcohol, and is driving in an emotional state on the highway?

SCHNEIDER: An alternative hypothesis is simply that the effects of the two drug processes are not additive, and there is evidence for that in the laboratory.

HURST: In laboratory tests, if you are talking about meprobamate, for example, and alcohol, there have been mixed findings about whether the effects are additive; if you are talking about barbiturates and alcohol, you won't find many studies that show a less than additive effect. Some seem to suggest the potentiation, but I am not at all sure about that since the proper model to test for potentiation has seldom been employed and otherwise it is impossible to distinguish potentiation from simple nonlinearity.

SCHNEIDER: The conclusion that an additive effect exists is very much subject to the dimensionality of the measures you are looking at. If you have just one figure of merit representing a complex of behavior, such as driving, and you are now observing an "additive" effect, this could be the result of a variety of highly different things at the physiological level, simply because the dimensionality for the actual task has been grossly reduced. The greater the reduction, the greater the likelihood of additive effect.

SMART: Does he mean additive for one function, but not another?

SCHNEIDER: What may be happening is that additivity occurs by virtue of the index of behaviors being used. The one drug may be affecting action "A" and the other drug may be affecting action "B". For example, one could be affecting visual search and the other could be affecting general activity. Because of the gross measures we use and the way we look at things, they look additive.

HURST: I would like to answer that. Again, I think that if you are considering laboratory tests with, for example, alcohol and amphetamines, it would be very much dependent on what your variables measure. The effects may be additive, subtractive, or something else. If you are considering alcohol and barbiturates, I think the profiles of the two drugs individually are pretty similar, and from what we know at this time, they tend to be additive by components. Of course, this is not exhaustive of everything that could have been done. But they both tend to cause people to slur their words, to stagger around, to have lapses of attention, to go to sleep and so forth, and I am willing to generalize enough to say that barbiturates and alcohol do seem to have very similar profiles.

CONGER: Wouldn't you also say the same for many tranquillizers and maybe antihistamines?

HURST: To a lesser extent. Librium, for example, has often been found not to increase impairment from alcohol.

NICHOLS: This idea of additive and synergistic effects has really been "played-up" in recent years and the emphasis on it has not reflected the essential complexity of the situation or the inconsistency of the research findings. Several problems are apparent. First of all, you have the problem of selecting experimental tasks which validly reflect the driving task. Then you have the complications arising from the fact that different drugs may similarly affect a particular skill, but by means of different actions on the central nervous system. Finally, there is the problem of determining "equal intervals" of deterioration in the performance of a particular task. Factors such as these are seldom pointed out in the many casual statements made concerning the interactions of various drugs.

As Dr. Hurst pointed out, with similar drugs such as alcohol and barbiturates, the depressant effects of each of the drugs appear to summate. Research results consistently reflect a skill deterioration resulting from a combination of these two drugs which is greater than that due to either drug taken alone. Seldom, however, have "synergistic" or "super-additive" effects been demonstrated in such behavioral studies. Furthermore, as one proceeds to combine less and less similar drugs (such as alcohol and anti-anxiety agents, alcohol and anti-depressants, or alcohol and CNS stimulants), interaction effects reflected by behavioral tasks are less and less apparent and the results of such studies become extremely variable. I would also like to comment briefly on Dr. Waller's statement concerning dose-response data. Certainly there is a lack of such data in the human performance literature. Furthermore, dose-related impairment data may be relatively more appropriate in dealing with other drugs than it was in dealing with alcohol. This is because the close correlation between behavioral impairment and the concentration level of alcohol in body fluids is not always demonstrated with other drugs. For example, drugs such as the amphetamines may remain unmetabolized in the blood long after the primary behavioral effects have subsided. Furthermore, there is evidence that with some barbiturates, maximum behavioral effects do not occur simultaneously with maximum concentration levels. The point that I am trying to make is that, for descriptive purposes, dose/time related data is more appropriate in defining the relationship between drugs and behavioral impairment than was the case with alcohol.

MOSKOWITZ: The discussion about the interaction of drugs and alcohol is very important. However, what precipitated it was the problem of DWIs with alcohol and barbiturates in their system. I have done some work in a small community in Los Angeles where we examined the kind of justice biases occurring between the arrest and those who were convicted. We found that there was a very systematic bias; black and Mexican-Americans tended not to refuse a blood test when challenged with possibly losing their licences for refusing. The Caucasian would not take the blood test and take his chances on meeting the challenge. He would hire a lawyer and would ask for a jury trial. The black and Mexican-Americans plead guilty in general and they were brought before a judge who would have a 97% conviction rate against the jury with a 65% conviction rate. So I would submit that biases independent of blood analyses results have a good deal to do with conviction rates.

WALLER: Several things. First, the data that were reported were based on screening among arrested individuals, rather than among those who were convicted. I want to just mention to Jim (Nichols) that I apologize for sloppy terminology in talking about a dose-effect rate. I knew better; I did mean concentration-effect relationship.

I wonder if I might, just for the moment, describe in greater detail work that we have been doing and indicate where we had problems and where I suspect others may get into trouble also if they try and do the same thing. Reg (Smart) had mentioned that what we need is a population of fatalities and a comparable population of individuals who are using the roads, but are not involved in crashes. DOT does have a contract now with Midwestern Research Institute to do testing for marihuana among fatalities in the ASAP areas. Since the state of Vermont represents an ASAP area, our fatalities are being tested for this drug.

We were going into the field with roadblocks at times and places where serious and fatal crashes had occurred, and it seemed logical to get the (skin) wipings for marihuana on a comparison sample. We were able to get them on a sample of 500 individuals at the roadblocks. But at the same time, we tested the method by sending the laboratory some samples taken within several hours after smoking by known users. They all came back negative. We sent in another batch collected within 1 hour after smoking. They all came back negative. This was after Midwest Research had specifically told us the wipings were stable once collected. As you found since, they appear not to be stable once collected, and as far as I can determine, nobody knows right now what is the period of stability. MRI is still trying to work this one out. Potentially, however, we do have the method here.

SMART: The LeDain Commission has done some work with this and they have been relatively successful up to a period of three hours. I am just not sure how soon after the collection they do the analysis.

WALLER: Since the original plan didn't work, what we did instead was to query a class of about 2,400 freshmen and transfer students starting in September at the University of Vermont. We found that all the students were being given a profile test on one single day, and we gave them a questionnaire about experiences with marihuana and driving. Among the first thousand or so I looked at, we only had 4 or 5 individuals who returned the questionnaire blank so we don't have the problem here of volunteers.

A rough estimate seems to indicate that about a third of the students say that they at least occasionally used marihuana during the past year. We are examining a frequency/quantity index for their use of marihuana and a frequency index for their use of alcohol in conjunction with marihuana. One of the things we have been finding is that there is a changing pattern from year to year, and that right now a lot of people are using alcohol in conjunction with marihuana. If we do find that these people are getting into crashes while high, is it because of the marihuana or because of the alcohol, or perhaps because of something else. We are getting information about other drugs, about the frequency of driving within an hour or two after using marihuana, and about the frequency with which they have some sort of effect on their driving from the marihuana and about the type of effect.

Many students are saying that their driving is not "better" or "worse" or "no different;" something else is happening, so we are getting qualitative information about what else is happening. We are also getting information about the crashes and citations and near-crashes and near-citations that they have after using marihuana.

Among the individuals who say something else was happening, instead of driving "better" or "worse," they are describing changes in the attention to the road, that they're getting very paranoid of other drivers, that they're having changes in perception of time, and in depth perception. I think we will be in a reasonable position here with all this information so we can begin to talk about the number of episodes of trouble per number of "trip-trips," that is trips while "tripping."

BAKER: Today, as we try to make up our minds about the relative magnitude of the various problems, I find myself going back to Dr. Barry's comments yesterday in regard to alcohol and its effects not only on perception and motor skills, but also on decision-making, risk-taking, and so on. Apparently, a combination of these effects is likely to be involved when an alcohol-intoxicated driver crashes. In the case of marihuana, I question whether it affects decision making and risk-taking behavior as adversely as alcohol. For instance, at the Baltimore City Medical Examiner's Office, we may get the bodies of two people who were drinking alcohol and listening to records, and because one of them wanted to turn off the record player and watch TV, they killed each other. I cannot imagine two people using marihuana (without alcohol) getting into an argument that would lead them to kill one another. Experiments with the overtaking behavior of drivers who had been smoking marihuana or consuming alcohol indicated that there was less risk-taking following marihuana usage. If marihuana does not produce big changes in decision-making, changes that might lead to violent behavior, then possibly high crash rates will not be associated with marihuana usage. You may find that many of your students are using it and driving and realize that they're driving when they're much influenced by the drugs, perceptually or in terms of motor skills; however, they may be compensating much more than the driver using alcohol or a combination of alcohol and drugs.

SMART: I was just going to say that let's assume that there is the typical sort of marihuana accident. It might well be a non-aggressive kind of accident; it may not be a passing accident or a high-speed accident. It may be a running off the road which could follow from the effects of marihuana on peripheral vision and attention.

NICHOLS: I would just like to suggest that crashes are caused by different kinds of driver errors. For example, there is evidence that alcohol may contribute to the aggressiveness and willingness to take risks of drivers, thus often resulting in a crash. Marihuana, on the other hand, may contribute to improper driving via other means, such as passivity or a lack of concern of the rules of the road.

PERRINE: It's entirely possible that among some individuals, the general hostility-aggressiveness component in response to alcohol which leads to hostility in crash-prone driving behavior is not present in marihuana, but rather, marihuana may result in a reduction in concern which would lead to another kind of driving behavior and thus a crash. These possibilities would seem to merit some investigation.

NICHOLS: I agree with Dr. Perrine. Certainly, some crashes involve, and may even be caused by, the use of marihuana. Furthermore, as the number of persons using the drug increases, it is reasonable to expect even more involvement of marihuana in highway crashes. But, the accidents involving this drug may be somewhat different than those involving alcohol. More specifically, they may less frequently be of the serious head-on variety caused by improper or illegal passing. The results of research conducted in the Providence, Rhode Island simulator facility offers some support for this viewpoint.

There is some relevance here for countermeasure activities. Back in 1970, I conducted a review of drug involvement for DOT in which I suggested that countermeasures such as stepped-up enforcement procedures were not what was required at that time to adequately deal with the drug situation. What I was trying to point out was that there was a disproportionate amount of emphasis and emotionality being directed towards drugs like marihuana and LSD, as opposed to alcohol. Part of this emotionality was due to the public's lack of understanding of the effects of these and other drugs and thus a subsequent fear of them. This fear existed in spite of the fact that the demonstrated adverse effects of such drugs were much less than the effects of alcohol on our society.

I think enforcement measures are particularly important in view of these circumstances because it appears, to me at least, that much of the public's fear and emotion finds its expression in law enforcement activities. Subsequently, given the backing of the same amount, or even less, research support, laws pertaining to other drugs are often enforced much more vigorously than are laws pertaining to alcohol. Thus, at the time of the review, I felt that there already was a disproportionate public emphasis developing with regard to the effects of drugs other than alcohol on highway crashes. This, in view of the fact that little research was available to support such an emphasis, and in view of the fact that no detection tools were available for objective enforcement of drug driving laws, led me to believe that emphasis would be placed upon research in this area rather than increased enforcement.

However, now after two years of research, there are two important findings which may alter that position somewhat. First of all, there was a questionnaire survey conducted in the state of Virginia which indicated that among fatal crashes involving young drivers in that state, as many as 36% involved the use of some mind-altering drug other than alcohol. Unfortunately, the presence of alcohol in such crashes was not investigated. Further, there are always questions concerning the validity of questionnaire studies and some rather sweeping assumptions and generalizations were made. However, results from a more recent analytical study which attempted to determine the presence of drugs in body-fluid samples of fatally injured drivers lends some support to the findings of the former study. In this latter study, the NHTSA asked coroners who were participating in ASAP activities to obtain biological samples taken from fatally injured drivers in their area and forward them to a central laboratory for drug analyses. The central laboratory was under contract with the NHTSA to develop and perform such tests. Some care was taken to minimize biasing the sample of specimens sent in by requesting that coroners provide body fluids from <u>every</u> fatally injured driver who died at the scene of the crash or soon thereafter. Out of the first 191 samples which were submitted in the first year of the project, 24% contained drugs other than alcohol and 51% contained alcohol. There was a considerable overlap among the two groups, with over half the samples which contained other drugs also containing alcohol. There was also a difference in the prevalence of certain drugs found, depending on whether or not alcohol was present. In the samples where alcohol and other drugs were detected, depressants such as the barbiturates were found twice as frequently as were stimulants. When only drugs other than alcohol were detected, stimulants were found with approximately the same frequency as depressants.

Hallucinogens, other than marihuana and LSD, were found in only 3 cases and evidence of a narcotic was found in only one case. The detection methods were not sensitive to marihuana and LSD. We are now continuing this study on into the second fiscal year and plan on obtaining at least 1,000 samples. In addition, we are now planning roadside surveys for drugs to determine the frequency with which drivers on the road are using such drugs. Needless to say, there are many problems involved in initiating such projects.

<u>BENJAMIN</u>: I would like to present a short summary of the various studies the National Highway Traffic Safety Administration is conducting in the drug-driving area. Jim (Nichols) mentioned the drug analysis of fatally injured drivers that is conducted by the Midwest Research Institute. This study, when completed, will cover 1,000 fatally injured drivers and a control of 1,000 drivers on the road.

In the first 190 cases, 24% show evidence of drug use other than alcohol (12% barbiturates; 6% amphetamines; and none for heroin or methadone).

The Research Triangle Institute under a combined contract with the Bureau of Narcotics and Dangerous Drugs and NHTSA examined the criminal, drug, and driving records of 2,270 subjects who had been arrested for various criminal offenses and found that 68% of these subjects used some drug at some time for non-medical reasons. Of those arrested for other reasons but drugs, 50% indicated use of drugs.

The total number of arrests were slightly higher in the drug users, but the arrests for crimes against a person were higher in the non-drug user.

In general, drug-user drivers of this select population have no worse, and frequently have better driving histories than non-drug users. The only exception involves the use of psychedelic drugs, where the accident rate of drug users is higher than that of the control group.

Dunlap and Associates under contract with NHTSA interviewed 1,562 methadone maintenance patients in New York state. The control group of 1,059 subjects was matched for age and socio-economic background. However, complete driving records could be obtained only for 718 experimentals and 579 controls. The interview data show that for users of non-heroin drugs, the percentage of subjects involved in accidents and violations is markedly and consistently increased for those who report driving immediately after drug use.

According to their own statement, the drug users, whether licensed or not, do drive extensively. However, according to the driving records, the drug users are not involved in more accidents than the controls. The violation rates for experimentals and controls are not significantly different, with the exception of violations for improper equipment and documents.

The subjects involved in the Methadone Maintenance Program have a rate of accidents and violations that is higher than the controls, but it is only a fraction of the rate found in subjects who report driving after drug use or the rate found in problem drinkers. If the data are broken down according to age, it becomes apparent that only those 20-30 years old have significant increase in accident rates.

To summarize the current state of knowledge:

1. Generally, the driving records of drug users are not worse than those of a matched control group.

2. Abusers of non-narcotic drugs who report driving immediately after drug use have more accidents and violations than those who do not drive immediately. It is not clear whether this is a drug effect or a difference of the psychological characteristics of the two groups.

3. Methadone maintenance subjects have more accidents and violations than the control group. It is not clear how far this is due to the drug or due to other stress factors.

<u>WALLER</u>: I just want to pick up on the comment that Reg Smart had made earlier that the crashes of persons using marihuana perhaps are more passive sorts of crashes. I've taken a quick glance at some of these questionnaires that the students are returning. I think in the batch I looked at, there were three crashes after use of marihuana. One of them was an individual who said that he went off the road because he just was having trouble paying attention, and he made the further

comment that "fortunately there were no obstacles along the side of the road. There was a wide clear area so I didn't get into too much trouble." This emphasizes the need for removing the environmental booby-traps so common on our highways. The second individual commented that he crashed into the back of somebody else's car, again because of difficulty with paying attention. The third individual commented that he had two crashes. This is a person using marihuana almost daily, who uses alcohol almost every time he uses marihuana, with a usual quantity of five or more drinks per sitting at that time. We asked specifically, "If you had some episode involving marihuana, what made you think that it was the marihuana?" The response was, "I had these two crashes and I think in each case that I was very impaired by the alcohol." So the two that were involved in marihuana only, suggest a more passive sort of thing rather than risk-taking behavior, although this obviously is not a very large sample on which to base conclusions.

NICHOLS: I think that is an important controversy that needs to be solved soon because even the President's Commission on Marihuana indicated that most users were not generally users of alcohol at the same time. My experience in knowing some people is just the opposite and alcohol is often used in conjunction with marihuana. So I think that's a problem that has to be resolved because there really are divergent opinions on this fact.

Chapter 8

8.1 THE JOINT ACTION OF ALCOHOL AND MEPROBAMATE

John A. Carpenter

INTRODUCTION

The work I am going to report was carried out as a joint effort of R.J. Gibbins and Joan Marshman of the Addiction Research Foundation, Toronto, Ontario; John R. Ashford and John Cobby of the Department of Mathematics, University of Exeter, Devon, England; and myself, of the Center of Alcohol Studies, Rutgers University.

The work is based on the conviction that the result of a combination of drugs can be determined only by finding out which of many possible models of joint actions of drugs best represent the observed data; then describing the combined action in terms of the characteristics of the model. Although models of joint action of chemical agents have been in existence for a long time (e.g., Bliss, 1939), none have been suitable for use with the kinds of behavior likely to be found in human subjects, that is, quantitative rather than quantal response data and non-monotonic dose-response curves (e.g., Carpenter et al., 1961). Ashford, who has been active in mathematical models (e.g., Ashford & Smith, 1964), and Cobby were interested in developing new models specifically designed for use with human and other mammalian responses.

One of the problems was that in order to test such models, empirical data are necessary. The data must represent dose-response functions of each drug. (As far as we can tell, it is logically impossible to determine the outcome of a combination of chemical agents on a living organism if the dose-response functions for each agent are not known.) Therefore, a complement to the development of models was the necessary activity of obtaining data with which to test the models. Of course, the data without the model would be useful, though of limited application.

One final word about the mathematical models of joint action: the models are expected to perform useful functions by providing criteria for classifying the joint action of drugs and by permitting the evaluation of joint action from the knowledge of the effects of the individual drugs. In other words, good models could theoretically eliminate the necessity of testing combinations of drugs. Computer simulation, based on the characteristics of the individual drugs, would be sufficient.

With the goal of obtaining data for testing the models of joint action, five experiments were carried out at the Medical Unit of the Addiction Research Foundation in Toronto. The first experiment was a dress rehearsal for the others. The second and third were back-up experiments for Experiments 4 and 5. These two represent the attempt to obtain the necessary data for testing the joint action models and will be presented here.

METHOD

All experiments were carried out on human male subjects whose mean ages ranged from 23 to 25 years. All experiments used the same two drugs, alcohol and meprobamate. Behavioral data were obtained on a fairly difficult psycho-motor task, from an apparatus called the Stressalyzer (Gibbs, 1967). It provides a tracking task in which movement of a steering wheel moves a pointer in the opposite direction. The object is to center the pointer on one of five lights that come on in random order. Several measures of behavior are produced.

Alcohol was given in five doses: 0, 0.25, 0.50, 0.75, 1.0 g of absolute alcohol per kg of body weight, in a 25% solution of orange juice. One hour was allowed for drinking. Meprobamate was given in five doses also: 0, 7, 14, 21, 28 mg/kg. The maximum dose recommended by the P.D.R. for out-patients is 1600 mg/day, which is equal to about 23 mg/kg for a 70 kg subject. For a 90 kg man, the 28 mg/kg dose would be 2500 mg, or somewhat more than 50% greater than the 1600 mg of the P.D.R. These two dose series were used in Experiments 4 and 5. Both drugs were given orally.

The major difference in the two experiments was in the administration of meprobamate. In Experiment 5, the meprobamate was taken in a single administration, regardless of dose, one hour before drinking the alcohol on each of five days of behavioral testing. In Experiment 4, one-third of each dose was administered three times a day for twelve days, during the last five of which alcohol was administered as in Experiment 5 and behavioral testing was carried out. In Experiment 4, the subjects were confined to the hospital for the twelve days of meprobamate administration, and drinking and behavorial testing occurred on successive days. In Experiment 5, the subjects were released each day after testing, and returned two or three days later for continuation of the experiment. Experiment 5 is an acute meprobamate experiment; Experiment 4 is a chronic one.

In Experiment 5, eight blood samples were obtained between 8 A.M. and 2 P.M. Blood sample numbers 3, 4, 5 and 6 were obtained at half-hour intervals between 10 and 11:30 A.M. Samples 7 and 8 were obtained at 12:30 and 1:30. Sample 1 was obtained before meprobamate and Sample 2 before alcohol administration. In Experiment 4, blood samples were obtained at 7:30 A.M., 4 P.M., 6:30 P.M. and 10 P.M. Blood samples were analyzed quantitatively for alcohol and meprobamate by gas chromatography. Behavioral tests were made on individual subjects twice prior to drinking and nine times at half-hour intervals following drinking in Experiment 5. The same procedure was used in Experiment 4, except that only one pre-drinking test of behavior was made. Drinking in Experiment 5 and 4 began at 9 A.M. and 4:30 P.M. respectively. Thus, the two experiments occurred at different times of the day. The apparatus for testing behavior presented 80 stimuli per trial, and 2 trials were run on each subject in about 5.5 minutes. This resulted in 1,440 stimuli per subject per day after drinking for both experiments. In other words, the behavior of each subject is well sampled. All post-drinking measures of behavior were adjusted for the behavior just prior to drinking. Results are presented in terms of differences between average behavior after and before drinking.

Twenty-five subjects were used in each experiment. Both experiments can be described as one-way designs, with latin-square subplots and repeated measures for the sub-subplots. The distinction between the experiments has to do with the location of alcohol and meprobamate in the designs. Given the fact that alcohol is a relatively powerful drug and meprobamate is not, the ideal design is that used in Experiment 5: alcohol doses are the treatment for the one-way design, with meprobamate the latin-square treatments. This gives maximum sensitivity to the detection of meprobamate effects. What this means is that five subjects were restricted to the same dose of alcohol on each of the five experimental days, but had a different dose of meprobamate on each of those days. This was repeated for each dose of alcohol with another five subjects. The latin-square means that all doses of meprobamate were given on all days and to all subjects. The result is that every dose of one drug is tested in combination with every dose of the other drug.

In Experiment 4, the location of the two drugs are reversed in the design. The meprobamate is the one-way design treatment and alcohol is the latin-square treatment. Chronic administration of meprobamate required that each subject remain on the same dose of meprobamate for each day of the experiment. It was therefore necessary to change the alcohol doses daily in order to obtain all combinations of the doses of the two drugs.

RESULTS

By far the most interesting results so far found in the incomplete analysis of the experiments is the effect of each drug on the blood levels of the other. This is particularly true of Experiment 5 where the drugs were consumed one hour apart. Since the full dose of meprobamate was taken an hour before alcohol and is slowly absorbed, both drugs were present in the stomach in significant amounts.

Three dimensional isometric graphs (Fig. 1) show the blood meprobamate concentrations (BMC) as a function of both meprobamate and alcohol dose in Experiment 5. The first graph came from blood samples obtained one hour after beginning to drink alcohol and two hours after ingestion of the meprobamate. The next graph is 1.5 and 2.5 hours respectively, and the last graph is 4.5 and 5.5 hours after alcohol and meprobamate. The irregular surfaces are attributed to the influence of alcohol in the stomach at the time of meprobamate absorption. There is a persistent valley at 0.75 g of alcohol per kg and a persistent peak at 1.0 g/kg alcohol, etc. This result is taken to mean that when the two drugs are taken simultaneously, alcohol can affect the blood levels of the meprobamate, depending on the amount of either that is present. Presumably concentration of alcohol affects this also. Here a 25% solution was used. What this might mean clinically is that it is possible to get an overdose or an underdose of a drug if it was given in the right combination with alcohol. That is, this drug taken in normal amounts could result in higher than expected blood levels if taken in conjunction with alcohol. It must be emphasized that the opposite is also true: lower than expected blood levels of the drug could result from the presence of alcohol. The ridges and furrows in Figure 1 are due to the effect of different doses of alcohol on any dose of meprobamate greater than 7 mg/kg, rather than to unique combinations of the doses of the two drugs.

Figure 2 presents BAC as a function of alcohol and meprobamate dose for the same blood samples shown in Figure 1. At 1.0 g/kg alcohol, meprobamate at any dose increased the BAC for the sample immediately after drinking. The results are more labile than the BMC results and ridges and valleys less apparent. This suggests that BAC is more the result of unique combinations of the doses of the two drugs than is BMC. Both BMC and BAC are statistically significant response surfaces over time.

The results of Experiment 4 are somewhat different. A comparison of BMC for non-alcohol days (day 5, 6, 7) and alcohol days (8-12) shows that the BMCs after high doses of meprobamate are responsive to the alcohol. This is based on the last blood sample of the day because this was the only sample that was common to both alcohol and non-alcohol days. Curves fitted to meprobamate dose for the non-alcohol days shows BMC to be a negatively accelerating function of meprobamate dose, whereas the curve fitted to alcohol days shows BMC to be a linear function of dose. At the highest dose of meprobamate, the days on alcohol produce a BMC 2.5 ug/ml higher than the same point on non-alcohol days. This means that the data are compact enough to detect differences in the shapes of the curves (M_1A, $p < .05$, M_qA, $p = .01$).

Figure 8-1. BLOOD MEPROBAMATE CONCENTRATIONS (BMC) AS A FUNCTION OF ORAL DOSES OF ALCOHOL AND MEPROBAMATE.

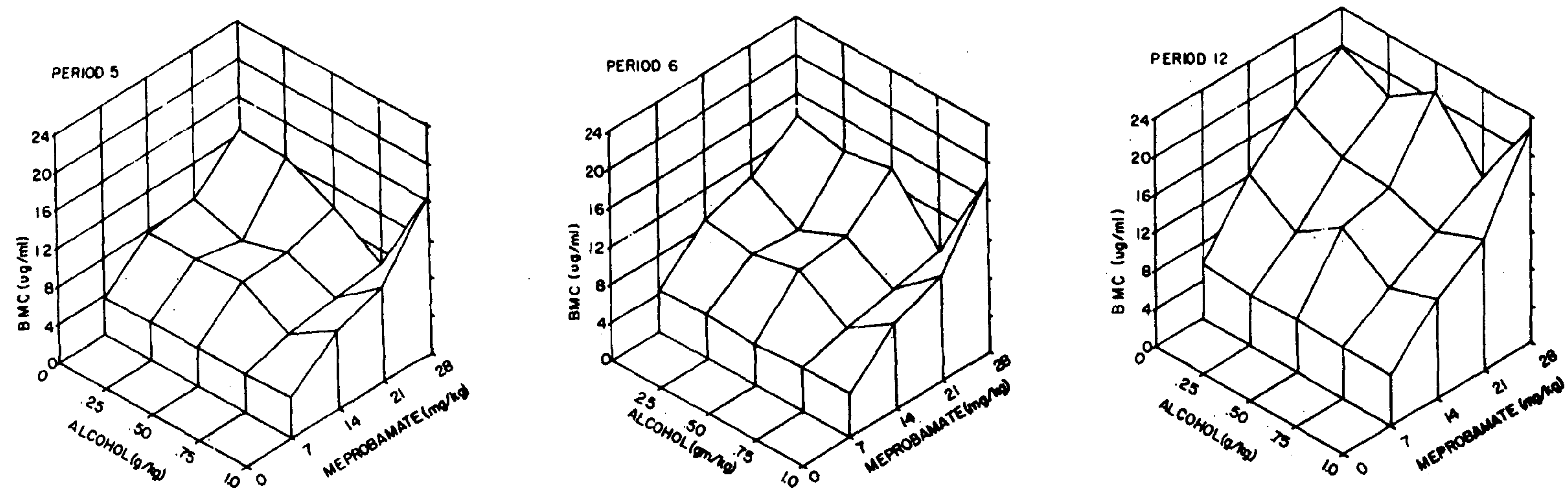
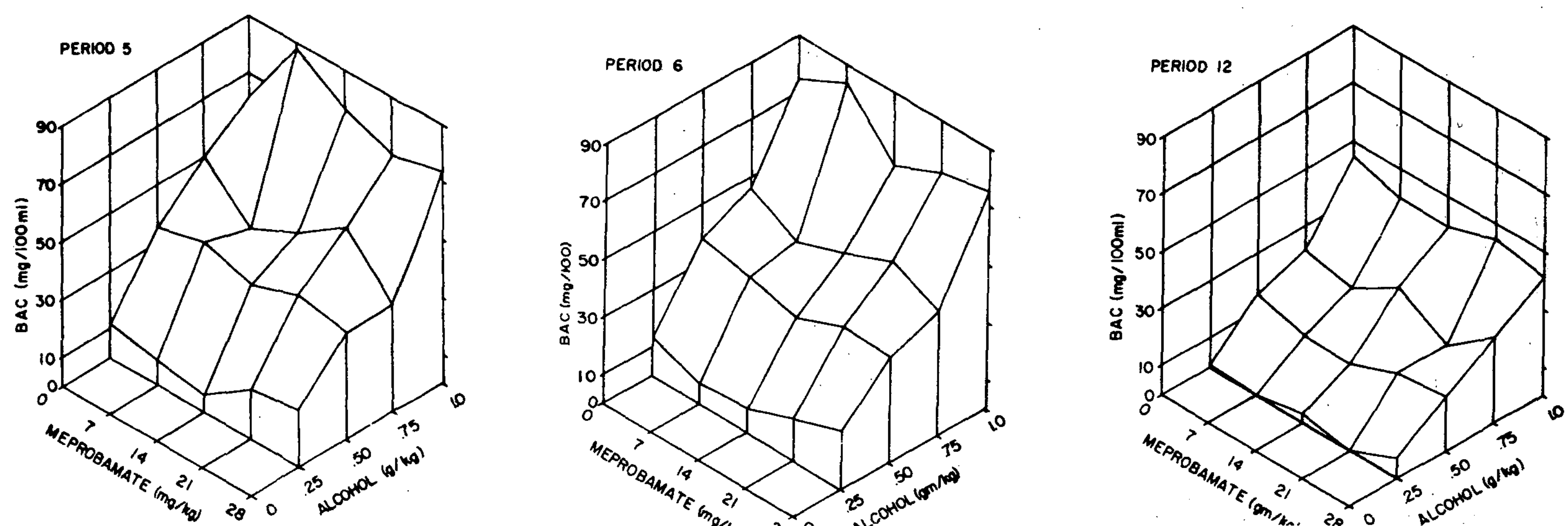


Figure 8-2. BLOOD ALCOHOL CONCENTRATIONS (BAC) AS A FUNCTION OF ORAL DOSES OF ALCOHOL AND MEPROBAMATE.



Since sample 4 occurred 5.5 hours after beginning to drink, very little alcohol is left in the body and the result suggests an inhibition of the metabolism of meprobamate. No effect of meprobamate dose on BAC was detectable. This might be the result of splitting the meprobamate administration into three per day so that only small amounts were present at the time alcohol was consumed. Contributing to this is the fact that the first blood sample in Experiment 4 occurred two hours after drinking, whereas the maximum influence of meprobamate on BAC was observed at one hour after drinking in Experiment 5.

Analysis of the behavioral results has not proceeded as far as the blood analyses. Of the five measures obtained, one will be used as an illustration. Reaction latency per target hit (RL) was the time it took for a subject to move off a light when a new light came on.

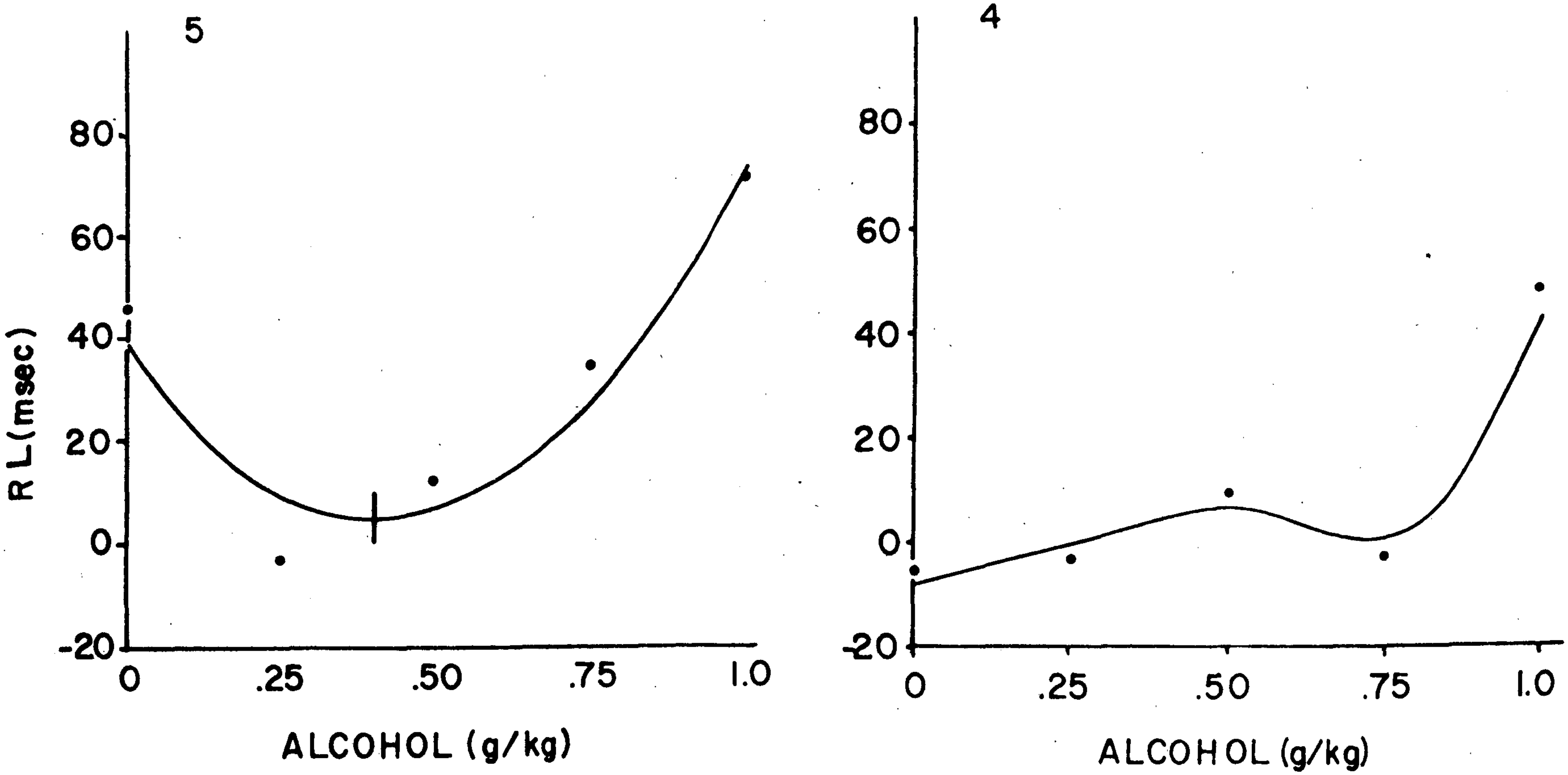
Analysis of variance carried out on the RL data shows the following pattern. In Experiment 5, the quadratic component of alcohol dose was significant ($p < .05$); the linear component of meprobamate was significant ($p < .025$). Two components of the meprobamate-alcohol (MA) interaction were significant (M_1A_q, M_qA_1; $p < .025$, $p < .05$). Nine components of PMA (Time periods X Meprobamate dose X Alcohol dose) were significant; two at $p < .005$, one at $p < .001$. There are 128 degrees of freedom in the PMA interaction so that the 9 significant components represent 7% of the df and 38% of the variance. Unfortunately, only 80 of the 128 df could be isolated and enough variance is left in the remaining 48 df for one or more to be significant. This is true for both experiments. In Experiment 4, the linear, quadratic, and cubic components of alcohol dose were significant ($p < .0005$, $p < .01$, $p < .01$). No component of meprobamate dose was significant. Comparison of these two results with their analogues in Experiment 5 illustrates the differences in sensitivity of the location of the drugs in the designs. The M_cA_1 was significant ($p < .025$) and 7 components, representing 33% of the variance, were significant in the PMA interaction. Only one of these was at $p < .005$.

Because BAC changes rapidly over the five hours from beginning to drink in both experiments, we would expect that unique combinations of the blood levels of both drugs would occur that are time dependent. This is especially true in Experiment 5, where BMC is subject to large changes because of the acute administration of meprobamate. This should make for highly significant components of the triple interactions. The triple interaction is equivalent to testing the MA interactions of the nine post-drinking periods for similarity. If so, components of the triple interactions should be more significant than components of the MA interaction, which is averaged over time. For the same reason, the double interaction (MA) should be more significant than the main effects. Given the differences in sensitivity of the two designs with respect to the location of the drugs, and the differences in potencies of the two drugs, this is about what happened, as best illustrated in Experiment 5. The significant triple interaction means that a significant MA interaction could be missed if one looked for it at the wrong time, or if it were covered up by non-significant interactions.

RL of Experiment 4 is the only instance of a significant component of meprobamate dose in all five measures of behavior that were used. RL increased linearly with a shallow slope over the doses of meprobamate, the increase from a fitted line being about 22 msec from 0 to 28 mg of meprobamate per kg.

The main effects of alcohol are shown in Figure 3, where RL is plotted as a function of alcohol dose. Experiment 5 is on the left. The curves are quite different. The calculated dose (0.42 g/kg) at which the minimum response occurred of Experiment 5 is significantly different from the zero dose ($p = .05$) and is indicated in Figure 3 as a vertical line. The minimum can be taken to mean that RL

Figure 8-3. REACTION LATENCY (RL) AS A FUNCTION OF ORAL ALCOHOL DOSES FOR EXPERIMENTS 5 AND 4.



at 0.42 g/kg is shorter than at 0.0 g/kg (i.e., improved performance). This result has been obtained before (Carpenter et al., 1961; Carpenter & Ross, 1965), usually with better confidence levels. Contrasting the results of the two experiments, it can be seen that the best performance in Experiment 4 occurred at 0.0 of alcohol per kg, whereas it occurred at .25 g of alcohol per kg in Experiment 5. The largest difference between the two experiments occurred at 0.0 g/kg alcohol: Performance in Experiment 4 was 52 msec faster than in Experiment 5. The worst performance was at 1.0 g of alcohol per kg in both experiments. In general, performance was always equal to, or better than, that of Experiment 5.

The MA interaction is shown in Figure 4, with Experiment 5 on the left again. Each curve represents a different dose of meprobamate. Again, the curves are quite different. Three doses of meprobamate (0, 21, 28 mg/kg) have definite minima that are very close together. The combined minimum is 0.45 g of alcohol per kg and is significantly different from the zero dose of alcohol; clearly improvement occurred here. The curves for 7 and 14 mg/kg are quite different from the other three. Although it is difficult to describe interaction between the two drugs, it has occurred. The curves of Experiment 5 are mathematically fitted. The meaning of interaction will be deferred for discussion.

The MA interaction for Experiment 4 is complex enough. The increase in RL at 0.25 g of alcohol per kg for 14, 21, and 28 mg of meprobamate per kg and the decrease for all meprobamate doses except zero at 0.75 g of alcohol per kg is quite unexpected and suggest that some combination of the drugs will result in performances that are unrelated to simple increases in the doses of each. Notice that, disregarding doses, the best performance occurred in Experiment 4 and the worst in Experiment 5.

The PMA interactions are too complex to present here. All the results will be presented in a Supplement of the Quarterly Journal of Studies on Alcohol, to be published in 1974.

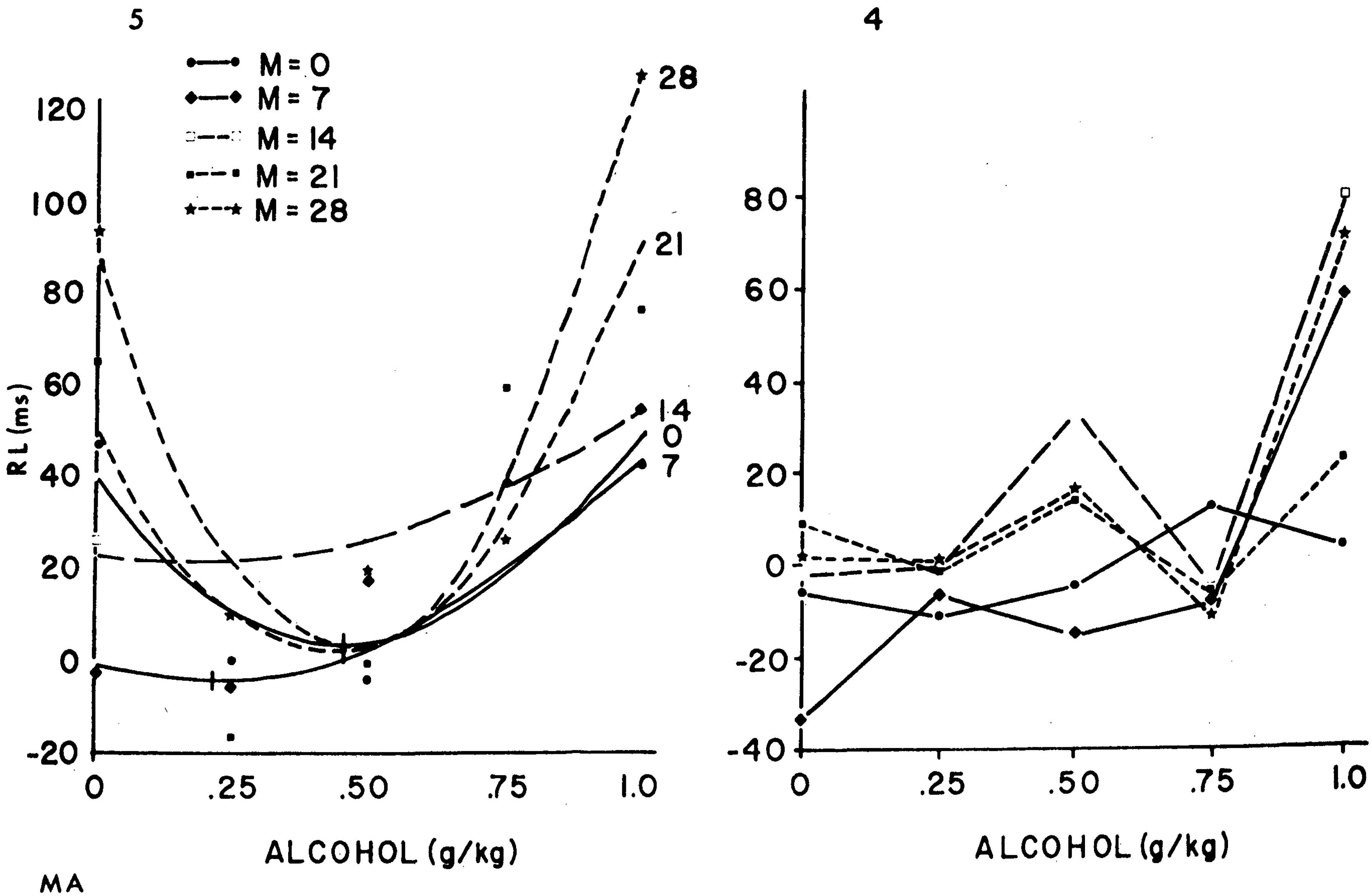
SUMMARY

In closing, the following points can be made. (1) The two drugs affect the blood levels of each other. Alcohol at large doses modifies the blood levels of meprobamate, the effect being progressively greater at higher doses of meprobamate, when meprobamate is taken contiguously with alcohol. This is probably due to alcohol effects on meprobamate absorption. (2) When meprobamate was taken chronically, alcohol modified BMC at high doses, possibly by influencing the metabolism of meprobamate. (3) When acute doses of meprobamate were given, different response functions of alcohol dose occurred as compared with chronic administration of meprobamate. (4) Considering either acute or chronic administration of meprobamate, the two drugs produced changes in behavior depending on the dose of each. (5) Because the absorption of each drug is time-dependent, unique combinations of BAC and BMC may produce behavior that is difficult to predict from a knowledge of the dose-response of each drug alone.

DISCUSSION

The discussion of this paper mainly concerned whether interaction of the two drugs occurred. The contributors to the discussion were Drs. Conger, Edwards,

Figure 8-4. THE ALCOHOL AND MEPROBAMATE INTERACTION IN EXPERIMENTS 5 AND 4: REACTION LATENCY (RL) FOR EACH ORAL DOSE OF MEMPROBAMATE AS A FUNCTION OF ALCOHOL DOSE



Stern, and Waller. The difficulty in answering the question is one of definition and orientation. One can be oriented toward statistical interaction or toward mechanism.

According to a statistical definition, the response is determined by two drugs. This means only that in order to predict the outcome of applying two drugs, the dose of each must be known. In this case, the mechanism is unspecified and unspecifiable with all but the simplest curves of each drug alone. There is no way to decide whether the response was greater than, less than, etc., what would be expected from each drug alone. Conclusions, in general, are limited to declaring the existence of a combined effect.

The other meaning of interaction has nothing to do with statistics, although it may show up as an interaction in a statistical analysis. In order to detect this kind of interaction, one must refer to real or hypothetical mechanisms.

Mathematical models, the hypothetical mechanisms, are statements of the relations among hypothetical constructs. The models of Ashford and Cobby, like those of other people, make use of a number of constructs, one of which is sites of action. Their physical nature is unspecified; it could be neurological, chemical, electrical, etc. A particular response of an organism to a combination of drugs occurs because of the number of sites of action activated by each drug alone and by the number of sites that can be activated by both drugs. Other things constant, response is determined by the relation of sites held in common to sites available to each drug alone. For example, the more sites held in common, the closer each drug becomes a substitute for the other. The actual models are a good deal more complicated than this. If interaction means all possible outcomes of drug combinations, the only way of placing a response on a continuum from antagonism to hyperpotency is by appeal to mathematical models. The aim of this exercise has been to provide data to be used to test the mathematical models that are being developed.

Did interaction occur for the data presented here? Yes, statistical interaction was demonstrated. Ashford and Cobby's results based on their models of joint action of drugs will be published in Biometrics.

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8.2 THE JOINT ACTION OF ALCOHOL AND AMPHETAMINES

Paul M. Hurst

In the interest of brevity, I will give you a brief summary of a number of amphetamine experiments. First, a general point concerning the acute effects of these drugs on performance. With a relatively simple task, performance will be facilitated by acute doses of amphetamines in the order of 10-15 mg. dexamphetamine. A complex task will show no facilitation. It is virtually unaffected. That is, a task like Smith and Beecher's calculus problems or our mathematical reasoning test, or even an IQ test, won't show much. Now, consider the effects on judged performance in conjunction with actual performance, where subjects don't really have any way of knowing how well they have done or only have very imperfect feedback. Their judged performance will tend to be biased upward on the more complex tasks, but not on the simple ones. So the drug helps the simple ones, but it doesn't make them overestimate their performance on them. It doesn't help the complex ones, but it does cause them to overestimate their performance on them.

Now I will skip down to another set of experiments which involved both alcohol and amphetamines. We were interested in risk-taking, and I had hypothesized the potential moderating influence of what is essentially risk vs uncertainty. Risk is where the person knows the probabilities. It's like a situation of tossing pennies where he knows that they will come up heads fifty percent of the time, as opposed to uncertainty, like what probability do you attach to the proposition that there is intelligent life within 30 light years of the planet Earth. Now, we devised a game I call Bayesian Red Dog, which included a calculated risk situation where subjects did know the win probabilities and a Bayesian situation where it was virtually impossible for them to calculate them, although the probabilities could be calculated. It's almost impossible to do on the spot.

On risk taking, 15 mg. dexamphetamine per 70 kg. had no effect. Alcohol 0.8 gm. per kg. had no effect, except that subjects tended to take more maximum bets. That is, when the chances were very favorable, they would be more likely to bet the maximum amount of money, which incidentally is the optimal way to play Red Dog. Whenever you have a better than fifty-fifty chance, you shoot the works. That was about all we found there. So to the extent that one could generalize on risk-taking influences from that, I would say alcohol might tend to increase the amount one is willing to risk in situations where one would otherwise be willing to bet on a favorable outcome, but wouldn't be willing to bet so much.

Amphetamines, on the other hand, have had varied effects in a number of different studies we have done on risk and judgement of performance. It seems that ego-involvement may be the moderator there. If the outcome is determined by nature, and the subject knows this, he is not likely to be more optimistic after amphetamine; but if it is dependent on his skill on some complex performance, then he is likely to be more optimistic. Incidently, we found that in a mathematical reasoning test, this effect held more for those who were relatively good in mathematics. The judgment distortion was greater for these people, and we thought this moderator role may have been an indirect reflection of ego-involvement. A person who is good at math seems more likely to be ego-involved with his mathematical ability. But I would say that's about all we have found in the way of situational dependency.

If you put the alcohol and amphetamine together, which we did in the same doses I mentioned, you get differing results with different variables. In the Red Dog game, we got essentially the alcohol effect, that is, the effect on the big bets with high win probabilities seemed to be the same whether the amphetamine was there or not. We had several dimensions of mood that had been extracted from a previous factor analysis and which seemed to be drug sensitive. On the mood measures, we got everything, depending on the dimension. We got additive effects; we got super-additive effects; we got subtractive effects; and we got relatively straight alcohol effects, or we got relatively straight amphetamine effects depending on which component of mood we were measuring.

DISCUSSION

"WERE THERE INDICATIONS OF POTENTIATION?"

HURST: On many mood indices, the combined effect was greater than the sum of the separate effects, but I am not going to call it potentiation because it was not the right model for testing potentiation. Whether a combined effect is greater than additive single effects depends on the particular units of measurement. There was also a latency dependency: Anxiety, being reduced by alcohol was still further reduced by amphetamine at low latency, but then tended to be raised back up at the greater latencies with the addition of amphetamine, as opposed to the straight alcohol.

"WITH REGARD TO AMPHETAMINES, DID YOU SAY THERE WAS A POSITIVE EFFECT IF IT INVOLVED SIMPLE TASKS, BUT THAT YOU DID NOT FIND ANY IMPROVEMENT FOR COMPLEX TASKS?"

HURST: That was generally what we have found.

"IS THERE A DEPENDENCE ON THE SUBJECT'S STATE OF FATIGUE?"

HURST: I can give you a partial answer to that question. I suspect there is an interaction with alcohol effects, although this has not been adequately explored. With the amphetamines, some experiments have been done in army marching and field exercises that suggest that if you take the amphetamine after you have gotten tired, it will give you a boost in physical performance or in vigilance performance. Holiday and Dille did a study of simple addition and subtraction of signed numbers with sleep-deprived subjects. They found that amphetamines did improve performance in this task; however, we found an almost comparable degree of performance improvement in non-sleep deprived subjects. To my thinking, this results simply because it is a boring and repetitive task. If the task is more interesting, you should expect amphetamine enhancement only after fatigue or sleep deprivation.

Chapter 9

ALCOHOL COUNTERMEASURES: SOLID ROCK AND SHIFTING SANDS

Gerald J. Driessen and Joseph Bryk

ABSTRACT

Recent findings and issues in several areas of alcohol countermeasure research and application are reviewed. The Alcohol Countermeasures Program of the U. S. Department of Transportation including preliminary results from eight Alcohol Safety Action Projects (ASAPs) is covered. Fatal accidents decreased 9.7% and fatalities decreased 8.6% in ASAP as compared to non-ASAP areas when considering data from 1970 to 1971. Other sections deal with laws and their enforcement, public education and mass media campaigns, rehabilitation, instrumentation, drinking pedestrians, and the lognormal distribution controversy. More than 100 countermeasures are listed. The authors recommend that a "cause-chain analysis" be applied to all proposed countermeasures in order to specify potential payoff.

1. INTRODUCTION

The phrase "alcohol countermeasures" as used in this paper refers to activities directed toward reducing alcohol-related traffic crashes. For the sake of brevity, and to harmonize with the bidding of Zipf's Law[1], they will hereafter be called ACs.

Stroh (1972) recommends concentrating on those ACs that are most effective and discontinuing support for those found to be ineffective -- a philosophy with which all would agree. The problem is deciding which are effective and which are not. In this paper, we will survey alcohol countermeasures and attempt to isolate some solid-rock facts from the shifting sands of conjecture. While progress is reviewed in several important areas, the paper is not intended to be comprehensive.

As is widely known, traffic crashes are a serious social problem. The commonly quoted statistics of the National Safety Council and the U. S. Department of Transportation (U.S. DOT, 1968) need not be repeated here. Havard (1972), however, states the tragic figures in global terms: The number of traffic deaths will soon reach a quarter of a million annually, while the yearly total of injured road users will exceed 10 million. We are dealing with a public health catastrophe on nearly every street of every nation.

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[1]The law (Zipf, 1949) is the source of the world's annual crop of acronymns. In paraphrase, it reads as follows: Long words or phrases become shortened to increase the efficiency of verbal communication, e.g., "television" becomes "TV". Other examples within close proximity to our subject are DWI, ASAP, DOT, and BAC.

Published discussions of ACs in general as they relate to the traffic accident problem are not numerous. Most studies devote themselves to one particular AC or to one class of safety countermeasures, such as mass communications (Haskins, 1969; Griep, 1969; Wilde, 1971). A brief literature survey yields the following reports dealing strictly with alcohol countermeasures in the traffic arena: Fox (1965), Little (1966), Fox (1967), U. S. DOT (1968), Bacon (1968), Griep (1968), AMA (1968), Haddon (1970), Zylman (1971b), Borkenstein (1972), and a series of reports from the recently established Office of Alcohol Countermeasures at the U. S. Department of Transportation (U. S. DOT, 1969; 1970a; 1970b; 1972a; Voas & Tabor, 1970; McKnight et al., 1971; and Burkhart, Crancer, & Voas, 1972). Other useful documents dealing with methods of evaluation include Suchman (1967) and O'Day et al. (1971). Bryk (1971) gives comparisons of alcohol-involvement across transportation modes that relate to countermeasure selection.

Haddon (1963) and the A. D. Little report (1966) both noted that surprisingly few research efforts had attempted to measure the effectiveness of alcohol control programs prior to their reports. A prevalent opinion was that more severe laws reduced the co-incidence of drinking and driving. There was little scientific basis for such beliefs. In recent years, the picture has begun to change. It is encouraging to see the ad hoc solutions and unscientific sloganism of the past give way to systematically controlled evaluations of alcohol countermeasures. Progress is slow, but it is progress nevertheless.

At an important meeting dealing with community response to alcoholism and highway crashes, Haddon (1970) stated:

> It is essential to recognize that highway safety is a social issue because of a social end result...damaged people and property. Therefore, anything that contributes to that end result, for instance: Disconnecting the abusive drinker from highway use; modifying the steering shaft or rigid roadside pole that favors his injury...making vehicles less delicate, without reducing the crash protection they provide; or ensuring far better emergency services, is a legitimate countermeasure....
>
> Nevertheless, it behooves us all to identify systematically our options in relation to the problem drinker per se, and to develop the means for ascertaining the magnitude of the payoffs their application would produce.

Payoffs is a key word here. In light of the total problem of alcohol and road safety, what payoffs can be demonstrated for the various classes of ACs? Haddon draws a useful distinction between countermeasures applied in the context of vehicle operation (i.e., to the drinking driver while he is driving) and those applied out of the context of vehicle operation (such as detection of problem drinkers through violation records and other "nondriving" techniques). He raises the issue as to which will have greater payoff over the long term.

Fox (1967) notes many specific numbers and percentages regarding payoffs. He quotes Allsop (1965), who stated that if no person drove with a BAC above .08%, the number of road accidents would be reduced by about six percent. Table 1 presents data on the role of alcohol in fatal traffic accidents in the United States, as well as some potential payoff percentages. The reported fatalities for 1967 (U. S. DOT, 1969) were the basis for the calculations. According to these figures, drinking pedestrians constituted 27% (2,560) of all fatally injured pedestrians (9,562) for that year, but only 4.82% of all traffic

TABLE 9-1

Role of Alcohol in Fatal Traffic Crashes in the United States

Item	1967[a]			1972
	N	% of subgroup	% of total fatalities	N
Pedestrian fatalities				
Related to drinking pedestrians	2,560	27	4.82	2,943[b]
Related to drinking drivers	1,920	20	3.62	2,180[b]
Unrelated to drinking	5,082	53	9.57	5,777[b]
Fatally injured pedestrians	9,562	100	18	10,900[c]
Driver & passenger fatalities				
Related to drinking drivers	25,492	59	48	26,786[b]
Unrelated to drinking	18,046	41	34	18,614[b]
Fatally injured drivers and passengers	43,538	100	82	45,400[c]
Total alcohol-related fatalities	29,972		56.4	31,909
Total fatalities	53,100		100	56,300[c]

a. Data from NHSB Priorities Seminar, Vol. 2 (National Highway Safety Bureau, 1969). See Figure 8.
b. Estimates based on proportions developed for 1967 data under column labeled "% of subgroup".
c. Source: Accident Facts, 1973 Preliminary Condensed Edition.

fatalities (53,100). Among fatally injured drivers and passengers, 59% were related to drinking drivers, and these 25,492 victims constituted 48% of all traffic fatalities. The 1972 figures were derived by applying the 1967 percentages to the most recent national fatality figures available at the time of writing. Zylman (1973) gives percentages for driver, passenger, and pedestrian fatalities at or above a BAC of .10%.

In a different area of traffic safety, motor vehicle inspection, Hall and O'Day (1971) have proposed using cause-chain analysis to help specify "payoff" for a particular traffic accident countermeasure. We believe that such a model should be directly applied to various ACs in order to estimate the relative payoff for each. Another useful analytic method in examining causal sequences leading to accidents in general appears in Driessen (1970).

2. THE U. S. ALCOHOL COUNTERMEASURES PROGRAM

The current federal effort in alcohol countermeasures involves a series of community projects, public education, manpower development, and research activities. Early pioneer studies by Heise (1934), Holcomb (1938), Lucas et al. (1955), and others revealed unequivocally that alcohol was heavily associated with roadway tragedy. The Borkenstein et al. study of 1964 gave long-needed perspective to the problem and still stands as one of the superior technical efforts in traffic safety research. Federal legislation in 1966 incorporated a significant section on alcohol programs and provided a basis for wide government action. The report to Congress from the Secretary of Transportation (U. S. DOT, 1968) is, of course, a landmark study that preceded the actual structuring of the alcohol countermeasures program. A meeting of federal government personnel at the Fredricksburg symposium (U. S. DOT, 1969) reoriented the agency's structure and funding to place ACs high on the list of priority efforts within NHSB (the National Highway Safety Bureau, now the National Highway Traffic Safety Administration, NHTSA).

In early 1970, the major restructuring of NHTSA took place. Table 2 shows the project development plan for 52 Alcohol Safety Action Projects (ASAPs), one in each state, Puerto Rico, and Washington, D. C.; included is the estimated budget for fiscal years 1971 through 1977. According to the ASAP plan, 52 comprehensive community programs are to be initiated and carried through to completion during this seven-year period. Each project will run approximately three years. Before the last group of 17 projects begins, the first group of nine will have been completed. Each project is funded at about the level of two-and-one-half million dollars, with a total expenditure of 133.4 million dollars. All funding is provided by the federal government. Hopefully, state and local resources will assume financial responsibility for continuing the program when federal support runs out at the end of three years.

Table 3 gives the projected budget for the entire alcohol countermeasures program. The maximum projected total is 158.7 million dollars. Of this, funding for ASAP projects constitutes nearly 84%; five percent (8.2 million) is allocated for public education and manpower development; and the remaining 11% (18 million) is assigned to research and development.

TABLE 9-2

ASAP: Project Development Plan and Estimated Budget[a]

Initial year	Number of ASAPs (Dollars in millions)							
	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977	Total
1970	9 ($4.4)	9 ($7.0)	9 ($6.6)					$18.0
1971	20 ($2.0)	20 ($14.0)	20 ($14.0)	20 ($14.0)				$44.0
1972		6 ($5.0)	6 ($7.7)	6 ($7.7)				$20.4
1974				17 ($10.5)	17 ($17.0)	17 ($17.0)	17 ($6.5)	$51.0
Total projects in force	29	35	35	43	17	17	17	
Total ASAP funds	$6.4	$26.0	$28.3	$32.2	$17.0	$17.0	$6.6	$133.4

a. Data from U. S. DOT (1972a).

TABLE 9-3

Alcohol Countermeasures Program[a]

Item	Dollars in millions						
	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976	FY 1977
ASAP number	29	35	35	43	17	17	17
ASAP funds	$5.5	$26.0	$28.3	$32.2	$17.0	$17.0	$ 6.5
Public education & manpower development	$0.6	$ 1.2	$ 2.3	$ 2.7	$ 1.0	$ 0.4	0
Research & development	$1.5	$ 1.5	$ 4.0	$ 5.0	$ 3.0	$ 3.0	0
Total	$7.6	$28.7	$34.6	$39.9	$21.0	$20.4	$ 6.5
Grand total							$ 158.7

a. Data from U. S. DOT (1972a).

The NHTSA program is based on the concept that alcohol intake by highway users, especially excessive use of alcohol by problem drinkers, is an important key to loss reduction. The main thrust to combat this problem resides in the various ASAPs and is structured around three concepts. The first is identification of the problem drinker through selective enforcement, improved evidence, court records, community agencies, insurance companies, and licensing agencies. The second involves the decision on courses of action by prosecutors, courts, probation departments, licensing agencies, and medical advisors using traditional diagnosis, nontraditional presentence investigation, prelicensing examination, court referral to treatment, license restriction, voluntary treatment and driver reeducation. The third concept or phase is action to reduce driving after excessive drinking, to reduce drinking to safe levels, and to evaluate the effectiveness of countermeasures taken (U. S. DOT, 1970a).

At present, little information is available on the evaluation of specific countermeasures in the program. Some early results, however, show overall effects in eight of the first nine ASAP project areas (U. S. DOT, 1972a). Table 4 presents fatal accident figures for a baseline year (1970) and the first operational year for the eight projects (1971). Since most of the eight ASAPs did not come into full operation until March, the 1971 figures reflect only nine months of impact for this group of projects. This implies a conservative estimate of impact. (A further report on ASAP countermeasure evaluation is being planned for the 1973 National Safety Congress in Chicago.) While fatal accidents decreased by 79 in ASAP areas, there was an increase of 246 in nonASAP areas. Table 4 shows similar trends for fatalities. Table 5 shows the percent change and indicates that the observed reductions are statistically significant. The careful reader will note that if Oregon were removed from the group, much of the effect would be blunted. In addition, the use of the chi-square test is subject to methodological question. The data involved are at least partially dependent (chi-square assumes independence of cell frequencies) and do not reflect population base changes from 1970 to 1971.

Overall evaluation reveals that fatal accidents during the midnight to 4:00 a.m. time period showed a statistically significant decrease. Further, alcohol-related arrests in all ASAP areas increased 72%, indicating a substantial increase in enforcement activity.

Cost-benefit analysis shows a probable return on investment of $13,450,000, based on a cost per death of $200,000. The number of fatalities experienced at ASAP sites in 1971 was 91 fewer than expected from 1970 baseline projections. At $200,000 per death, the saving of $18,200,000 minus the cost of operating the ASAPs through 1971 ($4,750,000) results in a figure of $13,450,000, or slightly more than 2.8 times the investment.

If the national fatality trend had followed thr ASAP trend (9.7% reduction), there would have been 4,897 fewer fatalities in the U. S. in 1971, or 50,103 instead of 55,000. Some additional results of interest from the report to Congress (U. S. DOT, 1972b) are as follows:

1. Seattle/King County (Washington):
   1971 DWI arrests up 250% over 1970.

2. Albuquerque/Bernalillo County (New Mexico):
   DWI arrests have doubled over 1970;
   a remarkable 100% conviction rate was obtained
   by using video tape to support police testimony.

TABLE 9-4

Fatal Accidents and Fatalities During Nine Months of Operation in ASAP Areas and Non-ASAP Areas[a,b]

State	ASAP Areas			Non-ASAP Areas		
	1970	1971	Diff.	1970	1971	Diff.
Fatal accidents						
Colorado	112	99	-13	476	455	-21
Michigan	64	57	- 7	1,799	1,833	+34
New Mexico	70	72	+ 2	403	376	-27
New York	161	158	- 3	2,651	2,759	+108
North Carolina	70	57	-13	1,450	1,518	+68
Oregon	124	94	-30	420	518	+98
Washington	175	160	-15	565	572	+ 7
Wisconsin	39	39	0	930	909	-21
Total	815	736	-79	8,694	8,940	+246
Fatalities						
Colorado	116	106	-10	581	539	-42
Michigan	78	66	-12	2,135	2,134	-1
New Mexico	78	80	+ 2	499	468	-31
New York	171	166	- 5	3,040	3,130	+90
North Carolina	87	95	+ 8	1,706	1,777	+71
Oregon	145	100	-45	550	593	+43
Washington	190	173	-17	698	718	+20
Wisconsin	45	46	+ 1	1,098	1,100	+ 2
Total	910	832	-78	10,307	10,459	+152

a. Non-ASAP control areas were regions in each state outside of the ASAP area, usually one or more counties.
b. Data from U. S. DOT (1972a).

TABLE 9-5

Fatal Accident and Fatality Trends[a]

Item	1970	1971	Change	Chi square
Fatal accident				
ASAP	815	736	-9.7%	5.99
Non-ASAP	8,694	8,940	+2.8%	$p<.02$
Total	9,509	9,676	+1.8%	
Fatality				
ASAP	910	832	-8.6%	4.37
Non-ASAP	10,307	10,459	+1.5%	$p<.05$
Total	11,217	11,291	+0.7%	

a. Data from U. S. DOT (1972a).

3. Washtenaw County (Michigan): Stressing use of disulfiram to assist problem drivers; more than 50% of court referrals are maintaining sobriety via this treatment; less than 7% have violated probation.

4. Nassau County (New York): 30% increase in DWI arrests; a 98% conviction rate. A neighboring county has initiated a satellite ASAP of its own because of the success and publicity enjoyed by Nassau County.

In general, the initial results appear to be in the desired direction. The last summary statement in the U. S. DOT report (1972b), however, hastens to add that, while the observed reductions in fatal crashes could have occurred by chance only five out of one hundred times, the results must be viewed as preliminary. More complete information should result from analysis of the 1972 data for the eight projects discussed, plus Vermont and the additional 20 ASAP's initiated in January of 1972.

3. LAWS AND THEIR ENFORCEMENT

European laws in this area and the enforcement of them tend to be stricter than in the U. S. (Bastarache, 1970). Table 6 contains partial information about minimum unacceptable BACs for several countries and the penalties for violation.

Bastarache (1970) observes that most Europeans think that the U. S. BAC limit of .15% is "ludicrously liberal." In Norway in 1968, only 15% of all fatal traffic accidents were caused by drinking drivers. In Sweden (U. S. DOT, 1969), the figure is 10% to 12%; in Denmark, the comparable figure is 10% (Wagner, 1969). In Czechoslavakia, a driver who has consumed <u>any</u> alcohol and drives is subject to arrest. In France, a country with the highest per capita alcohol consumption in the world, the BAC limit is .08%. Though subject to some debate, it appears that tough laws widely publicized and strictly enforced do reduce the proportion of fatalities associated with excessive drinking. In Finland, the DWI offender is often given a choice of four months in jail or in a work camp. Since a modest salary is paid in the camp, most choose it over simple imprisonment. According to one judge, almost all learn their lesson; recidivism is quite rare (Vocational Rehabilitation Administration, 1965). Because of significant cultural differences, strict enforcement may not have identical effects on the U. S. population, though this remains to be tested.

Enforcement of the Swedish laws is made more effective by the occasional use of roadblocks to apprehend drinking drivers. Although only 4% of the arrests for drunken driving were made through roadblocks (Klette, 1963), the psychological effect of such a countermeasure on the public should not be discounted. Borkenstein (1972) cautions that inconveniencing the overwhelming majority of law-abiding drivers to apprehend a few deviant drinker-drivers through roadblocks should be avoided if possible. He states that only one in 135 randomly selected drivers drives with a BAC higher than .10% during nighttime hours. Perrine (1971) and Borkenstein et al. (1964) provide useful information for any researcher venturing into roadblocks or the roadside survey technique. A summary based on a recent review of roadside survey results (Stroh, 1972) appears in Table 7.
Zylman (1971c) cautions against any easy comparison among such studies. Differences

TABLE 9-6

European Control of Drinking and Driving[a]

Country	BAC	Penalty for Violation
Britain	.08%	Fine of 100 pounds and 1 year suspension of driver's license, or up to 4 months in jail, or both.
Norway	.05%	1 year suspension of driver's license and 3 weeks in jail. A second offense leads to license revocation for life.
Denmark	.05%	1½ year suspension of license and 20 days in jail.
Sweden	.05%	Mandatory 2 year license revocation; 3 months imprisonment; insurance cancellation; DWI in accident bears all associated financial loss.
United States	.08%-.15%[b]	Variable, but generally not as severe as above.

a. Data from Bastarache (1970) and Wagner (1969).
b. Most states are currently at .10%.

TABLE 9-7

Results of Eleven Roadside Surveys[a]

Author, year, country	Length (Months)	Sampling time	Days	N	% Drinking drivers (rounded)	% at .05 or higher (rounded)
Holcomb, '38 (U. S.)	1/4	Continuous	All	1,750	12	6
Lucas et al., '55 (U. S.)	11	18:30 to 22:30	Mon. to Sat.	2,015		9
Borkenstein et al., '64 (U. S.)	12	Matched accident times	All	7,590	11[c]	2
Perrine et al., '69 (U. S.)	25	Matched accident times	All	1,184	14[b]	7
Biecheler, '70 (France)	4	Continuous	All	7,399	52[c]	7
Dutch Study, '70	3	20:00 to 04:00	Fri., Sat., & Sun.	2,675	26[c]	12
Mecklenberg County, '70 (U. S.)	1/4	19:00 to 03:00	All	766	22[b]	11
Bø, '71 (Norway)	24	22:00 to 02:00	All	1,927	3[c]	2
Carlson, '71 (U. S.)	1	19:00 to 03:00	All	748	25	10
Dutch Study, '71	3	20:00 to 04:00	Fri., Sat., & Sun.	2,967	33[c]	17
Thatcher, '71 (U. S.)	1/8	3 time periods	Fri., Sat., Mon., & Tues.	863	29[c]	15

a. Source: Data from Stroh ('72).
b. Equal to or greater than .02%.
c. Equal to or greater than .01%.

in methods and populations studied make solid generalizations difficult; conversely, spurious conclusions are easily available to the unwary interpreter.

In general, there seem to be four phases to a successful regulatory approach (A. D. Little, 1966): Establishment of adequate laws, enforcement by police, penalization of violators, and perception by the public that violations will be penalized. Little (1970) specifies, in somewhat greater detail, the operation of legal controls on the drinking driver. He poses the following set of questions:

1. Does the person know of the danger being controlled?
2. Does he believe the danger is significant?
3. Does he believe the danger is personal?
4. Does he know of the legal control?
5. Does he believe the sanction would be undesirable to him?
6. Does he believe that enforcement relates to him?
7. Does he have competing goals that motivate him to ignore the potential danger and/or the consequences of the sanction?

A limited empirical study by Little, in the same report, indicated that the drivers surveyed misunderstood the dangers of driving after drinking and the sanctions that apply. He concluded that modifying sanctions alone without considering other significant factors to control drinking drivers may be both a fruitless and frustrating exercise.

Some researchers have speculated that the law fails to control drinking drivers because penalties are too severe, and therefore judges and juries are reluctant to convict offenders. Little (1970) questions this reasoning, observing that persons who are charged with driving under the influence show a rather high conviction rate. On the other hand, severe penalties may influence the police officer's decision to arrest or not. This factor, along with others mentioned below, may account for some of the law's ineffectiveness.

Buikhuisen (1969) found that several levels of severity had little difference in effect on recidivism. Whether a group was subjected to imprisonment, fine, or restriction of driving, the proportion of recidivism was similar. He further found (1972a) that making sentences more severe was not an effective means to combat recidivism. In yet another report, Buikhuisen (1972b) states that punishment can act as a deterrent, but that the behavior of the population at risk is not merely a function of punishment. Other relevant deterrents are present and will vary in effectiveness according to the nature of the offense under consideration.

Zylman (1970) presents data to show that some drinking-driving laws are only weakly enforced. Only 50% of collision-involved drivers with BACs of .15% or higher and 10% of those with BACs between .11% and .14% were charged with DWI according to an analysis of data from the Grand Rapids study. Reasons for low enforcement levels include stiff penalties for DWI, long costly trials, inconvenience to the policeman, and a desire by judges and prosecutors to avoid clogging the courts. Apparently, the severity of the penalty must be accepted as reasonable by the police and the courts before it can become an effective part of the larger regulatory system (Crampton, 1969).

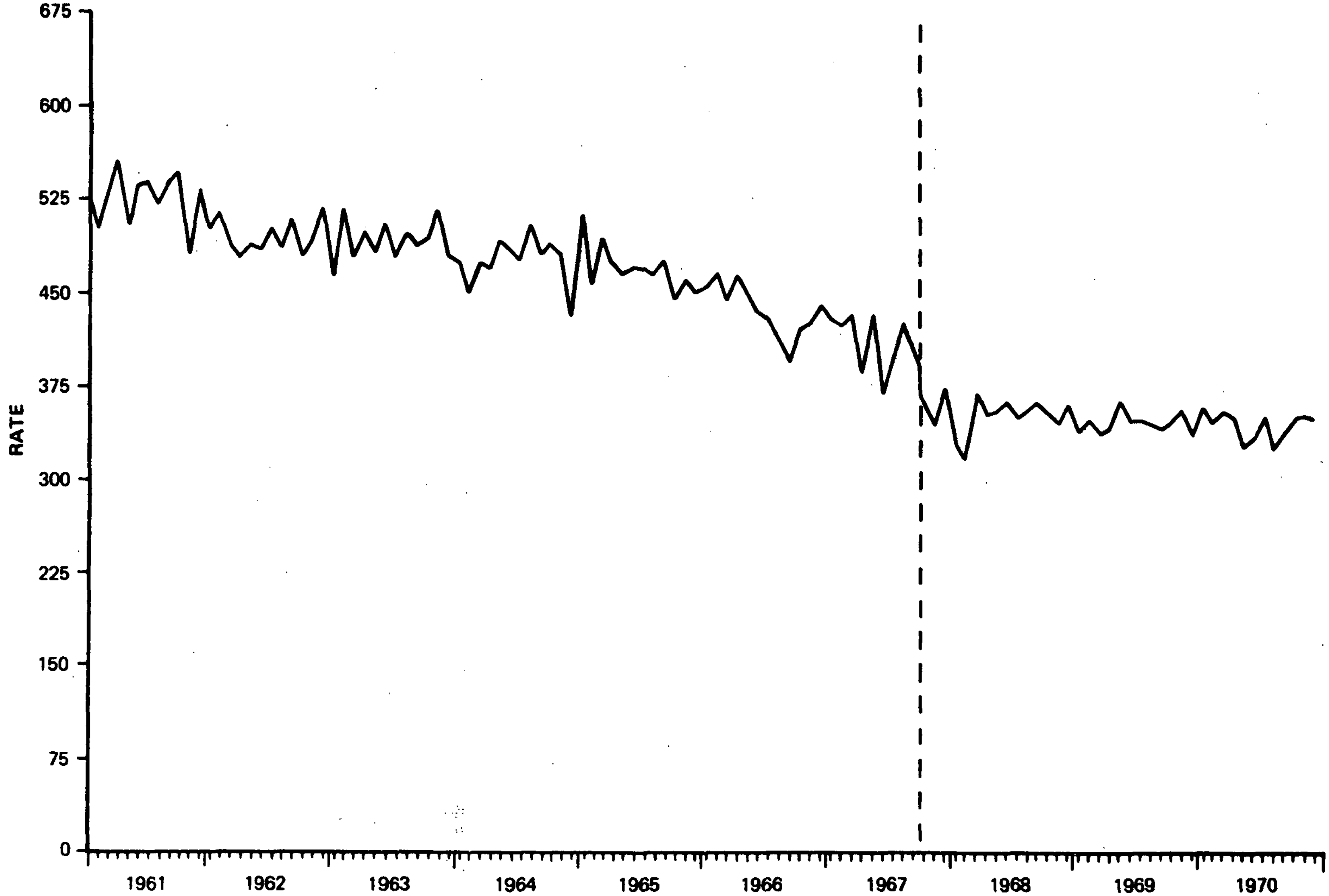
The precise effect of enforcement can be ambiguous. In a persuasive demonstration of how improper conclusions can be drawn from short-term before and after studies, Campbell and Ross (1968) showed that a speed crackdown touted as "highly successful" was much less effective when the long-term data trend was graphed. The effectiveness of enforcement is also clouded by the fact that controls successful with one group may fail entirely with others. Little (1968) states the need to develop countermeasures specifically for keeping alcoholics off of the road. Although threats and rules may influence social drinkers, they may be useless in dealing with problem drinkers. Borkenstein (1972) reiterates this opinion and presents persuasive arguments for classifying drinking drivers into special subgroups in order to select appropriate countermeasures. The "drinking driver problem" is not monolithic; neither are the available countermeasures. Crampton (1968) notes that enforcement is limited in its effects by lack of public understanding of legal requirements and by violators' confidence that they will not be detected, or, if detected, that they will go unpunished. He recommends that periodic random breath tests of drivers be established. Hurst (1971), using data from the 1968 U. S. DOT report, infers that over 80% of the fatal crashes caused by alcohol involved BACs higher than .10%. If fatal accidents are the primary concern, then countermeasure activity should be concentrated on these severely impaired drivers who represent only about 5% of all drinking drivers. He recommends stronger enforcement of the current BAC limits rather than setting more stringent limits at .08% that might generate widespread opposition and impede realization of the true goal.

The British Road Safety Act of 1967 has drawn world-wide attention. The legislation set a permissible BAC at .08% and authorized police to give pre-arrest, on-the-scene, breath tests under certain conditions (i.e., if the driver is involved in an accident, or the policeman has "reasonable cause" to suspect the driver of having alcohol in his body or of having committed a traffic offense while the vehicle was in motion) (Ross et al., 1970). If a driver failed the roadside test, he was to be taken to a police station for a more accurate test, on the basis of which a charge would or would not be made. Violation of the law carried a mandatory punishment of a one-year license suspension and a fine of 100 pounds ($240) or imprisonment for up to four months, or both. Severe penalties were also established for failure to submit to any of the tests for BAC determination.

Figure 1 shows some of the time-series data compiled by Ross (1973) to assess the effect of the law. It gives the casualties per 100 million vehicle miles (seasonally adjusted) before and after the initiation of the Act on October 9, 1967. Note both a reduction in the casualty rate and the variance of the data. Ross observes that previous legal efforts to control drinking and driving had been frustrated by inefficiences in the conviction process. In a formal sense, the law redefined the crime of drinking and driving to fit available laboratory and administrative procedures. Informally, the new law strongly altered the perception of the public regarding the chance of apprehension and conviction when driving after drinking. The Road Safety Act of 1967 had a "sharp, immediate effect in diminishing deaths and injuries on British roads" (Ross, 1973). While effects were noticeable through 1970, the dramatic reductions began to erode back toward former levels after three years. Ross surmises that the basic difficulty of detecting the drinking driver, along with administrative problems within the legal system, reduced the objective probability of punishment. This, in turn, allowed individual experience of non-enforcement to reduce the deterrent effect of the law. Havard (1972) studied the effect of the British law on fatal and serious casualties at varying times of the day and found this erosion effect to be strongest among casualties occurring between 4:00 a.m. and 6:00 p.m., predominantly daytime injuries. (See Figure 2.)

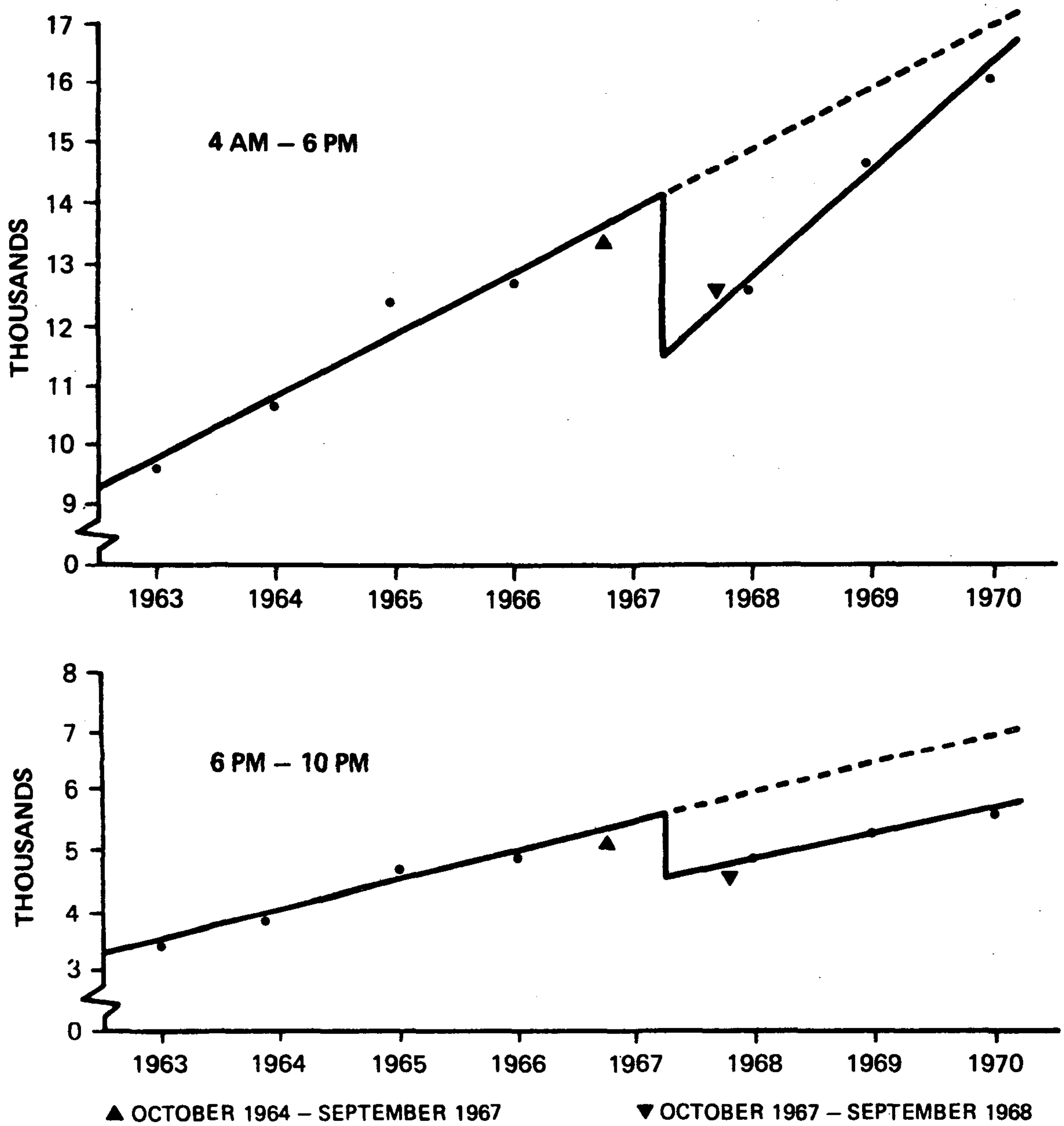
In recent years, police have been accused of directing enforcement heavily against minority groups. Two studies in this regard are of interest. Hyman (1972) concluded that the high frequency of DWI arrests among minority and disadvantaged

Figure 9-1 SEASONALLY ADJUSTED CASUALTIES PER 100 MILLION VEHICLE MILES BEFORE AND AFTER BRITISH ROAD SAFETY ACT OF 1967[a]



[a] From Ross (1972)

Figure 9-2 TRENDS IN CAR DRIVER CASUALTIES IN FATAL OR SERIOUS ACCIDENTS IN GREAT BRITAIN, 1963-1970[a]



[a] Figure adapted from Havard (1972)

groups more likely reflects a greater frequency of drunken driving among the groups than a police bias in arrests. Zylman (1972) supports the finding of no racial discrimination in the enforcement of drinking-driving laws. Using Grand Rapids data, he determined that nonwhites were involved in proportionately more collisions than whites and that nonwhites were overrepresented among drivers with high BACs. Once involved in a collision at a BAC of .15% or more, however, their chance of being arrested was equal to that of white drivers in the same predicament.

The International Association of Chiefs of Police (1971) has published a comprehensive manual describing a multidisciplinary approach to the drinking driver problem from the law enforcement officer's point of view. The document, along with its instructor's manual, represents a move forward in educating law enforcement personnel as to the ways and means of an effective alcohol countermeasure program at the local level.

3. PUBLIC EDUCATION

Significant reviews in this area include Blumenthal (1964); McMillan and Abbey (1966); Freeman and Scott (1966); Haskins (1969, 1970); Kates, Peat, and Marwick (1970c); Griep (1969); Fleischer (1970); Wilkinson (1970); Wilde (1971); Little (1971); Voas (1972); Swinehart and Grimm (1972); and Zylman (1973).

Few studies of the effects of public education campaigns are designed to assess the results of the educational component by itself. There are exceptions. Three poster studies have shown clearly positive results. Piccolino (1966) found that placing posters near a heavily used stairwell at O'Hare International Airport increased the number of persons who grasped the handrail on descent. Laner and Sell (1960) and Blomgren et al. (1963) showed positive effects of posters on industrial safety behavior and traffic signalling behavior, respectively. Planek (1969) has reviewed these and other studies. Fleischer (1973) found that public service announcements on radio and television did not significantly affect safety belt use in a controlled study.

Numerous studies evaluate the effect of mass media campaigns in conjunction with some other factor, such as a change of law. Studies by Barmack and Payne (1961), Sheppard (1968), and Ross (1973) fall into this category. Some studies have dealt directly with public education campaigns in the alcohol and traffic safety area: Naisbitt (1961), Scottish Ministry of Transport (1964), Sheppard (1968), Dempster (1969), Waller (1968c), Leys (1970), Kates et al. (1970a, 1970b), Cake (1971), Hedrick et al. (1971), Swinehart (1972), and Morris (1972) are examples. Yet, none of these shows that alcohol-related accidents were reduced as a result of just the mass media campaign. Morris (1972), however, stated that several road safety campaigns in England were cost-effective. Little (1971), on the other hand, concluded that public information measures in the U. S. at the time of his writing were highly ineffective.

Public education campaigns have successfully communicated knowledge about and general awareness of specific legislation. One well-documented example is the Swedish change-over to right-hand traffic (Spolander, 1968). Sheppard (1968) also claimed some slight effects from a public education campaign prior to the 1967 Act in Great Britain, and Kates et al. (1970a, 1970b) reported decidedly strong effects in several areas of knowledge gain. In general, public education campaigns do appear to educate to a measurable degree. Robertson et al. (1972) and others have shown, however, that behavior change does not come easily, or even at all, using some mass media techniques. Although this judgment may be true for short-term effects, it may also reflect the American bias toward immediate results. Public health campaigns, for example, have a cumulative effect that may not appear for several years after initiation of the public education effort (Rossi, 1966). The absence of an effect early in a campaign may not reflect its total failure, but only the impatience of the investigators.

Mass educational countermeasures may be of greatest benefit in increasing public knowledge and awareness, or in reinforcing already established behavior patterns. Planek (1969) offers a highly useful model based on Roger's innovation of diffusion and Laswell's basic communications theory. According to his model, mass media are best used to initiate awareness, to convey information, or to strengthen partially established behaviors. Two-way, more personalized communications can bolster the initial thrust of a mass media campaign by more directly moving the target audience to decide to adopt a new behavior suggested, to seek confirmation for the adoption decision, and to actually perform the behavior. An urgent need exists for evaluating public education campaigns and making these results available to other campaign planners. Figure 3 shows one model for campaign design and evaluation (Wilde, 1971). In general, public education campaigns appear to be most effective when combined with enforcement and some form of personalized persuasion.

4. REHABILITATION

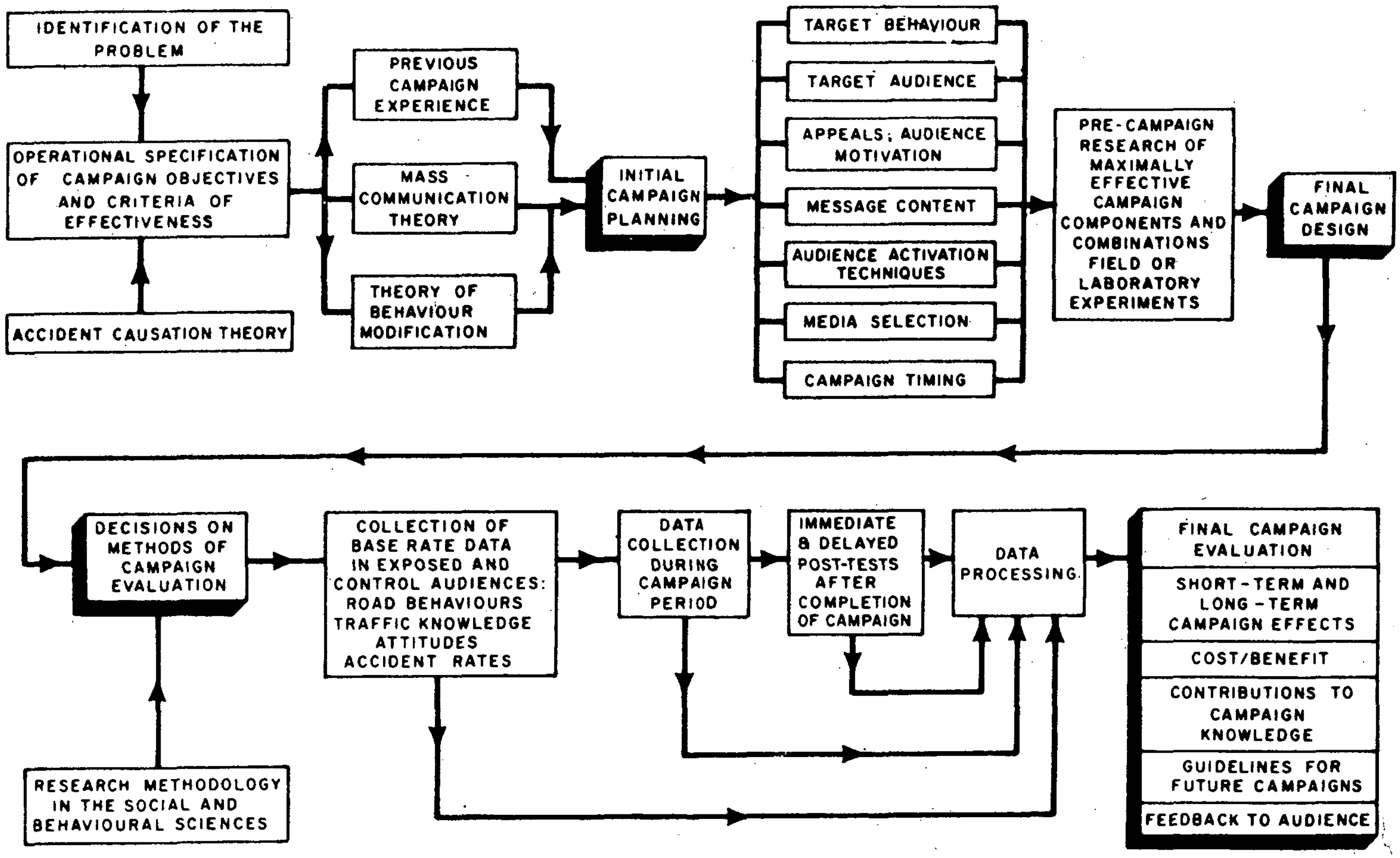
As a countermeasure for alcohol-related traffic fatalities, rehabilitation seeks to: (1) reduce the alcohol consumption of the problem drinker, and/or (2) reduce his driving while under the influence of alcohol. Rehabilitation programs may be broad-based community efforts or quite narrow, single agency actions. Generally, rehabilitation has been applied to problem drinkers rather than social drinkers. Included within the range of treatment options classified as rehabilitation are: Drug therapy (Antabuse, Temposil), individual psychotherapy, group psychotherapy, Alcoholics Anonymous, behavior modification, schools for alcohol problems, industrial alcoholism programs, and other specialized programs for the reeducation of problem drinkers. Fox (1967) describes several of these in detail.

Current attitudes about rehabilitation as a countermeasure are clearly expressed in the relatively new "health-legal approach" (Filkins, 1970; Little, 1971). This approach views problem drinking as a form of disease rather than a criminal act and contends that court-referred treatment for problem-drinker drivers is more likely to effect changes in alcohol-related traffic fatalities than traditional penal sanctions (fines, imprisonment, license revocation). Rehabilitation is presented as a substitute for penalty, with the understanding that this new orientation will reduce the high rate of recidivism among problem drinkers. The complexity of the health-legal approach should be emphasized. Treatment is the last step in a four-step process; Case finding, diagnosis, authority attainment, and treatment. Recent evidence compiled by Joscelyn et al. (1971b) indicates that, on a national basis, current court procedures for handling problem drinkers are not consistent with an ideal health-legal approach.

More recently, several ASAPs have made use of the health-legal approach. Table 8 presents the frequency with which various rehabilitation approaches have been undertaken at three ASAP locations (Voas, 1972). Whitley and Daetwiler (1970) have outlined the difficulties in developing a single rehabilitation

Figure 9-3

DIAGRAM OF SAFETY CAMPAIGN DESIGN AND EVALUATION [a]



[a] From Wilde (1971)

TABLE 9-8

Range of Treatment Options in Three ASAP Locations[a]
(Numbers of Court Referrals)

Treatment	Site A	Site B	Site C
Group therapy	109	76	19
Chemotherapy (Disulfiram)	19	86	14
In-patient	8	1	4
Alcohol and Highway Safety School	23	168	149
Individual psychotherapy	58	8	26
Alcoholics Anonymous	30	8	11
Mental health program	35		
School for Alcohol Problems	121		
Supportive counseling	25		
Private counseling	8		
Vocational counseling	6		

a. Data from Voas (1972).

program for problem drinkers selected through ASAP procedures and have proposed a number of treatment modalities, each designed for a subgroup of the problem-drinker population. They found that many of the drinking drivers contacted are: in the early stages of problem drinking, predominantly male, less than 35 years old, disproportionately from minority ethnic groups, still employed, and with their family intact. Current forms of treatment involving insight and verbal interchange appear to be inappropriate; innovative forms of treatment more fitting to the social class, life style, and cultural background of the clients are being developed. Examples are the work by Adams (1971) involving behind the wheel self-analysis of driving behavior among problem-drinker drivers and that of Mills, Sobell, and Schaefer (1971) in behavior modification. Corder et al. (1972) have shown the possible value of a combined husband-wife treatment program, while Sackman et al. (1972) have developed a model treatment re-education program for use by ASAP agencies.

Table 9 shows the extent of the referral activity in five ASAPs during 1971 (Voas, 1972). Inspection of these data reveals a low proportion of the convicted drinking drivers being "diagnosed" as problem drinkers, but a high proportion of the "diagnosed" problem drinkers being recommended or referred for rehabilitation.

Studies that attempt to determine the effectiveness of rehabilitation programs are generally limited by the specificity of the program under investigation and the criterion measure used. In evaluating rehabilitation as a remedy for alcohol-related traffic fatalities, the criterion must be a reduction in alcohol-related crashes. In the absence of this criterion, inferences regarding a reduction in alcohol-related crashes may be made from a reduction in alcohol consumption or a reduction in drinking-driving behavior. Presently, the evaluation of rehabilitation as a countermeasure is largely limited to such indirect measures of effectiveness.

Perhaps the most prominent example of a program designed for individuals convicted of driving while intoxicated (DWI) is the Phoenix DWI Program (Steward & Malfetti, 1970). While not designed specifically for the problem drinker, this program does educate the convicted DWI regarding drinking problems and their consequences (particularly driving consequences). The four two-and-one-half hour sessions are devoted to: (1) The drinking driver, (2) alcohol and driving skill, (3) problem driving, and (4) personal action. Crabb et al. (1971) completed an initial evaluation of this program using historical data on 500 students and 500 control DWI drivers. A significant reduction in recidivism was found for those who had taken the course.

Although not directly concerned with alcohol-related traffic fatalities, Bjerver's (1972) study of individuals referred to the Stockholm Treatment Agency for the care of alcoholism provides some evidence of the effectiveness of court referral programs. Bjerver studied the progress of several groups placed under compulsory treatment in comparison to a control group. He found an improvement in general health in the compulsory rehabilitation group. Unfortunately, no data were reported that indicate the effects of such treatment on the driving patterns of the study groups. Similar findings appear in Weber (1968).

Barmack and Payne (1961) have reported on the effectiveness of a countermeasure designed "to change the attitudes of tolerance for airmen who drink and drive recklessly." Although the countermeasure combined administrative, psychotherapeutic, and educational elements, it is probably best described as a rehabilitation effort. Driving after drinking was described as "disturbed" rather than as masculine or brave behavior; a lost-time accident would expose the airman to a

TABLE 9-9

Presentence Investigations and Rehabilitation Referrals in Five ASAP Areas during 1971[a]

ASAP	P.S.I.s[b]	Problem drinkers	Recommend to rehab.[c]	Referred to rehab.[d]	Recomm. accepted
Colorado	905	483	435	332	76%
Michigan	664	391	462	462	100%
New Mexico	842	152	218	182	83%
Oregon	989	520	396	382	96%
Washington	1,849	867	787	759	96%
Total Mean	5,249	2,143	2,298	2,117	92%

a. Data from Voas (1972).
b. Presentence investigation consisted of personal interviews of clients and record checks from sources such as police, motor vehicles, and social/health agencies.
c. Recommended on basis of ASAP investigations. In some instances, social drinkers were recommended to rehabilitation for special drinking driver schools.
d. Referred to rehabilitation programs by the courts.

thorough career review and, on occasion, referral to a psychiatrist. Significant reductions in accident experience were demonstrated following the introduction of the program. Similarly, Hilker (1970) reported a reduction in both off-duty and on-duty occupational accidents following participation in a company-sponsored alcoholic rehabilitation program.

More recent evidence of the efficacy of rehabilitation programs comes from the initial experiences of two ASAPs. These findings, however, are tentative, since they are based on preliminary investigations. The Nassau County ASAP has developed an attitude modification program using group discussion for convicted DWI drivers. This program includes both "therapy" and "referral" services in severe cases of problem drinking. Evaluation of the Nassau County program revealed that while the recidivism rate for those taking the course was lower than for a control group, the course participants had a higher crash rate (Nassau County Traffic Safety Board, 1972). In Washtenaw County, the ASAP program involves referrals of problem drinkers to a voluntary, medically supervised Antabuse program. Convicted DWIs are permitted to drive, as long as they demonstrate abstinence through weekly blood tests for the presence of Antabuse. Preliminary findings from this program showed a lower recidivism rate for DWIs treated with Antabuse than for DWIs given other court penalties (Washtenaw County, 1972). Voas (1972) has cautioned, however, that selective factors in referring drivers to the Antabuse program make the Washtenaw County results equivocal. Final assessment of the effectiveness of rehabilitation countermeasures within the ASAP program is not yet available.

5. NOTES ON INSTRUMENTATION

Chemical tests for intoxication are an appropriate countermeasure to alcohol-related traffic accidents to the extent that they facilitate the detection and removal of the drunk driver from the roadway. They form one highly significant part of a sequence of countermeasure activities. Their effectiveness is short-lived since they do not keep the same driver off the road for a long period of time; however, penal sanctions, procured through evidence provided by chemical tests, can function as a control mechanism of longer duration. As countermeasures, chemical tests have a wide range of application that includes both social drinkers and problem drinkers.

Current thinking in the United States emphasizes the use of breath testing devices in both pre-arrest and post-arrest determinations of blood alcohol concentrations as an efficient and simple detection procedure for the large-scale control of drunk driving. However, while pre-arrest screening for intoxication is an integral part of the British Road Safety Act, it remains a subject of constitutional debate in the United States (Hricko, 1970).

In addition to questions of the reliability of chemical test procedures (see later discussion), other components of the testing system appear crucial to the successful and lawful use of the resulting evidence. The effectiveness of chemical tests for alcohol may be determined by all of the following: (1) The selection of the most appropriate method for local needs, (2) adequate training of police officers who administer the tests, (3) compliance with technical standards of analytic methods, (4) operation within legal requirements, and (5) submission of the entire process to medical-technical supervision (American Medical Association, 1968).

Despite the complexities involved in implementing a chemical test program as a countermeasure, the need for it in most police enforcement programs appears great. Waller (1971) has reported on police estimates of drinking by fatally injured drivers and pedestrians in comparison with the actual blood alcohol concentrations determined by the coroner's examination. Both the presence and amount of alcohol were usually underestimated in the police report. Alcohol was least likely to be reported for persons 60 or older, pedestrians, nonresponsible fatalities, and drivers of new cars. These results emphasize the need for chemical tests in post-fatality investigations of crash victims. Further, they suggest that subtle factors may influence a police officer's assessment of alcohol involvement in an accident. Indeed, the presumed unreliability of clinical or observational assessment of intoxication initially provided impetus for the development of scientific measures of blood/breath alcohol concentrations.

Recent evidence (Prouty & O'Neill, 1971) has suggested that inexpensive, disposable breath tests for the qualitative estimation of blood alcohol concentrations may be unreliable. The investigators studied eight different commercially available screening devices and found high levels of both false positives and false negatives. This evidence is discouraging since the evaluators of the chemical test results were police officers--individuals most likely to actually apply such procedures in either pre-arrest or post-arrest evaluations of intoxication. With respect to these problems, Goldberg and Havard (1968) have outlined a noteworthy research program for assessing the merits and demerits of various chemical test procedures.

Several forms of safety interlock systems are being developed to prevent intoxicated persons from operating a vehicle. Examples include a breathalyzer-like device connected by relay to the ignition (Alexander, 1966), or the more recent "phystester" being developed by auto manufacturers in coordination with governmental agencies (Jones & Tennant, 1972). Electronic sensors in the road to detect erratic driving have been proposed. A highly encouraging device is the electronic breath alcohol tester that is sufficiently small and portable to be taken by police officers to the scene of arrest. Field evaluations of this equipment are in progress now.

In a broad sense, another form of instrumentation is the paper-and-pencil test. Selzer and Chapman (1971) describe the MAST (Michigan Alcohol Screening Test) that successfully distinguishes between alcoholic and non-alcoholic persons. Mortimer and Lower (1971) describe additional work in the area of tests to identify the problem drinker-driver.

6. DRINKING PEDESTRIANS

Fatalities attributable to alcohol consumption by the pedestrian have received recurrent, but relatively minor attention in the traffic safety literature. Countermeasures for such drinking pedestrian fatalities remain largely untried. Haddon et al. (1961) performed pioneer work in the area by showing the high degree of alcohol involvement and by gathering useful epidemiological data on age, time, and other circumstances of urban pedestrian fatalities. An extensive survey of American metropolitan areas (American Automobile Association, 1970) showed that 36% of the cities responding tested pedestrian fatalities for alcohol. In the 78 cities with populations over 25,000 that maintain alcohol accident data for pedestrians, approximately 46% of the pedestrian fatalities were tested for alcohol. The results of chemical tests from 99 cities on 328 pedestrian fatalities revealed that 58% had BACs over .10%.

In an intensive study of 50 drinking pedestrian fatalities in San Diego County, 78% had BACs of .10% or higher and 66% had BACs of .15% or higher (Marsden, 1972). The 50 cases represented 20% of all pedestrian fatalities in the county for the period studied. None of the accidents occurred during daylight hours. The greatest number of fatal collisions occurred on highways and freeways where there was little or no lighting and where, in several instances, pedestrians were prohibited by law. Further, during the eight months studied, no two fatal drinking pedestrian accidents occurred at the same location. Based on these and other findings in the report, Marsden concludes that several of the pedestrian countermeasures proposed by NHTSA would be ineffective, e.g., improved lighting near drinking establishments and special caution signs in high collision areas.

Generally, countermeasures for dealing with the drunk pedestrian appear to be at the developmental rather than the implementation and testing stage. In the meantime, traffic safety programs will probably rely upon the general countermeasures that have been proposed for dealing with pedestrian accidents. Biehl (1969) reviews the effectiveness studies on a number of specific pedestrian accident countermeasures, and the absence of research on countermeasures for drinking pedestrians is noteworthy. More recently Snyder and Knoblauch (1971) have presented an extensive analysis of pedestrian accidents in relation to countermeasures. Since their study covered all types of pedestrian accidents to all ages (rather than adult fatalities as in the Haddon et al., 1961 report), the level of alcohol involvement was quite low: 2% for drivers and 4% for pedestrians. If just fatal cases are considered, the level rises to approximately 7% for both drivers and pedestrians. This figure is quite similar to the estimate given earlier in Table 1 for pedestrian fatalities related to drinking.

7. THE LOGNORMAL DISTRIBUTION

A recent controversy in the alcohol literature has implication for the type of countermeasure one should select. Smart and Schmidt (1970) have asserted that the distribution of BACs in non-accident drivers is approximately lognormal. They infer that, if the mean BAC of all drivers is reduced, then the proportion of dangerous drivers with BACs over .08% will also decrease. Thus, countermeasures should be directed against drinking and driving in general. Zylman (1971a), however, has suggested that measures against drinking should be directed at specific target populations. If such a policy were adopted with some positive results, presumably the lognormal distribution would no longer be descriptive of the BACs among drivers. In relation to this line of reasoning, Little (1971) estimates roughly that the drunk problem drinker represents a risk more than 10 times greater, on a relative population basis, than that of the drunk social drinker.

O'Neill and Wells (1971) state that reduction of the mean of all drivers' BACs will not necessarily reduce the proportion of impaired drivers. They challenge the statistical methods and mathematical reasoning of Smart and Schmidt. There are an infinite number of lognormal curves, they reason, with the same mean, but with different proportions of cases above some specified value of the variable. Thus, O'Neill and Wells imply that the argument by Smart and Schmidt for countermeasures directed against drinking and driving in general, cannot be justified on the basis given and is subject to considerable doubt. Ekholm (1972) has entered the controversy by pointing out an error in the reasoning of O'Neill and Wells. He observes that the proportions under discussion depend on both the mean and the variance. Changes in the variance can, within limits, counterbalance changes in the mean. He states that while the real answers remain to be determined by empirical work, there are theoretical and empirical reasons for believing that the proportion above an arbitrary risk level will vary in the same direction as the mean BAC, *if* the lognormal is a correct description of the distribution both *before* and *after* the application of a countermeasure. Both sides of the discussion may have some validity in the long run.

8. LIST OF ALCOHOL COUNTERMEASURES

This list combines items from Fox (1967) and Hedrick et al. (1970), with several countermeasures added by the authors. While the listing is not grouped into a logical structure, the rational classification of alcohol countermeasures has been of some concern to the authors. Fox (1967) structured his listing into five loose areas: "Legally oriented", "motivation to avoid accidents", "physiological methods", "opinion-influenced motivations", and "detection of alcoholics and pre-alcoholics." The U. S. Department of Transportation report (1968) and the more recent guidebook for ASAP project planners (U. S. DOT, 1970b) contain other classifications. None of the above are fully satisfactory in their present form. It would be of clear benefit to the field to develop a better framework for current ACs as well as those that evolve in the future.

1. Record in driver's record alcohol-related traffic convictions for court records.
2. Record in driver's record nontraffic alcohol-related convictions.
3. Record in driver's record all alcohol-related information from social/health agency records.
4. Provide for flagging vehicle record for cars owned by problem drinkers.
5. Include alcohol safety questions in license examination and driver handbook.
6. Provide for certification by the license applicant regarding previous arrests and treatment for alcoholism.
7. Provide for including chemical test data in accident record.
8. Provide for chemical tests and specify concentrations.
9. Provide for implied consent for chemical tests.
10. Require license revocation if test is refused.
11. Set specifications and procedures for chemical tests.
12. Establish qualifications for alcohol safety personnel.
13. Provide for special enforcement of drinking-driving laws.
14. Provide for special training on breath testing equipment.
15. Determine locations and times of day of accidents involving drinking pedestrians.

16. Require presentence investigation of convicted drinking drivers.

17. Provide for referral of problem drinkers for treatment.

18. Establish medical advisory boards (MABs) for licensing agency.

19. Provide for review of convicted DWI drivers by MAB prior to reinstating license.

20. Empower MAB to require physical exams on drivers whose records they review.

21. Provide for vehicle impounding for driving while license is revoked or for second DWI conviction within three years.

22. Provide for cancellation of collision insurance if insured driver has BAC above 0.10%.

23. Provide for special surveillance of revoked drivers.

24. Develop special pedestrian safety programs in areas of high accident risk or drinking, e.g., better lighting, re-route traffic, reduce speed limits, special caution signs.

25. Provide special patrols to assist intoxicated pedestrians.

26. Arrange for detoxification and treatment assistance for pedestrians.

27. Provide for suspension or revocation of license plates of vehicles owned by persons covicted of a drinking-driving offense.

28. Provide for special tags or registration certificates for vehicles owned by convicted drinking drivers.

29. Prohibit the transfer of vehicles with special registration certificates.

30. Develop mass-media, public education campaign on alcohol safety. Possible topics include: Extent of drinking-driver problems, effects of alcohol on driving behavior, detail of laws, characteristics of the problem drinker driver, amount required to reach .10%, sources of help, public support for government and private agency efforts, penalties associated with DWI conviction, etc.

31. Develop speakers bureau program on alcohol safety.

32. Augment alcohol safety sections of high school driver education programs.

33. Add sections on alcohol to primary safety courses and to appropriate secondary courses. (Family life courses)

34. Develop school driver improvement programs for special offenders.

35. Implement a driver assistance program in cooperation with social and health agencies.

36. Provide colored driver licenses for under-age persons who might try to falsify entries on a license to purchase alcoholic beverages.

37. Revoke driver's license for multiple convictions of drunkenness, even if unrelated to driving.

38. Establish more severe penalties for drinking and driving.

39. Provide insurance discounts for nondrinkers.

40. Advise taverns and public drinking places of identity of convicted DWI offenders and forbid sale of liquor to them. (Practical only in small towns.)

41. Make tamper-proof, breath-meter control of car starting a mandatory device for all vehicles.

42. Control maximum speed according to BAC as indicated by breath-meter.

43. Place notices on liquor and beer bottles telling maximum legal blood alcohol.

44. Use twisting obstacle driving course on the road. Those who knock over cones or lights are tested for alcohol.

45. Take the convicted DWI offender out some distance on a road without buses and force him to walk home. (Used in Turkey.)

46. Revoke licenses of teenagers who drive after drinking any amount.

47. Provide for prosecution of an individual who can prevent an intoxicated person from driving but doesn't.

48. Provide for self-testing by commercially available screening breath tests.

49. Revoke license for lifetime after three convictions for DWI.

50. Establish a BAC of .05% as legal limit for those under twenty-one.

51. Use state commission to contact DWI offenders who may be alcoholics for purposes of attempted rehabilitation.

52. Establish national prohibition, effectively enforced. (Do special studies to determine why earlier law failed.)

53. Establish crisis intervention centers similar to suicide prevention centers.

54. Promote the adoption of per se laws and strong implied consent laws.

55. Establish selective licensing limitation on time or place of permitted driving.

56. Distribute portable breath testing devices to bars.

57. Establish blockades at the roadside.

58. Request high school principals to announce publicly the names of students killed or injured in alcohol-related accidents.

59. Establish measures to increase probability that prosecution for DWI will take place for actual DWI.

60. Establish measures to increase awareness of an increased probability that conviction will follow guilt.

61. Arrange for free mass transit on high drinking holidays.

62. Pass a law stating that to purchase liquor, one's BAC must be less than .10%.

63. Show color sound films of DWI suspects to lawyers and court.

64. Make penalties less severe, but more likely, e.g., all DWIs are fined two weeks' pay and required to work for local government for two weeks.

65. Provide "state-dependent" training, i.e., teach persons while they are intoxicated, to drive safely.

66. Educate businesses (for example, promotion of liquorless parties or provision to transport people home without driving, in case drinking does take place).

67. Offer free coffee (mostly to delay driving long enough to reduce alcohol level somewhat).

68. Pay for taxis to take people home.

69. Sponsor the availability of individual nondrinkers at parties.

70. Create a youth driving corps, first for holiday driving such as at Christmas and New Years, and then use such a youth driving corps for every weekend (night?) in the year.

71. Provide for manufacturers' imprinting of liquor bottles warning of the dangers above certain levels.

72. Have cab companies with two-man teams of drivers avilable; a cabbie to drive a drinker home and his companion to drive the drinker's car home.

73. Educate as to methods of diminishing alcohol effects.

74. Search for counter-chemicals to antagonize alcohol effect, e.g., a sober-up pill that rapidly oxidizes alcohol in the body.

75. Change opinions of peers. This might be especially effective in high school and early college-age groups. The drinker would now be a member of an out-group, not an in-group.

76. Change the self-image of the drinking driver. For example, show sound color films or photographs of himself under the influence of alcohol <u>to him</u> rather than to the lawyers or jury for legal purposes.

77. Change the self-image of the driver by having drinking drivers referred to a psychiatrist, psychologist, or "mental health counselor," as was done by Barmack and Payne (1961).

78. Use publicity in regard to those convicted of driving while intoxicated.

79. Put person on an alcoholic ward over a weekend after first DWI conviction so he sees and talks with late stage alcoholics.

80. Teach young drivers how to stay awake while driving at night: Shoes off, window open, sing, loud radio, short nap at roadside, etc.

81. Bring "peer pressure" to bear on the buyer of alcohol for under-age drinkers.

82. Use telephone "hot lines:" For drinker assistance, 24-hour information and referral, or for direct access to previous driver record.

83. Reduce time and "red tape" requirements for arresting officers.

84. Use mobile breath testing vehicles that move directly to scene of arrest or accident.

85. Organize and utilize local volunteers for public education efforts.

86. Make convicted DWI offenders who are at fault for an accident, responsible for all associated financial losses, up to a level of 50% of their total net worth.

87. Have judges and police officers drink, in a protected environment, until their BAC reaches .10%.

88. Form a union of nondrinking drivers to lobby for legislation, reduced insurance rates, etc. (Andreasson)

89. Publicize the place at which the driver or pedestrian had been drinking as part of the accident report in alcohol-related accidents (especially fatals).

90. Use alcohol-related trigger films for group discussions.

91. Enhance social tolerance for alcohol abstinence.

92. Encourage employers to use the threat of job loss as a lever to move problem drinkers to obtain treatment.

93. Focus on early detection of problem drinking (alcoholism, like cancer, can be controlled if detected early enough.)

94. Improve host behavior, e.g., serve fewer drinks, serve less potent drinks, serve food, provide sober drivers for heavy drinkers.

95. Publicize widely the stages of alcoholism and, especially, the symptoms associated with early stages.

96. Encourage public to drive less during high-risk hours for alcohol-related accidents.

97. Teach alcoholic drinkers (gulping pattern, several drinks in short time period) to become social drinkers (sipping pattern, fewer drinks over same period of time). (Mills, 1971).

98. Have police officers randomly sample BACs in bars and issue warning to those with BACs at or above .10% that they cannot drive.

99. Double the taxes on alcohol and devote increased revenue to countermeasures against alcohol-related traffic accidents.

100. Encourage the idea that even small amounts of alcohol may be deleterious to health.

101. Establish a new bar tax to which exemptions are granted on the basis of proximity of the customer's residence to the bar (P. Hurst, personal communication.)

102. Make technical literature and samples of previous alcohol-oriented public information campaigns available free to persons who request it (Highway Safety Research Institute, Public Communications Group, 1972)

103. Standardize the closing time of all drinking establishments and increase substantially the enforcement shortly before and after that time. (See Raymond, 1969.)

104. Promote the adoption of pre-arrest breath testing similar to that used in Great Britain.

105. Develop, validate, and apply paper-and-pencil tests to identify potentially dangerous drinker drivers (Selzer & Chapman, 1971; Mortimer & Lower, 1971).

106. Identify community officials likely to be working with abusive drinkers and enlist their support in the planning and execution phases.

107. Reduce the frequency of "plea-downs," informal arrangements to plead guilty to a lesser offense, e.g., reckless driving rather than DWI.

9. SUMMARY

While more than 100 countermeasures against alcohol-related traffic accidents are listed in this paper, precious few have had the luxury of a fair and objective devaluation as to their true effectiveness. Almost none have been sufficiently defined and then tested against a nontreatment control group to assess the comparative value of one course of action versus another. The single program having the most potential in this regard is the U. S. Department of Transportation's Alcohol Countermeasures program. Because almost half of U. S. pedestrian fatalities are alcohol related (27% - drinking pedestrian involvement; 20% drinking driver involvement) and, because more than half of the driver and passenger fatalities are related to drinking drivers (59%, according to estimates in Table 1), the federal government mounted an extensive program to reduce alcohol-related traffic accidents, especially fatalities. A major portion of this effort consists of 35 Alcohol Safety Action Projects (ASAPs) located throughout the U. S. The major countermeasures used in these projects are: selective enforcement, public information, rehabilitation, and legal-judicial action. Preliminary results from the first group of ASAPs indicated a decrease of fatal crashes (9.7%) and fatalities (8.6%) in ASAP areas as compared to nonASAP areas when data from 1970 and 1971 are examined. Evaluation of the specific countermeasures used will be forthcoming from special analytic studies at each ASAP site. Few of these were available at the time of the Vermont Symposium.

In regard to enforcement, European data indicate that with lower levels of BAC and generally stricter enforcement, the percent of total fatalities in which alcohol is a major contributing factor appears to be much lower than in the U. S., with its more lenient laws and less severe enforcement. The authors surmise that tough laws that are widely publicized and strictly enforced reduce the proportion of traffic fatalities associated with excessive drinking. To be successful, four phases are required: the establishment of adequate laws, thorough enforcement by police, penalization of violators when brought to court, and perception by the public that violators will be penalized. Any weak or missing link in the chain reduces total effectiveness of the system. The most convincing demonstration of the effectiveness of an enforcement countermeasure is found in the recent British experience. A time-series analysis indicated that casualties per million vehicle miles, fatalities per 100 million vehicle miles, and serious injuries on Friday and Saturday nights show a relatively abrupt decrease after the initiation of the British Road Safety Act. The program had a "sharp, immediate effect in diminishing deaths and injuries on British roads" (Ross, 1973, p. 2).

At least part of the effectiveness of the British experience resided in the public information and education components of the program. A few studies in the literature indicate the public information campaigns, by themselves, can change safety-related behavior in desired directions. Several studies found, however, that public information efforts alone may be unsuccessful in changing behavior. It appears that mass media campaigns have stronger effects when combined with other countermeasures, such as legal changes and strict enforcement. When using mass media, knowledge and attitude changes can be produced with greater facility than can the more resistant behavioral changes. Perhaps the most useful application of mass communications will be in increasing public awareness or in reinforcing already established behavioral patterns.

The evaluation of rehabilitation as a countermeasure to alcohol-related traffic crashes is largely limited to indirect measures of effectiveness, e.g., a reduction in drinking generally or in drinking-and-driving behavior. However, Barmack and Payne (1961) showed significant reductions in traffic accidents, and Hilker (1970) reported similar results for nontraffic accidents after participation in rehabilitation programs.

Additional brief consideration is given to instrumentation, drinking pedestrians, and a recent controversy dealing with the lognormal distribution. The paper ends with a listing of 107 alcohol countermeasures.

Precise recommendations as to which countermeasures can be applied to specific situations with the greatest degree of cost-effectiveness await the results of future evaluative research. In this regard, it is noteworthy that very few studies in the literature have used control groups at all, much less adequate control groups with random assignment of subjects to treatment and non-treatment conditions. The authors heartily recommend a careful reading of Evaluative Research (Suchman, 1967) before such evaluations are begun. From both a technical and practical viewpoint, the book is immensely helpful to evaluators and the managers of the program being evaluated.

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DISCUSSION

PERRINE: We have a few submitted questions already. I will give preference to those questions concerned with countermeasures per se, rather than with epidemiological considerations.

"YOUR TEXT IMPLIES THAT DEAD DWIS AND CONVICTED DWIS ARE FROM THE SAME POPULATION. ARE YOU SURE?"

DRIESSEN: Where does the text imply that? Is that in relation to the ASAP data?

ZYLMAN: Yes.

VOAS: Could I make an attempt at that? I don't think that the idea that arrests are related to possible reductions in crashes and fatalities need necessarily suggest that the people that are taken off the road by arrest are the same people that get into crashes. The effect of the arrest can be deterring to people who are not arrested, never are arrested, but could be in crashes. Therefore, the increased enforcement level could produce deterrents which could affect death rate without the two populations being identical. Does that answer the question?

ZYLMAN: The reason I asked is because in spite of all the effort to show that they are of the same population, in your own data here in Vermont, for example, when you get right down to the final paragraph, you hedge a little when you say that these DWIs appear to be from similar populations to those being killed. The same thing happened in Filkin's study. Then, you go out to California and Thomas and Chang, after studying the differences between those who were killed while drunk and those who were convicted drunk drivers and who in fact had been involved in prior collisions: These were presumably similar populations, and they found very significant differences. I really would begin to question whether or not we're dealing with the same population.

PERRINE: Would you like to comment on this, Julian?

WALLER: Yes. With one exception, the hedging on our part was simply scientific caution. When we corrected for age, recognizing that many more fatalities than DWIs were people under the age of twenty-five, we found that on all except that one variable (number of prior convictions), the DWIs and the fatalities did represent what I will call part of the "same population." I don't like to talk about the same population, because I don't think scientifically we can ever really say that we are dealing with the same population. That's the only reason why we hedged and spoke about "similar populations."

BUIKHUISEN: It has been said that convicting people will deter others. I think this is an hypothesis which has lived as long as there has been a law. And although the law has existed a very long time, we have hardly made any attempt to verify this hypothesis. I would like to suggest that we start doing so. Let us perform some simple experiments like: assessing the blood alcohol concentration distributions among driver populations, then change police surveillance or the severeness of the penalties for drunken driving; and after this is done, establish again the BAC distributions by comparing the distributions before and after the introduction of the experimental variable. Then, we can say if, and in what respect, changing the penalties has had any deterrent effect. I hope to be able to carry out such experiments in the Netherlands next year. We are especially interested in the question of whether impounding the car would be a good deterrent.

I think these kinds of experimental investigations are badly needed. As long as we have not verified the hypothesis about general deterrence, we should be very careful in applying this principle in our sentencing policy. Passing more severe sentences for the sake of general deterrence could be highly unjustified if there proved to be no deterrent effect in our penal sanctions.

VOAS: I think I'd have to agree with that. I would like to just mention that all of our projects are required to use voluntary roadside surveys of driver blood alcohol levels with this in mind. Now, in terms of the data to date, we have not seen substantial changes in the few projects in which we have a before-and-after measure. We may not yet have enough data. I think Dr. Borkenstein has felt that we may need to have a continuous roadside survey in order to see these changes occurring. At present, we require one survey every year; that may not be frequent enough. On the other hand, the Canadians have done one study in which they have found a significant shift in the blood alcohol levels on these surveys.

BUIKHUISEN: May I say something? I think if you would measure the effectiveness of a new way of sanctioning or new legislation, you need not wait very long to observe any change in behavior. The most important thing is that the population-at-risk be familiar with these changes in sentencing policies or laws. If they know them, they probably will adjust their behavior. You need not wait long to be able to register these differences. Another point is that after some time, some differences might disappear, because people realize that the change in sentencing policy has not been followed by a change in law enforcement. To establish this second reaction, it is necessary to carry out follow-up studies.

WALLER: I think John Havard presented some relevant data on this issue at the Traffic Injury Research Foundation of Canada Conference in Montreal this past Memorial Day, in which he showed that immediately after the 1967 British Road Act, there was approximately a 40% drop in blood alcohol concentrations below 100 milligram per cent and about a 25% drop above that concentration. About two years later, there was a residual of about a 20% or 25% drop of persons below 100 milligram per cent and virtually no drop among the individuals who had blood alcohol concentrations of 100 milligram per cent or higher. This would suggest that there may be some deterrence, but perhaps not in the group in which we would like deterrence.

BUIKHUISEN: I think the perceived risk of detection is important in this respect. People usually associate a change in legislation with a change in law enforcement. After some time, the insiders know that only the law has changed, but that the probability of being caught by the police is as low as before. Heavy drinkers get more feedback from their "colleagues" than occasional drinkers. Therefore, they rather soon return to their former drinking-and-driving behavior. Such tendencies have been observed in Germany after the introduction of their second traffic law related to this problem.

SMART: I'd like to say that we ought maybe to be very cautious about seeing some of these drops or recovery from drops after legislation and we ought to be cautious about seeing the returns to previous levels as a simple decay function over time.

In Britain and also in Canada, a number of things happened to lead the population to expect things were going to be different in regard to the law. In Canada, I made a small study of cars in parking lots of drinking establishments before and after the .08 law. There was a big initial drop, but then, there was quite a large recovery, just as one sees in the British data. But in Canada, the police made certain statements after the new law. They said, "Well, we aren't going to be standing around outside of drinking establishments watching for the people who get drunk there. We're going to be very cautious." And there are certain legal decisions that required that a sample be made available to persons in charge. Then, there was the legal decision that the officers asking the person to take the test had to have some good reason for asking. He couldn't just ask people at random, "Would you mind, since you're driving this car, taking this breath test?" So I think in Britain too, there was a lot of concern in the beginning on the part of the public that the police would watch drinking establishments. We're only interested in drivers who are involved in serious situations. So I don't see in this instance a decay of effect over time. I want, indeed, to look at what's really happening.

WALLER: But you still get this difference in deterrence between groups with the lower blood alcohol concentrations and those with the higher blood alcohol concentrations. In one case, there is a rather substantial -- and I use the word advisedly -- residual effect, and in the other case, there is virtually no effect remaining at this point as far as proportion of drivers going around with a given blood alcohol concentration.

SMART: Well, I think there, we still ought to wonder whether some of the social changes that accompany new laws have differential effects on different people. I still would rather not feel that there's some sort of situation where whenever you have a new law, there will be an effect, and no matter what happens, the effect will wear off.

BUIKHUISEN: I think these things are rather obvious. From criminology, we know that general deterrence is only effective in cases where the offense itself is not an expression of, let us say, the need of the personality or of the subject. And that's exactly the case with your population.

MOSKOWITZ: The implication I draw from Reg (Smart) is that the effectiveness of the program depends on the enforcement policy. If you pass a law and it is not well enforced, then nothing is going to happen to the behavior you are trying to change. This is similar to Dr. Buikhuisen's comment which noted that you are depending on negative reinforcement to suppress the unwanted behavior. The negative reinforcement involves the arrest, conviction, and legal penalties designed to suppress driving under alcohol. If the probability of being arrested and receiving negative reinforcement when you exhibit the unwanted behavior is very low, then no learning to suppress the behavior will occur.

It should be noted that in countries where there is vigorous enforcement of a .05 law such as in Norway and Japan, the much lower fatality rate associated with alcohol indicates that this technique of negative reinforcement does change the behavior. Therefore, it appears important to discuss what can be done to improve the enforcement of already existing laws in this county since we have seen the evidence that enforcement is really quite low.

DRIESSEN: One thing we can do in that regard is, rather than severe penalties, use very minor penalties. These should be strong inconveniences rather than serious punishments. You don't put a man in jail for three or six months, but you might make him go down to the courtroom on Monday morning and stand there for three or four hours waiting his turn in line. But if the very high probability of a minor punishment is present, this may deter more than a very severe punishment.

MOSKOWITZ: The question is, "Do you think that it's the fact of the nature or extent of punishment which is preventing the police from enforcing it?" I don't know if that's it.

DRIESSEN: Well, this also came up in the conversation last night. The informal systems the police use in determining who is arrested and who isn't arrested are pretty interesting, and we don't know much about them in a published way, i.e., in the literature. However, I do think some people know a great deal about them. For example, police tend not to arrest a man if he is the teacher of the policeman's daughter at the high school in the small town in Iowa or wherever it is.

BUIKHUISEN: I am sorry to say that it is not only a matter of severeness of sanction or the sanction system. What is essential, is what Herb (Moskowitz) has said before: the probability of being caught. That is the most crucial thing. You can change all sanction systems, but if the probability of being caught remains the same, it does not help you very much. Especially with regards to drunken driving, the population-at-risk is not very much impressed by law enforcement. We have just finished a study in the Netherlands in which we asked one hundred drunken drivers on entrance to prison how many times they had been driving under the influence of alcohol the past half year before they were sent to prison. Those one hundred subjects admitted that they had done so, on the average, 50 times each, which is about twice a week. If you ask DWIs who have been convicted, "How great do you think the chances are that you will be caught?" about a quarter of them say the chance is zero and another quarter say it is about 2%! It should be obvious that if people think the probabilities are that low, you need not expect much of whatever sentencing policy. Therefore, the first thing we have to change is the law enforcement. There should be more police control.

KELLER: I was trying to bring the discussion back to something which keeps getting overlooked and this is the different kinds of population. And actually Dr. Buikhuisen was just referring to that. We have a population which is subject to being influenced not necessarily by the strength of punishment, but by the chances of getting punished. They are not willing to take chances if they would feel that they may get caught and get arrested. We also have a population that disregards the chances -- apart from the fact that if they ever think of it, they'd say the chances are very low -- because they're driving with a lot of alcohol in their blood system all the time and they're only caught once in a great while. Even if they did think about the chances of getting caught, they can't help driving with a lot of alcohol in them. There are two factors here: they are disregardful of sanctions for one thing -- sanctions mean less to them; and secondly, they can't afford to think about them because for them the need to loosen up by drinking a lot is so great. That's the population to which Julian Waller was referring, those who showed no continued drop.

EDWARDS: It's easy to show in an informal way that the behavior which is here being described as appearing is in fact the most rational behavior to occur. Indeed, this is true by a very large margin. So that if one looks at the advantages of putting additional effort, let's say either into increasing the penalty or increasing the probability of being caught, there are very large orders of magnitude differences in the expected change, in favor of change, and the probability level is similar.

ROSS: I'd like to support the many things that have been said. The British experience does seem to be interpretable as the effort by a government -- perhaps not fully consciously -- to increase the perception of drivers that they are running a risk of being caught. The decline in the initial effectiveness can be explained on the grounds that the perception was false. The police (for many reasons which I explore in a work that I propose to mail to all of you in January) were not seizing the opportunity, which they were granted under the legislation, of increasing vastly the number of people who were tested and therefore might have failed the test. The law was written so liberally that the police had the option of testing everybody who violated any kind of traffic law concerning what we call a moving violation. It's very likely that had they done so, the British government's promise to the public would have been kept.

Let me make one other point. Law is tempting to us because it is cheap, compared with putting seat belts in every car, or passive restraints, or making the car a better piece of machinery, or improving the roads. All you do is pass a law, write something out, and print it. If there are costs involved, it's not evident to the legislators because the costs do not come out of the public treasury. So law is something seductive in social change, very generally. Because of that very reason, we ought to be particularly wary of the effectiveness of law; we ought to be particularly concerned with seeing that when we propose legal changes, we evaluate them carefully.

Let me state flatly, in order not to take too much time, I think the ASAP evaluations, as summarized in this report and the interim report, indicate a lack of sophistication in the way in which legal change is analyzed, and I'm hoping that the DOT people here demand a better job and feel it worthwhile investing at least a marginal amount of money in seeing that we know a little better what we're doing.

DRIESSEN: For example, by using the time-series analysis.

HURST: Another observation I made in my paper which I think does bear upon this particular point, and is also connected with what Dr. Ross has just said (and I hope I'll be corrected by those who are more familiar with the British studies than I, if I'm wrong). I remember reading in the Manchester Guardian an article supporting the .08% limits of the new act when it was first put forward. They said, "After all, you wouldn't want people on the road with eight or nine whiskies under their belt, which is what it's going to take them to get over the limit. This is a liberal limit. You don't want people that drunk on the road." Then, once the law was passed, people wanted to know how much they could drink. "You'd better stay under two or three drinks, or, man, you'll get busted!" And, of course, this is perfectly true. They took the two extremes of the distribution, time factors, and differences in Widmark's constant over the whole population. You couldn't really say that it was wrong either time. I'm not saying that the government was responsible for this either. I'm saying this is what came out in the media that the people read. Now, when you impose something like that on the public, is it not reasonable to expect a reaction to set in which in this case may result in pulling the law's teeth?

PERRINE: Let's move on to the next question.

"WAS THE OREGON PROGRAM UNIQUE IN ANY IMPORTANT WAY THAT MIGHT EXPLAIN ITS SUCCESS RELATIVE TO THE OTHER STATES?"

DRIESSEN: I don't know enough specifically about the Oregon ASAP program to answer that. That's where by far the largest reductions came.

VOAS: I think the best answer to that is that all of the programs are complex in that they embody a multiple set of countermeasures. We were not able to find a factor which would correlate with the reductions in death that we got from project to project. We felt that level of enforcement might have the most significant relationship, but the correlation is weak at best.

<u>BUIKHUISEN</u>: Could you mention something of these countermeasures? I heard you (Voas) in London last year speaking about ASAP, and even then I didn't hear anything about what countermeasures were being used.

<u>DRIESSEN</u>: There is a list of countermeasures at the end of the paper and I had hoped to classify them and put them into groupings.

<u>WALLER</u>: Are these the ones actually used, or are these just proposed logical sets?

<u>DRIESSEN</u>: Well, they're mixed, and there is some duplication within the list. I didn't have time really to put it through the kind of processing I had hoped. I had planned to organize these into groups and then add more. This is really just a list from Fox's paper in Michigan a couple of years ago and from a document of the OAC (Office of Alcohol Countermeasures) dealing with public information and program feasibility. But one countermeasure that one group used was to take the first offense DWI and bring him out to an alcoholic ward for a weekend and just let him see what it was like. In other words, the persons weren't chronic alcoholics when they were first picked up, but there was some attempt to create the perception of what was in store for them if they kept on drinking. Also, there is some indication in the Denver project that early detection is quite critical. In other words, the problem drinkers that get into the ASAP project are not the old souses that are barely bumbling down the road, but they are young male, married individuals who have a job and are relatively well-integrated people, but they are beginning to develop problem drinking patterns.

<u>BUIKHUISEN</u>: But what are the countermeasures involved in the ASAP program?

<u>DRIESSEN</u>: I would think the heaviest countermeasure would be the enforcement factor, namely, the use of additional police officers who are trained in the use of breath analyzers. They are deployed particularly at special times when they expect high drinking-driving. In the area of treatment, there are about eight different types of treatment, including group psychotherapy, individual psychotherapy, and behavior-modification techniques, such as the man in California who is shocking people sitting at the hospital bar gulping -- if they gulp, they get a shock. If they drink regularly, they are not shocked.

<u>BUIKHUISEN</u>: Do you find all these treatments or countermeasures in ASAP?

<u>DRIESSEN</u>: Well, there are 35 ASAPs going, and each of them has at least 4 or 5 types of countermeasures ranging across enforcement, rehabilitation, and several others.

<u>BUIKHUISEN</u>: Maybe you can specify them in your final draft.

<u>VOAS</u>: There are four areas of countermeasures that are represented in 90% of the ASAP projects: (1) <u>Intensified enforcement</u>: Generally achieved by using special patrols on weekend and week nights at sites that frequently have alcohol-involved crashes. (2) <u>Adjudication</u>: The courts are provided with funds to enable them to handle the expected increases in arrests so that the backlog of cases will not increase. A program is also initiated to identify individuals with drinking problems as part of the case processing. In addition, a referral system is established to insure that individuals receive treatment. (3) <u>Treatment/reeducation</u>: With the cooperation of community alcohol-treatment facilities, a driver-improvement program centering on alcohol is established. (4) <u>Public Education</u>: This is directed primarily at making the public aware of the intensified enforcement effort. This part of the program is aimed primarily at people who are not going to be arrested, that is, the social drinkers; whereas the

enforcement-judicial-treatment system is designed with the problem drinker in mind. While these four countermeasures appear at nearly every site, the specific activities are highly individualized.

ZYLMAN: Just one quick comment. It appears that the glowing report out of Portland, Oregon which was reported here was a little premature. The first six months of this year seem to indicate that they have already lost the ground they gained last year; and so it doesn't look too good at the moment.

DRIESSEN: Sorry to hear that. But I have heard that things are looking much better at several of the other sites.

ROSS: As I read the ASAP evaluation, I felt sympathy with the underlying idea that a complicated problem requires a complicated solution. But I also felt sad as a sociological methodologist. The complexity of the programs make it impossible to expect that we are going to be able to pull out from the successful ASAP programs very much information concerning what it is that makes them successful.

DRIESSEN: I think in some local situations, you will be able to do precisely that. In other words, when you combine the recidivism data from all 52 projects, there are a lot of difficulties because we are talking about different things. The data used are not equivalent. Recidivism may require a six-month time interval at one project and a full year at another. But where definitions and time periods are identical, evaluations can legitimately be made.

ROSS: What I am suggesting now that I have a chance to speak to people who do make some decisions in this matter, is the desirability of simplification of some of the programs in the areas that have not yet received the ASAP designation. Perhaps, for example, there might be a division among programs so that one ASAP would represent a reform of a certain kind in a certain area.

VOAS: Just one piece of information. The last 17 ASAPs that are noted in Jerry's (Driessen) paper have not been approved by Congress, so they will not be initiated. The result is that we are limited to the 35 already underway. In relation to the question of trying just one countermeasure, I will speak to that issue. I frankly have the opinion that this is not viable. You cannot simply change the level of police enforcement and ignore the effect on the courts. If you do, the countermeasure is not complete. The courts may not be able to handle the increased flow and so you haven't made a workable countermeasure. This tends to be true of every project. We have one project that had a nice experimental design. Their experimental design was: the first year publicity only; the second year enforcement only; the third year, both. The problem is that the first year, they publicized widely; they "cried wolf," and it had no substance. The second year, it had substance, but nobody knew! There is no reason, apriori, to believe either of these approaches will work. This is one of our problems: we sometimes work without valid models of our countermeasure system. I think one must carefully avoid setting up research designs that are neat, but won't work in the real world.

MOSKOWITZ: A study with which I was associated offers support for the belief that a consistent and probable negative reinforcement will affect unwanted behavior. This was a study of arrests for plain drunkenness in San Diego. To execute this study which involved testing the efficiency of various treatment measures, a new policy of having all drunk arrests funneled through a single judge in San Diego was adopted. Prior to this, several judges were involved and the sentences received for plain public drunkenness varied considerably with different judges and on different occasions. In the new procedure, only one judge saw all arrests, and he applied a uniform policy of penalties, with 5 days suspended sentence for a first offense, 30 days for a second offense, and so on. All suspended penalties were vigorously administered for recidivism. A large and sustained drop in re-arrests followed the institution of this policy. When the experiment ended and the judge was shifted to other work, the arrest levels rose again. The interpretation I offer for this study is that a consistent and known policy of deterrence, with high probability of the potential penalty being applied, will affect the behavior of at least a portion of people exhibiting unwanted behaviors associated with their drinking.

STERN: Perhaps the cops were not bringing them in.

MOSKOWITZ: That is a possibility, although we inquired and received assurances that such was not the case. However, this study, plus the other inferential evidence we have heard about, suggests that a better test of the role of a consistent negative reinforcement for driving under the influence is worth executing.

PERRINE: In the interest of time, may I suggest that we have one more question before we move on to the task of the ratings. One of the most important single considerations is, "What criterion or set of criteria are used to evaluate countermeasures?" We talk about the various kinds of countermeasures; we list them. There are all kinds of potential countermeasures activities in which we could engage, but the final decision about the effectiveness of a countermeasure must be based upon some decisions as to the criteria for evaluating the countermeasures. The following question is addressed to Jerry Driessen, who allegedly made the statement but he would welcome someone else having a go at it.

"YOU SAY THAT YOU HOPE THE FEDERAL GOVERNMENT DOESN'T RELY TOO HEAVILY ON FATAL CRASHES IN EVALUATING ASAP EFFECTIVENESS. WHAT ARE THE OTHER PRACTICAL POSSIBILITIES FOR MEASURING REDUCTION OF HIGHWAY LOSSES DUE TO ALCOHOL?"

PERRINE: The distinction here, of course, is that between intermediate measures of effectiveness, that is, intermediate measures of what is going on, such as roadside surveys to measure blood-alcohol concentrations or breath-alcohol concentrations in individuals in the population-at-risk who are on the road at certain selected points in time. The obvious goal, of course, is the ultimate criterion measure, since we have defined the problem in these terms, namely, deceased drivers with detectable alcohol on board, or ideally, with sufficient alcohol so that we can assume that there is not just an association, but that there is a causal relation between the fatality and the presence of alcohol. As you know, the ultimate criterion measure of high alcohol in fatal crashes is a relatively rare event. It does not occur in sufficient numbers to permit adequate evaluation of the effectiveness of a program. Therefore, the question becomes, "What intermediate measures are available, that is, what other variables can we identify and measure which bear a direct -- or at least correlational -- relation to the ultimate criterion measure?" The one used most frequently, of course, is the roadside survey to obtain breath alcohol concentrations or some other indication of what is going on in the population-at-risk and then using changes in the intermediate measure as a basis for inferring the influence of the countermeasure or set of countermeasures. Other possible intermediate measures should perhaps be discussed by Bob Voas and others who are a little more closely involved. But as I see it now there is not much else available to use except to test people on an intermediate basis and then infer that there is a relation between the data defined as the intermediate measure and the ultimate criterion measure, namely, fatal crashes.

DRIESSEN: The ultimate criterion isn't just the fatal crash; I think it is alcohol-related injury crashes too, and even property damage crashes. But the point is, we typically don't get any alcohol measures for these accidents.

PERRINE: Yes, but the problem has nevertheless been defined pretty much in terms of the fatal crash, and even though that is not necessarily what we are exclusively interested in, it does seem to be the prime source of concern and is the one event which is most frequently recorded and most accurately recorded.

WALLER: I think one of the problems we have to deal with is the fact that there is now a major emphasis on improvement of emergency health services, as well. A reduction in fatalities at this particular time may reflect improvement in quantity and quality of emergency health services as much as it may reflect other things. There is, perhaps, another way of looking at it, recognizing that we can't count on police officers being able to identify alcohol in all cases where it exists following the usual pattern of detection. This is to look at injury-producing crashes at nighttime, which we know have extraordinarily high proportions involving alcohol. So you can use this as another final measure if you will. It is slightly watered down, but not that much.

BAKER: One thing we badly need is to have blood alcohol concentrations determined routinely on crash survivors who are treated in emergency rooms. This would not only give us general information that we presently lack, but it would greatly facilitate emergency treatment of the crash victim. One emergency room physician told me that he simply makes the assumption that anyone coming from a crash is drunk: "We have to make some sort of assumption and that is the most logical one." However, decisions relating to diagnosis, anesthesia, etc., should be based on fact, not assumptions (e.g., Is this patient's level of consciousness explained by a head injury or by a high BAC?). Even a rough estimate of BAC would be valuable in such cases. I raise the point in hopes that eventually there will be enough push from professionals interested in the problem to overcome the present resistance to routine alcohol determinations in emergency rooms.

ROSS: I agree with everything that has been said by the commentators, but I would also like to defend the use of fatal accidents. We know, they are more reliably reported than other kinds of accidents. It is arguable that fatal accidents are the most important aspect of the accident problem, and we know also that they are more likely to be responsive to measures that are supposed to act on the consumption of alcohol while driving. In the British study, I did find that the savings in accidents were, percentage wise, greatest for the fatals. I also found that the turn-around and reversal of the trend after a while was greatest for the fatals and least for the slight injuries. One final point is that, in the area of traffic law, I think we have a more direct and unambiguous measure of what we are supposed to be doing with the law than we have elsewhere. That is, we are trying to save lives or injuries or property damage. On occasions, we have evaluated traffic law in the absence of knowing what our goal really was. Take for example, the Connecticut speed crackdown where I think it was possible to show that, in fact, the change in 1955 did result in lower speeds. People were following the law. What didn't happen was any savings in lives. To take only the first finding and say, "Look what we have done here; isn't it great? We have controlled speed," and to call that the end of the investigation is a mistake. We should always judge our reforms in terms of whether or not they are achieving the ultimate goal, where we are lucky enough, as in traffic, to have an ultimate goal.

SCHNEIDER: I just wanted to talk about what the goal is. It is not just to minimize fatal accidents, and it is not just to minimize the loss aspect of the transportation system. It is to improve the transportation, both from the loss and also from the gain aspect. It is desirable to have people get where they are going with less energy and also with a better probability of actually arriving. So, the ultimate goal is better and safer transportation in many regards, and the reason we have to keep that in mind is that when we talk about countermeasures, the inconvenience caused by intrusion of a countermeasure (the false-positive) has to be remembered. It is very easy to get lost because the fatals are well-reported, very dramatic, and very compelling, but the real goal has to be the overall improvement of the quality of the transportation system.

ROSS: If people are driving slower and there is no saving in accidents, actually that is a negative reform.

SCHNEIDER: That is correct.

GOLDSTEIN: A couple of years ago, I collected all the information I could with respect to the British study. I found that they had engaged in a tremendously large, intensive, and expensive public information program, or propaganda program, preceding this. I quickly concluded that I could not conclude what was or was not effective at all.

My second comment is with respect to a study that is already being quoted very widely as solid evidence that you can't do anything by way of changing behavior, and that is the IIHS study on the use of seat belts with and without the buzzer and light system. Indeed, the difference in percent of use between the two groups was quite small: about 18% versus 16%. The investigator did a chi-square test (there were a few thousand cases in each group) and it was not significant at the .05 level. However, although I have personally never used a one-tail test, from everything I have heard and examined, there are times when a single-tail test is quite legitimate. If this is true, I think this is a case where it surely is. Could the buzzer and light system conceivably, reasonably, be expected to reduce the use of seat belts? I think not.

HAHN: But that, I think, is the experience: that it does in fact reduce usage among some groups.

DRIESSEN: Because of aggravation, they tie it off to bypass the buzzer.

GOLDSTEIN: Would you expect seat-belt users to stop using seat belts because of the buzzer? No. If you agree that single-tail tests are okay, here is a case where it is. Instead of a chi-square -- which is the same as a two-tailed t-test when there is only one degree of freedom -- we use a single-tailed t-test; the difference turns out to be significant at the .05 level. Also, I believe IIHS did the study which showed that dealers and salesmen at new-car dealerships frequently tell the customer -- without being asked -- how to circumvent the buzzer and light system. This happened to me, too. So the interpretation of the outcome of that seat-belt study is very questionable. And the study is being quoted as evidence that you cannot influence driver behavior.

DRIESSEN: If I can have the last word, then. The study that I was referring to was the one on the effect of a television campaign on safety belt usage, not the survey of the effect of the buzzer system; so those are two different studies. One final thing -- I do quote some studies that do show positive effects of just an educational campaign, but they tend to be poster-type studies. They did produce some constructive behavioral change. So behavior change is not dead; there is still life in the old girl yet.

Chapter 10

10. FORUM DISCUSSION

10.1 Alcohol Countermeasures and the Vermont Symposium

Robert B. Voas

10.1.1 Perspective

Alcohol and Drugs in Relation to Highway Safety is obviously an interdisciplinary field. It is too broad to be fully covered successfully in one meeting. Thus, the intent of this program was to focus on behavioral science, with some commentary from other specialists. It may be reassuring to the specialists in other fields if I make it clear that the NHTSA has programs underway to summarize information in other areas as they may relate to alcohol countermeasures. For example, working with Al Pawlowski and his agency, the National Institute on Alcohol Abuse and Alcoholism, we are engaged in a project to review the literature relevant to the potential for the development of a cortical blocking agent for the effects of alcohol. This involves a complete review of the physiological effects of alcohol on the cortex.

Another program underway involves a broad survey and commentary on all of the state laws currently in existence relative to drinking and driving. Thus, while this conference focuses upon behavioral science, we do not intend to neglect other relevant areas.

Another issue which may concern some of you is whether operational considerations are receiving the attention they deserve at this conference. At one point in the planning of this conference, we had considered the inclusion of operational specialists, enforcement officers, judges, and lawyers, to describe the problems that they were encountering and to indicate the issues that they saw as requiring research investigation. The research specialists could then react to suggestions. However, to do this properly really requires another conference. We could spend several days in this activity by itself without covering all the operational requirements in the field of alcohol safety.

Being unable to cover both operational needs and behavioral science, we decided that the NHTSA already had reasonably good contact with the operational specialists and was in a position to get their input. However, the NHTSA was in a less effective position to get the kind of comprehensive input on behavioral science that is being received at this conference. Thus, this report, when it arrives at NHTSA, will be contrasted with the kinds of inputs that we are getting from our ASAP projects on the operational needs of the program.

Finally, we did see as one of the goals of this project, the development of priorities for research in the area of behavioral science as it relates to alcohol and drug countermeasures. As a result, the rating system which you all have been involved in was developed. I know that this rating activity gives many of you a great deal of uneasiness. I feel fairly relaxed regarding these ratings because I view them as just one other input to the session chairmen who retained the prime responsibility for the summaries of their specialty. It seems to me that the rating system just enriches the data that your chairmen have available to them in trying to develop research priorities.

10.1.2 Specific Reactions to the Symposium Content

Now let me summarize some more specific reactions to the content of what has been happening here for the last two and one-half days. Perhaps it is my selective perception, but I think there has been an emphasis on the study of motivation in contrast to cognitive factors in this conference. This fits in with my own bias. It seems to me that in the past, too much of the focus of research in this area has been on skills at the expense of risk-taking, emotional involvement, personality, etc. In considering the role of alcohol and drugs in highway safety, these elements deserve more attention. The relatively small effects of alcohol on most skills, together with the ability of drivers to compensate for these effects, suggest that emotional and personality issues will ultimately turn out to be the most important in relation to crash causation.

Secondly, as I sat through the review this morning, I felt that an appropriate emphasis was placed upon alcohol and drug interaction effects. And it seems to me that interaction effects are too frequently overlooked. It appears that many government administrators and most of the public believe there is a trend in our nation to replace alcohol with some other drug. The young, for example, are giving up alcohol in favor of marihuana. I suspect that this is an oversimplified view. In this society, we have one drug that is used widely: alcohol. The "new" drugs are not going to replace alcohol. They are likely to be overlaid on top of the alcohol culture. Therefore, it is probable that drug-alcohol interactions will be the more important topics for study than studies of single drugs; recognizing, of course, that you have to have some understanding of the effects of the drug itself before you can understand its interaction with alcohol.

A third emphasis, I detected was on interest in individual differences. This is a very significant problem viewed from an operational framework. Because it is very difficult to modify the behavior of the entire population, it is desirable, if possible, to locate a smaller group who demonstrate deviant behavior and focus our program at these individuals. A key issue in this connection is whether the problem of interest, alcohol-related crashes, is primarily attributable to a relatively small identifiable group, or whether the drivers who cause these crashes are drawn by chance from the large number of drivers who also drink.

10.1.3 Proposed Axioms Related to the Development of Countermeasure Programs

I have distributed to you a sheet that is entitled "Proposed Axioms Related to the Development of Countermeasure Programs." The word "axiom" is a scientific cover name for outrageous statements. The purpose of this sheet is to indicate some of the biases which I have as an operational specialist.

The first axiom states that, "Resistance to a program is directly proportional to the frequency in the culture of the behavior to be modified." This is why I have mentioned my personal interest in individual differences. If we can find specific individual deviant behavior which is related to alcohol-involved crashes, then the small group which exhibits this behavior will be much easier to control. I think a clear example of this has been our actions with regard to alcohol. When the United States tried prohibition, which was an attempt to modify everyone's behavior (or at least that two-thirds of the population who drink), we found it to be an impossible task. In the driving situation, we are trying to change the behavior, really, of only a small deviant group, those individuals who get on the road above some alcohol level like .10 percent.

The second item says that, "The probability of imposition of a penalty is inversely related to its perceived severity." I think we have been talking about that. We have noted the biases of the police. We have not mentioned the biases that occur in court proceedings. Prosecutors, judges, and juries are all reluctant to impose stiff penalties. If penalties requiring imprisonment, work farms, taking away the license permanently, or high fines are required, the judicial system simply refuses to impose them. Cases are not processed, or are reduced, or delayed, or defendants are judged not guilty. Moreover, I think that research indicates that the effectiveness of prison terms and high fines is not great. But even assuming they were, it is very difficult to implement them because if the penalty is very severe, the police do not like to arrest people, the judges do not like to convict, the juries do not like to convict, the prosecutors do not like to prosecute, and so on. The American legal system, at least in the traffic safety area, operates on an informal consensus of what is fair. Penalties can be effectively imposed which do violence to what the system believes is fair, but then the system adjusts and you have great difficulty getting the severe penalties implemented.

The third item says, "The effectiveness of public education messages are directly related to their simplicity, while the effectiveness of countermeasure programs are inversely related to their simplicity." Basically, what that says is that to communicate over TV and radio in a 30- or 60-second time limit, the message must be very simple, but is very unlikely that the program you implement can be anywhere near that simple. The result is that there is frequently a substantial difference between what the public is told and what the countermeasures program is actually doing. This becomes a significant problem in working in countermeasure areas.

The fourth item says, "It is not possible to have an operational countermeasure program without evaluation." That statement will give many people a great deal of trouble. However, if the statement read "It is not possible to have an operational countermeasure program without management," it would be accepted without question. But evaluation is a part of management. Management cannot manage, if it cannot get feedback. Badly evaluated programs, are badly managed programs. Scientists have all too frequently contributed to the lack of evaluation in operational programs by setting up distinctions between research countermeasure programs and operational safety programs. If at least a portion of the operational safety programs were adequately evaluated, a large amount of data would be available for scientific use. They must have a management information system; they have to feed back.

The fifth statement says, "No countermeasure program involves only one countermeasure element." A corrolary to this opinion is that it is impossible to evaluate a single countermeasure element. An example of this is the British Road Safety Act of 1967. There were at least two countermeasure elements: the police were given authority to require pre-arrest breath tests, and a large public education program was mounted to tell the public about this new law. The two countermeasures -- intensified enforcement and public education -- were used together. As we heard discussed earlier, there was some question whether it was the public education or the police activity which produced the resulting reduction in traffic casualties. But it would not be possible to evaluate separately the public education from the police countermeasure. The implementation of one required the other. For the new procedure to produce deterrence, the public has to know that the police have a new weapon. So, this program must be evaluated as a package.

TABLE 10-1

Chain of Evidence in Support of Countermeasure Effectiveness

Evaluation element	Example
Expenditures	Budget vs. expenditures
Effort level	Increased police patrols
Quantitative output	Increased arrests
Qualitative output	Reduced average BAC level of arrested drinking drivers
Public attitude change	Opinion survey shows increase in perceived risk of arrest
Public behavior change	Reduced BAC levels in roadside voluntary surveys
Change in consequences of behavior	Reduction in alcohol-related crashes

The sixth statement holds that, "Countermeasure effectiveness can only be established by a chain of logic system." Table 1 indicates what I have in mind by a "chain-of-logic system." In the NHTSA ASAPs, what we try to do is to set up a measurement at all levels. We start out by counting the dollar that gets spent and then we count the hours of increased police activity for which these dollars are spent. Then we count the number of increased arrests which the increased hours produced and then we count whether the quality of those arrests have improved as indicated by lower BAC levels in the arrested drivers. Then we go out and do public opinion surveys to try to see whether the public believes there is a higher possibility of being arrested. Finally, we also do roadside surveys to try to see whether the behavior is actually changed, that is whether there are fewer drivers at high alcohol levels on the road. As a last piece of information, we determine whether the criterion of alcohol-related crashes has been reduced. Now, it is this chain or pyramid of measures which, if all change in the expected direction, leads to confidence that differences observed are produced by the ASAP program. If that chain is broken, then we can be less confident that the ultimate results were produced by the project. It is very important in evaluating countermeasure programs that a chain of logic is created that supports the project effectiveness and that we do not just measure as the end result, the reduction in crashes.

Finally, in relation to this conference, I might point out that to me, "countermeasure programs are developed directly, neither from basic research, nor from applied research, but from the models of human behavior which evolve out of these research programs."

Unfortunately, I didn't have with me any good examples of the model, but I passed out an article of mine, in which there is a model that attempts to analyze all the steps that start from the person who will do the drinking and lead to the accident. (See Figure 1). It is the sort of cause-tree analysis technique that O'Day has pioneered and it represents one kind of model. It is a very simple one; I don't make any big claims for this model; it is only to illustrate the concept. There are some words to go with it, and you can see the kinds of derivations you try. One of the concerns I would have about the impact of what all of us are doing here, is the problem of assembling the information into a model which can be used by operational specialists for developing countermeasures.

10.2 The Drinking Driver and Research Activities of the National Institute on Alcohol Abuse and Alcoholism

Albert A. Pawlowski

First of all, I'd like to say that I greatly appreciate the opportunity to attend this symposium as a representative of the National Institute on Alcohol Abuse and Alcoholism because it has given me the chance to learn about issues regarding the drinking-and-driving problem. One of the jobs I was given, however, was to identify areas requiring further research. In this connection, without referring to the excellent papers presented, I can identify two high priority areas which obviously need further work. As I think about the wide ranging discussions during the open-house periods and the refreshments which facilitated, not to say disinhibited the discussions, I've thought that more research is needed on a rapid and efficacious cure for hangover. However, based on the excellent attendance of the meetings and the high quality of discussions, perhaps a cure is in hand.

The second area of needed research was suggested by the ambient temperature of this meeting room and the clothing worn by some of the participants. On the one hand, some participants continue to wear overcoats and one panel member gave his talk while wearing gloves; while on the other hand, Bud Perrine, alone, stands unaffected. Perhaps funds can be found somewhere to support research into the nature of the dysfunction of Bud's thermo-regulatory mechanism.

The mission of the National Institute on Alcohol Abuse and Alcoholism is somewhat different from the National Highway Traffic Safety Administration. Our problem is the overall one of alcohol abuse and alcoholism. Essentially, we are charged with the mission of determining the etiology of alcoholism, identification of the alcoholic person and bringing him into treatment, and the prevention of alcoholism.

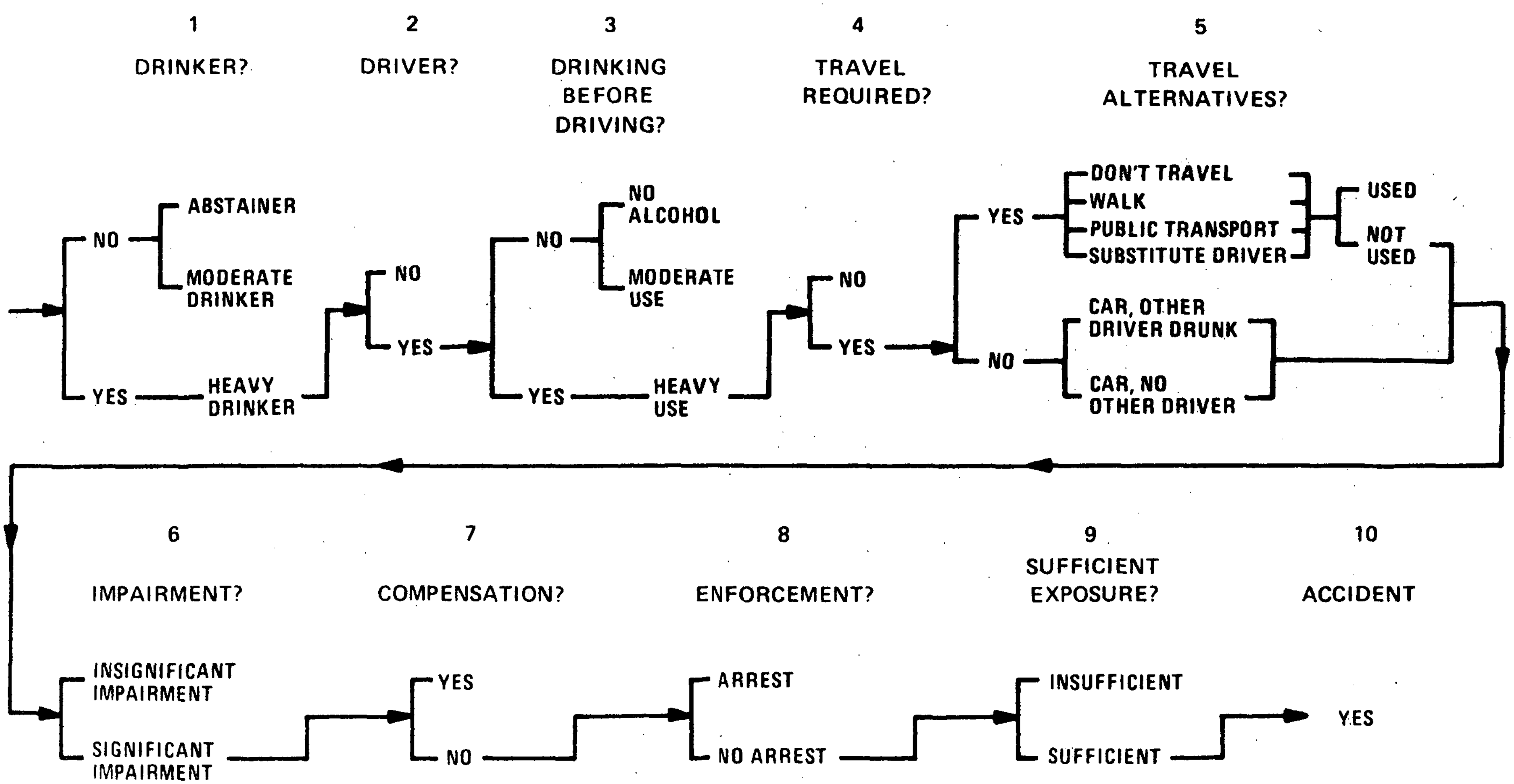
To implement programs in these areas, the NIAAA is organized into four divisions, each having two branches. The divisions are:

1. The Division of Prevention: Alcoholism and alcohol abuse can never be controlled solely by treating casualties; therefore, the Institute places high priority upon programs of public education, especially among youth.

2. The Division of Community and State Programs provides assistance for the treatment and rehabilitation of alcoholic persons through direct grants to

FIGURE 10-1

ANALYSIS OF EVENTS LEADING TO AN ALCOHOL-RELATED ACCIDENT



communities and through formula grants to the States.

3. The Division of Special Treatment and Rehabilitation Programs houses programs targeted at reducing and preventing alcohol-related problems in special population groups, including drinking drivers, alcoholic employees, and native American peoples.

4. The Division of Research contains a Laboratory of Alcohol Research, which is the in-house research arm of the Institute, and an Extramural Research Branch, which is responsible for the provision of funds to scientists for research on a wide variety of problems associated with alcohol ingestion. Research in the area of drinking and driving is funded by this unit.

In fiscal 1972, the NIAAA funded 156 grants for research on all aspects of alcohol use and abuse. Forty percent of the grants were awarded for various biological or physiological studies; 22% for psychological/behavioral studies, and 23% for clinical/treatment research. The remainder of the program includes research in such areas as prevention and education, community research, and surveys.

The NIAAA has identified several areas as having high priority because these areas have been previously neglected or because the activities in these areas may have high pay off. The specific area relates to special populations of alcoholic persons. They include: the native American people, the alcoholic employee, the public inebriate, and the drinking driver. Alcoholism among these special groups is highly visible and/or of such dimensions as to have a large impact on the economic and social welfare of the community.

With respect to the drinking-and-driving problem, two branches of the NIAAA have activities in this area. The Special Projects Branch has an administrative unit which works closely with the ASAP Program of the NHTSA. The unit provides funds to the community for a treatment program to be conducted in connection with the activities of the DOT ASAP Program. To date, 25 ASAP sites have received NIAAA funds.

The Extramural Research Branch funds basic and applied research on all aspects of the alcohol use and abuse. As mentioned above, a total of 156 grants were awarded during FY 1972. Of this group, eight grants were awarded on one aspect or another concerning drinking and driving. I'm pleased to note that five of the eight principal investigators of these projects are present at this symposium.

Most of the projects are addressed to assessing the effects of alcohol on perceptual, cognitive, and motivational aspects of driver performance. Some of the studies are investigating other drugs as well as alcohol. In this area, one of the first projects funded by the NIAAA is concerned with the influence of alcohol on perceptual-cognitive behavior (Principal Investigator: M. W. Perrine). The effects of three beverage alcohols on several aspects of behavior assumed to be necessary for coping with driving will be studied. Another study is focused on the effects of alcohol ingestion by adult males on tasks demanding selective or concentrated attention; performance requiring attention to auditory and visual stimuli; immediate memory; and investigations of a possible age-alcohol-attention interaction (Principal Investigator: H. Moskowitz). In this connection, it is hoped that subjects up to 75 years of age will be tested.

Another project will encompass several studies regarding normal driving performance, response capabilities, as well as those that describe the limit of performance prior to loss of directional control of the vehicle (Principal Investigator: R. Mortimer). These studies will include moderate drinkers as well as individuals with a drinking problem.

The effect of varying levels of blood alcohol concentration on visual search performance and motor-motor integration is being studied by another group (Principal Investigator: J. A. Stern). This study will subsequently assess the potentiating effects of chlorpromazine on alcohol.

Finally, an NIAAA grant will provide funds to measure alcohol-produced behavioral impairment (Principal Investigator: W. D. Edwards). The tasks undertaken are to assess relative impairment by alcohol of different types of tasks such as perceptual, tracking, choice-reaction, sorting, and logic. Particular attention will be paid to the effects of alcohol on risk-taking behavior in a driving simulator situation.

Three projects are non-laboratory studies. One of these will examine relationships among drinking behavior, social-psychological attributes, and driving behavior in a sample of young males (Principal Investigator: D. C. Pelz). Interviews will be conducted regarding motivational characteristics life events possibly associated with social stress, interpersonal conflicts, school achievement and amount of alcohol use, changes in drinking habits, frequency of driving after drinking and drinking prior to accidents or moving violations.

The goal of another study is to provide a comprehensive clinical demographic and psychosocial profile of persons convicted of driving while intoxicated or driving under the influence of alcohol (Principal Investigator: M. L. Selzer). Potential treatability of convictees will be appraised and procedures for determining treatment-related characteristics in drunk-driving populations will be developed. Other goals of the study include the determination of how many drunk drivers have serious and chronic drinking problems and to assess their motives and attitudes regarding their drinking behavior, to isolate factors which contribute to the act of drunk driving.

The remaining project receiving NIAAA support is an evaluation of the impact of new legislation in the State of Tennessee which automatically imposes a jail sentence of 48 hours and driver's license revocation up to six months for a first offender convicted of drunken driving (Principal Investigator: N. E. Schover). Highway fatality statistics from Tennessee and bordering states will be analyzed and statewide time-series data showing rates of arrest for drunken driving will be collected and analyzed.

The NIAAA is vitally concerned that over 50,000 alcohol-related highway fatalities occur annually, and it is intent on reducing this burden to the individual, his family, and the community. In funding research in this area, the NIAAA hopes that underlying conditions leading to driving after alcohol ingestion can be identified. What factors are associated with the decision to drive after the consumption of large amounts of alcohol, or, to put it in another frame, what factors are associated with the circumstance, not to say decision, of drinking excessively while being aware of the eventual need to drive? Thus, what are the antecedent conditions leading to driving after excessive alcohol consumption? Another problem of interest is the identification of different types of drinking drivers. The development of a typology of drinking drivers may have importance for devising different modalities of treatment for, say, the occasional drinker and the chronic drinker who happens to be arrested for drunken driving. It is a first order interest of the NIAAA that persons arrested for driving while drunk should be provided with appropriate treatment, whether it be a short educational program informing him of the consequences of alcohol abuse or medical care or other therapy to help him achieve insight into such factors that might underlie his excessive drinking. If differences among types of drinkers is psychological, it would be helpful to identify such constellations of factors as discriminate among those who cannot stop their alcohol intake from those who do, knowing they have yet to drive.

In summary, the NIAAA has an abiding interest in the support of research in the drinking driver area. Some research is currently being supported, although it does not as yet represent a major investment of funds. There is no doubt that more funds will be allocated for projects addressed to so serious a problem. Of especial importance is the need to inquire into the identification of alcoholic drivers and to develop treatment modalities particularly suitable for the treatment of this group of persons.

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DISCUSSION

GOLDSTEIN: Al, with respect to given proposals, do you have provisions for input from consultants who are in NHTSA?

PAWLOWSKI: We do have a DOT-NIAAA liaison committee that meets every other month to discuss common problems.

GOLDSTEIN: With respect to research grant proposals or funding or what?

PAWLOWSKI: On all programs.

VOAS: We have some joint-funded programs. That is, there have been cases where we've transferred funds to NIAAA for a piece of research that we have a particular interest in.

WALLER: I note that the name of your institute is: Institute of Alcohol Abuse and Alcoholism. Yet at one point, you abbreviated it as the Institute of Alcoholism, and in all of your discussion you spoke either about alcoholism or about social drinking. I'm wondering where the role of alcohol abuse short of frank alcoholism fits in because I think that's a large part of what we're talking about in the present situation.

PAWLOWSKI: I'm not sure if there is an official position on this. I think many people on our staff believe that it's difficult to distinguish between the alcohol abuser and the alcoholic. There comes a time when you go from one to the other. I personally would like to see a broader definition of our position on this issue, and that includes simple drinking without the abuse.

PERRINE: I think Julian's (Waller) position would be that all alcoholics are alcohol abusers, but that not all alcohol abusers are alcoholics.

WALLER: Mark Keller and I have been discussing the question of the definitions of problem drinking and alcoholism. We concluded (correct me if I'm wrong, Mark) that if one is having a pattern of repetitive involvement or repetitive misbehavior, we could call this problem drinking. One can then approach alcoholism as a condition where actual organic changes are found. Mark Keller, in working with Judge Burg, had reported that 20% of the DWIs that they've found were alcoholics and the other 80% were social drinkers, as if there is no world in between. I think there is a very important world in between and that much of our payoff is going to come from identifying and dealing specifically with that world.

PAWLOWSKI: I was just going to make a comment on that. One definition of the alcoholic person is that he is someone who drinks, gets into some sort of trouble, and then someone says that the reason he's in trouble is because he drinks. The critical thing is the labelling process. Without having labeled him as an alcoholic, is he an alcoholic? Someone has suggested a comparable situation with regard to diagnosing another illness, cancer. For instance, imagine a person seemingly in good health going for his annual physical examination during which a cancer is found. The question is: when was he ill with cancer? Before the examination, or after someone, in this case the physician, said "Aha, you have a cancer." The labelling process is important since the problem must be identified in order to deal with it. Some would say that without the label, the problem does not exist. The person with an undiagnosed cancer may be said not to have the disease, and if there had been a spontaneous remission of the tumor, who is to say that the person was ill.

PERRINE: In view of the original task at hand, we should probably terminate our discussion of this issue, even though it is a very important semantic question with important implications for program and for program-domain. Nevertheless, in view of the limited time, we might more profitably spend it discussing some of the issues which are more directly related to the sets of programs represented by Bob (Voas) and Al (Pawlowski). With that in mind, I will offer the kind of question which -- from my own biased point of view -- I would like to see addressed.

During these sessions, we have rated a variety of topics, across alcohol and across drugs. All of us would have to agree that these are key topics, regardless of the semantic nuances of any individual keyword. How does this assembled group of specialists evaluate the ratings of the key topics? What does it all mean in terms of the programs and issues that many of you have been raising throughout? One topic which was consistently rated as being lowest with regard to present knowledge was the central nervous system. Regarding both alcohol and drugs, the topic of central nervous system function came up on the top of the list for basic and applied research priorities, across all categories of participants. Where is there room in any of the complexes of programs which your federal agencies represent for either a basic or applied approach to research pertaining to the influences of alcohol and/or drugs on central nervous system function? That's an example of the kind of question I would prefer to see discussed.

BAKER: There is one particular area of basic research that has not even been suggested as a possible area for emphasis or for priority, but which I think should be mentioned. This relates to the research which is necessary to develop a good test for drug usage, particularly in connection with marijuana. We have had a number of questions relating to the usage of the hallucinogens by the general population, by crash-involved drivers, and so on. Before we can appropriately discuss population rates, risk factors, and countermeasures, we must develop testing procedures in this area. I gather that NIAAA is not particularly involved in drugs at this point, but in view of all the interest both in biochemical problems and in the combined actions of alcohol and drugs, it is evident that we feel these issues relate to some of our biggest problems. This may be an area in which NIAAA and DOT could jointly prompt some very productive research.

PAWLOWSKI: The reason why the NIAAA is not involved in drugs as much as probably they ought to be is that there is a Division of Drug Abuse within the NIMH and that's their primary mission. We do provide support for grants in this area if the drug is used in conjunction with alcohol as a comparison compound. But otherwise, projects primarily focused on drugs would not be assigned to us for funding.

VOAS: I might just comment that the NHTSA is presently funding work in the area of drug detection in bodily fluids and in breath. We have a technical group at the Transportation Systems Center that has a general assignment in this area. Furthermore, there are some contracts out for the development of related devices and measures for the most important drug groups. We also have programs to identify drugs in fatally injured drivers, as discussed very briefly the other day by Dr. Benjamin. We also have some interagency agreements (with groups such as the Bureau of Narcotics and Dangerous Drugs) to work together in developing equipment to identify drugs. The bureau's job is to set the risk requirements and/or the danger levels for drugs, and they request information from us as to what is known about the driving risk related to the drug.

PERRINE: Any further comments on this issue? If not, are there other issues or other questions? Ward Edwards.

<u>EDWARDS</u>: We have heard in various papers, particularly Paul Hurst's, evidence that one has to take considerable account of variables other than BAC to predict the effect of alcohol ingestion on driving. We've heard from all of the reports on drugs that no methodology is presently available to routinely detect drugs. Indeed, even if we could detect a drug's presence, the real issue is likely to be the interactions between drugs and alcohol, drugs and drugs, etc. We haven't heard, but I will assert, that there is a real issue which has to do with the fact that some people are just plain better drivers than others. What this all leads to is the question: Why are we worrying about all these intervening variables, and constructing our control systems around them? Why are we not realizing that it is not the enforcement of a set of laws specifying morality which is important, but rather the enforcement of a minimum current level of competence at driving? If we could structure what we are doing to find some procedure that was adequately predictive of current capability at driving, it would seem to me that we might be able to get around many of the difficulties that plague us because the intervening variables plague us.

<u>GOLDSTEIN</u>: I think the reason may be that alcohol is so disruptive of even good competent behavior that...

<u>EDWARDS</u>: I said <u>momentary</u> capability. What we should be concerned with is that anyone on the road be competent to drive. This implies a necessary capability for measuring current momentary competence to drive -- directly or indirectly -- and have sanctions for driving when one is not currently competent. Enforcement systems and educational systems, for example, could be constructed around this concept.

<u>GOLDSTEIN</u>: Yes, but measuring that competence...

<u>EDWARDS</u>: Momentary competence to drive is indeed the issue!

<u>GOLDSTEIN</u>: It really is not an issue.

<u>EDWARDS</u>: Sure, it's an issue.

<u>ZYLMAN</u>: There is apparent support for these concepts. The table that I referred to in my discussion yesterday indicated that teen-age drivers and very old drivers are involved in more collisions without alcohol than middle-age drivers at moderate levels of alcohol. I also published an article in 1968 indicating that drivers under twenty and over seventy years of age are involved in more collisions at certain times of day without alcohol, than drinking drivers twenty-five and over are after midnight with alcohol. This may be a result of the way the data was handled, but I doubt it very much. This suggests that rather than talking about lowering the legal BAC levels, we should be concerned with increasing driver proficiency.

<u>SNYDER</u>: As a point of information, the Department of Transportation is involved in the study of interlock systems which prevent incompetent drivers from using their vehicles.

<u>NICHOLS</u>: I think that rather than deal with complex cognitive and emotional forms of behavior, we should concern ourselves with the simple skill situation which we really have.

EDWARDS: There is certainly no reason why a measure of competence to drive should only be concerned with apparent skill. I am certain that constant measures of competence to drive could not be so limited.

DRIESSEN: I'm sorry, but I feel the current discussion is almost irrelevant to the conference. What you're saying is we should make our comparisons between safe drivers, and we should measure competence, and so forth. I see that as irrelevant because we're concerned with the effects of alcohol on safe driving at this conference. And if you talk about the young driver and the old driver as having higher accident rates, even when they don't drink alcohol, that is also irrelevant.

PERRINE: I will assume the role of moderator here and agree with both of you. The issue should be raised on the one hand because it is a fundamental concern for considering drug effects. On the other hand, it probably extends too far beyond the immediate purview of this conference, and should perhaps more meaningfully be the basis for another conference.

BUIKHUISEN: In general, competence to drive is not a topic for this conference, but competence to drive in relation to blood alcohol level is very important. I would like to comment in this respect by giving you some information about Dutch legislation. In the Netherlands, we always had a feeling that you should legislate competence to drive, rather than alcohol level. But we are presently changing this law for the following reason: many drivers agree that they have been drinking very much, but they disagree with the assertion that they are intoxicated. And they continue to drink heavily because they think that they are not intoxicated. By instituting laws regarding blood alcohol level, the individual can adapt his drinking pattern to remain below a blood alcohol level, rather than attempt to determine whether he is intoxicated.

WALLER: One of the items that arose several times as a high priority item for future research, whether basic or applied, is the relationship of stressors to the sense of impairment that occurs under alcohol or other drugs. I think this is one item that we tend to overlook when we discuss the competence of the driver and the competence of the pedestrian (for the pedestrian is also an important part of the problem, especially in urban areas). We should realize that not only must we improve the drivers' competence, but also recognize that for the forseeable future, we are going to continue to have such impaired people around, and look at the question of what are we going to do with some of the things that stress the driver and the pedestrian. Are we going to have adequate identification of what these are? Are we going to have adequate identification of the extent to which they impair? Will we implement appropriate countermeasures to these unnecessary stresses that exist in the motor-vehicle and pedestrian environments.

VOAS: In relation to using a performance, rather than a chemical test in the area of alcohol and highway safety, I will summarize the issues as I would see them. First is the issue of using human performance data in attempts to obtain stress-sensitive tests. The voluminous research in this area indicated that the inter-individual and the intra-individual differences are very broad, and only through long periods of practice could they be reduced very greatly. Therefore, I don't believe these types of tests allow very much hope for the degrees of reliability needed. This is supported by the research of Phil Davis at the Transportation Systems Center, and we might ask him to comment on that. Secondly, I think it would be an inappropriate approach to the public, although it does seem to have logic to maintain that what is important is not whether you've been drinking, but your level of competence. However, it would be more difficult for the public to rate, evaluate, and control their competence than their drinking. I will admit that, at present, the public has had a difficult time in determining their blood alcohol concentration. But it's possible, both through education and the provision of measurement devices, to allow the public to obtain much better information in relation to their alcohol consumption than their level of competence. It is easier to explain the program to the public ultimately by stating, "Thou shalt not drive above a given alcohol level." Finally, there are the matters of who shall judge and the lack of control conditions. We see this in our whole legal system in the failure of the police to recognize and arrest intoxicated individuals. The data suggest that about half of these people are not arrested by the police, even though they come in contact with them. Obviously, for the people who actually have to enforce the law, there is a great deal of difficulty making this judgment. So while there is a certain parsimony of logic to the concept, I think it's illusory in relation to the requirements of a practical program.

ABERNATHY: In answer to Monroe Snyder's comment; the interlocks are tied to behaviors which are affected by alcohol alone. They have nothing to do with competence in any other kind of performance, and if performance is measured, it only has face validity to driving.

VOAS: I would just object to comment regarding the face validity to driving. I don't think that that's necessarily an issue. The correlation with BAC level is the issue. But I think any task which had a high correlation with BAC level would be important to examine.

ABERNATHY: Studies are not designed to look at driving per se, but to look at the BAC level.

VOAS: That's correct.

PERRINE: I think we would all welcome a reliable interlock device that did more than just correlate with BAC reduction. We're examining one problem at a time, and it's a question of an efficient research strategy to examine one dimension which accounts for a large portion of the alcohol problem.

VOAS: I think there's also a bigger issue than that. I don't believe there's any behavioral task with a known correlation with crash probability. We're not trying to measure driving competence; we are trying to measure probability of crash. When a person is in a crash, he is untestable, possibly maimed, and certainly emotionally upset, so you cannot take an immediate task and determine current performance levels. However, one can take a blood test. Therefore, I don't think we know any task that we can confidently claim is related to crashes other than the chemical tests. That's why I think we have to take the approach of saying, if we're going to try to use some performance measure, we'll have to correlate with the intermediate measure which is blood alcohol level. However, I don't think we ever will have such a performance measure. I don't know of a design situation where you can get behavior which is reliably related to crashes.

SCHNEIDER: Larry Ross talked about legal restrictions as a "cheap" cure, essentially because the expenses involved were not borne by the legislators. In a sense, looking at the alcohol involvement is also a cheap cure. We have good methods, thanks to Dr. Borkenstein and others, for chemical tests of the amount of alcohol in the blood. Presently in development are more complex, more clinical methods of getting this measure. We could rationalize this procedure by stating that alcohol is involved in a large proportion of fatal accidents. We can reliably measure alcohol and could take this approach. But I think that the larger question to be addressed, which is not beyond the scope of this conference, is examining behavior as it correlates with drugs. We have agreed that we lack information regarding the correlative elements of a driving task. We're still treating driving as a series of discrete events. We claim that if the driver's response meets some criteria, he's competent to drive. This is just the interjection of our methodology, and it is not appropriate to the basic behavioral images of this kind of a task. It's not enough to just measure a psycho-motor task, for example, all elements have to be taken together as a system. We have to integrate as part of our research strategy, regardless of the difficulty, some measures of competence, because competence is part of the generalized problem of improving performance decisions that we are trying to solve, regardless of whether the cause is alcohol, senility, or drugs. We have to have some sort of an understanding of the driving task, and the relative contributions of all of these factors, to identify each individual as a point in some competent space. It is a hard job; and you're right, maybe for ten or fifteen years, we're not going to have a really good understanding of this. But that doesn't in any way deny its importance and priority in the basic research area.

STERN: I wanted to raise some issues. It's legitimate to discuss the issues of competent drivers and incompetent drivers, but it seems that if one examines the drunk driver, it will be evident that he's usually competent. It's seldom that he gets in trouble. There are conditions when he becomes incompetent, and conditions under which anyone is incompetent. From what I've heard so far, it seems to me that two conditions have been specified that deal with incompetence. One is that levels of alertness may vary so that you have drop-outs in performance. I think Moskowitz, for example, talked about marijuana producing drop-outs in performance, and that's one kind of incompetence. But remember that driving competence is very time-limited; there are short periods in time in which a person is incompetent and long periods of time, between those periods of incompetence, when he behaves quite adequately.

EDWARDS: Are you saying that that means that you could not develop a behavioral measure of observing the occurrence of an event?

STERN: No, you can observe the occurrence of an event, but over the extent of an hour, he may be competent for 55 minutes and incompetent for 5 minutes. That's one point. The second point of incompetence, that's been identified, is when a person must process a greater than normal amount of information. The person under the influence of alcohol then develops selective attention, and doesn't attend to some of the possibly important aspects of the environment. In this situation, an accident may occur. But I'd like to suggest that rather than talking about competence to drive, that what we have to look at is what are the situations in which the person is incompetent and develop measures to assess those, rather than an interlock system to stop him from driving. Furthermore, I suspect that many alcoholics can handle, or learn to handle, interlock systems very effectively.

INTERMISSION

GOLDSTEIN: Ward (Edwards) was proposing a test of momentary competence. I'm convinced that all the data to date, with respect to predicting individual involvement in accidents, indicates that the criterion of accidents has low reliability which, therefore, limits the validity. I'm willing to wager that you won't get more than a .3 correlation even if you have an optimal composite of six variables. I'm saying that with a validity that won't exceed that level, you will have a more difficult time implementing such a procedure, than the relatively simple procedure of a blood alcohol determination. The evidence in favor of the latter procedure is quite favorable and quite convincing.

EDWARDS: How can you get good validity for BAC and not for any other measures?

GOLDSTEIN: The concern with alcohol primarily relates to the point that it is heavily involved in fatal accidents. Its involvement in non-fatal accidents is, at the moment, less well known and documented. Obviously, you only obtain autopsy data in fatal crashes. As far as we can tell, and this involves a considerable amount of opinion and judgment, the involvement of alcohol in non-fatal accidents is far less. Roughly half of the fatalities on the highway, with respect to drivers and pedestrians, involve alcohol, and many of them involve alcohol to the very highest degree. There is a good deal of evidence to show that certainly above .15 blood alcohol level, virtually everybody is badly impaired. There are exceptions, I'm sure. Above .10, a very high proportion of people are impaired; again there are exceptions. The validity is apparent.

EDWARDS: If you're right, the idea of finding behaviorable measures will not be successful. But your argument is not that you're right with regard to the data; rather, it is that you're right a priori. The kinds of studies that I'm discussing have, for the most part, not yet been done. Why is it impossible to obtain behavioral predictors that would be as effective as BAC is for alcohol impairment when one's function is impaired by drugs?

SNYDER: I don't see how anyone can argue that, as Ward Edwards claims, it may be possible to build a better test. It may be that I am not as optimistic as he is, based on our discussion at dinner. However, I cannot tell him that it is impossible, because it may not be.

DRIESSEN: By being at this conference, and in part by being interested in reducing alcohol-related traffic crashes, I've received a few fresh ideas. One thing that I had wanted to mention in my paper presentation, but never really got around to, was that one of the important rehabilitation techniques involves the notion of early detection. I heard Vernon Wilson of NIAAA discuss this. Apparently, there is the feeling that, as in cancer, if you detect the condition early enough, there is an excellent prognosis for cure. By cure, I am referring to controlled drinking. Rehabilitation should occur while a person has a job, while a person has a wife and family, and while a person is beginning to move into a problem drinking stage. It is at this time, if you provide him with information about the dangers of alcoholism, and about the personal techniques he could use to reduce his budding problem drinking situation that perhaps the most effective rehabilitation countermeasures can be taught. On this basis, we might devote more effort towards detecting the early problem drinker, as I think Waller and others have discussed, by using social agency records and DWI records, than in detecting the drunk who is on the road and driving. I would offer that as an important issue for consideration.

One other thing I'd like to offer is "accident research principle no. 1," and that is, use the right accident subset. Many of the people in this room are very experienced researchers, and I don't mean to be talking down, but a recent researcher, for example, examined the accident record in terms of dynamic visual acuity. Well, there are a lot of accidents that are totally irrelevant to dynamic visual acuity -- blowouts, rear-end collisions, and many more that are irrelevant to dynamic visual acuity that were entered into those correlations. We are underestimating our effectiveness, in evaluating countermeasures or the effects of experimental variables, when we use total accident records. We have to attend to only that segment of accidents that are relevant to the variable we're testing. B. J. Campbell, for example, when examining the beneficial aspects of reflectorized license plates, only considered nighttime rear-end accidents. He didn't consider daytime accidents, and he didn't consider other variables, all very legitimately. The New York State Port Authority, for example, used daytime running lights on their fleet of vehicles. What they obtained in overall accident-rate reduction was something like 2 or 3%, which was non-significant. However, what they found when they considered just those accidents expected to have been reduced by the use of daytime running lights, was a significant 20% reduction. By looking at the appropriate subset of accidents, the effectiveness of your countermeasure is much more likely to be validly evaluated.

MOSKOWITZ: It wasn't quite clear what Ward (Edwards) was hoping to do with that competence test of his. Was it to establish some kind of standards for people to accept their individual limits of drinking?

EDWARDS: I did not really raise the question of what you would do with a behavioral procedure predictive of driving performance. However, I don't think anyone in the room is going to argue that if we had such a device we wouldn't find a use for it.

MOSKOWITZ: No, I thought you were talking about studying the effect of alcohol on this. What would bother me is if you were attempting to make a prediction, you would have to take into account a series of variables in which many of the accidents involving alcohol are found. For example, most fatal accidents with alcohol occur in the evening and in the late hours; after work, people are fatigued. The accidents are a function of driving experience, and although you might have a test that is correlated with some fundamental skill important to driving, I would wonder about its correlation during the learning periods. In order to do this effectively, you would also have to repeat the test, because I've found some evidence for an age-by-alcohol interaction, such that alcohol has a greater effect as you get older. In practical terms, I think that a device for non-alcohol purposes has probably more validity in attempting to find important determinates of driving skill, than it would have for the issue of what limits should an individual set for himself before driving, because that varies with other factors.

KELLER: I've been surprised by the suggestion that we couldn't make an instrument which will measure driving competence. I think that in 1900, anybody could have thrown a rock up into the air and represented it as proof that it's impossible to make a heavier-than-air instrument that can fly. I think that in 1930, it could have been asserted with the same confidence as we have asserted that a competence-measuring instrument can't be made, that nobody would be able to inform us as much about alcohol as the present Breathalyzer. I believe that if the right people, who have the competence of those who worked on the Breathalyzer problem, approach this problem, we will have such an instrument in less than 25 years.

PERRINE: Along these lines, I might interject that one of the problems which arose in the preliminary meetings of the chairmen was an attempt at defining what the time-frame was for judging research priorities. We discussed the feasibility of having both a short term and a long term qualification to the ratings of applied research priorities. I mention that here because I have the impression that much of our discussion this afternoon has been constrained by the feeling that we must only endorse research with immediate relevance. This may be partially influenced by a given administration requesting results before the next election. However, I don't believe we should be unduly influenced by this pressure. I think that procedure would reduce or obliterate any longer term basic research. We must blend our levels of approach to obtain success at various points along the time-frame, whether one-year, five-years, or x-years hence. But this gets back to the problem that some of you have been discussing, namely the criterion for structuring the problem: What is the problem? Unless we define the problem very specifically, we cannot confidently aim our countermeasures and solutions towards these problems. One part of the problem that has been mentioned is driving. Driving is not a homogenous unitary package. There are many different aspects of driving. If we discuss driving competence, what kind of driving are we referring to? We have to go into an analysis of the driving task, as was suggested earlier by several of you. Rather than perform the criterion decisions at an implicit level, we should try increasingly to be explicit regarding the assumptions, criteria, and problems we have in mind. Would anyone like to comment on that?

GOLDSTEIN: Yes, at long last, somebody did emphasize the basic problems of definition. However, I'd like to refer back to a couple of things. I think it would be extremely helpful if we could define with confidence, the relevant variables, such as time of day, socio-economic background, and age. Are we including alcoholics in the same population as those who abuse alcohol, and so on? It would be very helpful to have the capability for identifying the capability to identify developing alcohol abusers. On the basis of having attended the recent NIAAA meeting in Washington, I have considerable hope that we can identify some characteristics of alcohol abusers. This is an area that, I think, deserves a lot of attention. And I would emphasize again that it is very basic to define the problem in terms of who, what, when, at what age, and so on.

VOAS: I think the suggestion was made that denying such a possibility is something like denying the possibility of the space program. Since I was involved in the space program, I would be the last one who would not want to appear to be forward looking. However, I would not be interested in developing a test of driving competence, because from the operational side, I could argue that we're not really interested in driving competence. Rather, we are interested in crash reduction. Therefore, I would like to suggest that we develop a test which is related to crash behavior. I believe we need to do what Dr. Borkenstein did in Grand Rapids. That is, we have to measure the frequency of behaviors in association with crashes, and then the frequency of the same behaviors of the exposed population which was not crash involved. I have some suggestions for how this might be done. A proposal from another department within NHTSA, interested in examining acceleration, suggested placing a set of continually functioning impact-recorders on a large number of vehicles. Upon impact, the recorder ceases functioning and reveals information from occurrences prior to the accident. With a sufficient quantity of recorder-equipped vehicles, a large data base could be developed. We could compare these data to those obtained from equally exposed, but non-crash involved vehicles. That is one possibility. Another possibility involves obtaining radar recordings from both uninvolved, but exposed vehicles, and crash-involved vehicles. This kind of work is going to be expensive and time-consuming. However, I can see this research identifying crash-related behaviors in the same manner in which we have identified BAC involvement in crashes. At this point in time, this procedure is the necessary first step.

I think we must be careful in using the term "driving competence." This relates to one frightening aspect of all of the work that's been done in driver education where certain kinds of assumptions have been made about what good driving is, and then we often have difficulty in ever relating this to crash behavior. As long as we focus on crash behavior, I think we can ultimately avoid that problem.

EDWARDS: May I stipulate that wherever I use the phrase "driving competence" what I was in fact intending was exactly the same as what Bob Voas was just talking about.

DRIESSEN: I was interested in the time-frame notion that Bud (Perrine) brought up. I'd be interested to know if anyone knows of a federal government multi-year plan. If not, I wonder whether it wouldn't be worthwhile to assemble a smaller group than this one to devise such a priority plan. Although I'm aware that the Alcohol and Drug Committee of the National Safety Council has been functioning on a sub-optimal level, I offer that as a possible location for such a plan-formulation mechanism. It may be a five-year plan or a ten-year plan.

PERRINE: It would certainly be safe to assume that the problem is of such magnitude that any initiative would be welcome at whatever level. This is the sort of recommendation that you could relay to such a committee.

ZYLMAN: I've been surprised, although I shouldn't have been, that educational programs for attorneys and judges were ranked at the top of the priority list for applied research. I wonder if everyone is really aware of how critical this is. I had the experience in the last several weeks interviewing about 88 police officers, 10 judges, and 10 prosecutors, in a heavily urbanized area. Three of the questions they were asked were: How much do you weigh? How many ounces of 86-proof whiskey, or bottles of beer, could you drink in two hours before you would feel that you've become an unsafe driver? Using the same temporal and drinking criteria, how much could you drink within two hours before a policeman testing you would find you legally under the influence at .15? The results were somewhat shocking. The vast majority of those questioned indicated very reasonable amounts, the kind that would keep them well under .08, most of them around .05 or .06. The same results were found with the judges and the prosecutors. However, when questioned in relation to what it took to reach the .15 level, all, except three of the policemen grossly under-estimated. The vast majority, from 66% to 95% depending on the group, estimated their own drinking levels as being to, or greater than, what they thought the law would permit. This indicates that these individuals judge the law as more stringent than their own capabilities or their own mores would permit. And this was found within the criminal justice system, which I think is the critical point because these are the people supposedly operating the system. Yet, they are apparently operating the system contrary to their own conceptions of justice. This, incidentally, is the very essence of the "there but for the grace of God go I" attitude, because the majority of these policemen, prosecutors, and judges felt that they could be charged with .15 drunk-driving when they would actually be around .05 to .08. I think this is a critical area.

DRIESSEN: Dick (Zylman), have you ever given them a .10 dose of alcohol and tested them on the Breathalyzer in order to have them experience feedback? - Or Prof. Borkenstein? Have you done that?

BORKENSTEIN: We have done this quite extensively.

DRIESSEN: Have you found that procedure to be enlightening to the individual?

BORKENSTEIN: Yes. We have them drink normally for an hour, wait 20 minutes, test them, and then present feedback relating to their BAC. This seems an effective means for allowing the individuals to judge their normal drinking patterns.

DRIESSEN: O.K., fine. I guess what I'm saying is that in order to convince the prosecutors, the policemen, and the other critical people in the system, it's better to have an actual experience related to BAC determination, rather than to remain solely at the verbal level although the former method could still be useful.

VOAS: Did you have any of these people estimate their BAC before you tested them?

BORKENSTEIN: They did it on their own; we didn't require it. We found that in order to get over this purely abstract number, a three-corner learning process was required: How much did I drink? How do I feel? What is my BAC? The only instructions we gave were to relate these three questions. You might say that this is a self-teaching process, and it's an extremely powerful technique. Otherwise, we are in effect asking people to monitor their drinking before driving, which is as impossible to do, numerically speaking, as it is to adhere to a speed limit without every having had a speedometer in the car.

DRIESSEN: Have you ever done this with alcoholics?

BORKENSTEIN: I don't know if they were alcoholics or not. We just took a cross-section of the population at hand.

PERRINE: Just judges and attorneys.

VOAS: Larry Ross claimed the other day that the law is often the easiest way of doing countermeasures, specifically, just changing the law without necessarily attending to methods that would make that law effective. I do have some concern about education; in fact, all of us who come up through the education system probably have a strong visceral belief in it. I think, in general, the American public has a belief in it, and it's the easy way, because it's not painful, at least it's not as painful as jail, fines, and the other sanctions we impose on people when they get in trouble. So, it tends to have good social acceptance. However, it has proved to be a pretty weak tool. We have very little evidence in most of our studies for its effectiveness in relation to the very special criteria we're talking about: crashes involving alcohol, etc.

ROSS: As professional educators, many of you may share my belief that you can get caught by ideas and you can do cognitive things in education, but it's extremely difficult to change attitudes and values in our attempts to educate. Education, like law, is seductive, it's cheap, and it's considered the universal panacea in our society. Yet, the evidence is fairly convincing that this is a very ineffective countermeasure. I agree with Zylman that there is a lack of knowledge on the part of people who are supposed to be "in the know," such as judges and attorneys. I asked a similar question in England after the enormous and expensive educational campaign in 1967, and the judges reacted exactly as you described. These individuals grossly underestimated the amount of alcohol that would have to be consumed in order to surpass the legal limit. So, I'm not sure that we really know how to educate them. I'm not sure that it is going to be possible to educate them in the desired manner. And I'm not sure the whole enterprise is actually very meaningful. I think, for instance, that one could achieve more efficient police enforcement of the drunken-driving laws, if they were given the proper bureaucratic credit for drunken-driving arrests. Regardless of how the policeman evaluates the law, one of the problems to be solved is that the arrest doesn't count for much. It's just another traffic arrest; nobody is going to pat him on the back and say, "Well now, you spent the day at this arrest, and you got a conviction, and that was a good job."

That simply does not happen. Considering the issue as a bureaucratic or an organizational question is a more efficient procedure in the quest to change police behavior, than is trying to educate the policemen on the importance or quantifications of the alcohol problem. I think this is a promising area for research and/or for countermeasures. In brief, the last area in which we should be devoting our energies is in changing conscious behavior, because it is the most difficult of tasks. Although it looks easy, it's an inefficient and a limited means of handling the problem. There are other areas, which have been pioneered by many of you and which are very strongly endorsed by the government, where we should spend our time and our resources.

PERRINE: May I just footnote what both of you have said by commenting on national differences in approaches to solutions. In this country, for example, we have been greatly influenced by the assumptions underlying the earlier American philosophy concerning the notion of free will and being able to change oneself directly through one's own efforts. By implicitly and explicity emphasizing environmental -- as opposed to hereditary -- influences, this American orientation culminated in the behavioral approach and, in particular, the modification of behavior through education. These beliefs are clearly reflected again in terms of our approach and what we have just been discussing. By contrast, some of the European approaches stem from assumptions based on hereditary transmission -- as manifested by the traditional aristocracy. Thus, some European approaches regard individuals with the assumption that "that's simply the way people are and we can not change them" -- except by changing the system under which they operate. In other words, "if people aren't going to change, we will have to change the system."

As has been suggested here, both implicitly and explicitly, it might well be time for a smaller group to assemble and examine some of the basic values, instead of more mounds of data.

HURST: I think I'd have to agree with some of the evidence cited by the last two speakers, that the education is not sufficient and that perhaps we are failing to distinguish between the necessary and the sufficient conditions. Now, I don't think public education, or propaganda, is sufficient to bring about much of a change on voluntary behavior. But I do think it is necessary in conjunction with some other programs. Public education will remain necessary as long as the "authoritative sources of information for the public retain the same old mythologies that they've been clinging to for years and years regarding alcohol. I cannot see how an ASAP-type program, or anything of that sort, can progress when everybody believes in a lot of fairy tales.

BUIKHUISEN: I would like to return to an earlier point. I think we should not confuse certain things when we say that solving the problem by introducing new rules is cheap. It is my experience that many rules are not introduced because they are very expensive. What we are confusing here is the writing of a law and the enforcing of that law; and what makes every law very expensive -- and I hardly know of an exception -- is its enforcement.

Also, we should be very aware of the context in which the law is applied and in which the law is enforced. Therefore, you can't say that the law is actually ineffective, but you can say that the law enforcement is ineffective. There are several examples in the world that every undesirable behavior can be suppressed by law enforcement even those undesirable behaviors which we do not believe can be suppressed. If you want to enforce a law, and if you use all possibilities you have to enforce it, you can do it. But, what you are actually doing is suppressing the symptoms. Although, you've solved one problem, you may find you've developed another one. We should realize that many of the behaviors which we try to influence with laws serve needs. And the best way to solve the problems in society is to present people with alternatives -- or to take away their problems, and that of course is a utopia.

PERRINE: It is now time to begin closing this final session, as well as the Symposium itself. I would like to do so by offering some brief concluding remarks, and I would like to begin by thanking several organizations and individuals. First of all, the Vermont Symposium would not have occurred without the active endorsement and the personal commitment of some of those individuals who are here from the U. S. Department of Transportation. In particular, Bob Voas and Bob Borkenstein have been very, very helpful in sharing their ideas and their enthusiasm. And of course, Jim Nichols has been very involved as the contract technical manager of this project. Secondly, we feel especially fortunate that Al Pawlowski of the National Institute on Alcohol Abuse and Alcoholism was able to join us and to contribute so much, especially in the many informal sessions. I have had the particular pleasure of talking with him at length about some of his innovative ideas and programs which I very sincerely hope can be implemented within the scope of his domain. Next, I would like to thank Jerry Driessen, representing the National Safety Council, who has been very helpful on several aspects of the Symposium, especially on one that some of you may have overlooked, namely, the coffee served during the intermissions was provided through the courtesy of the National Safety Council, and Jerry mediated the arrangements.

I am deeply grateful to my fellow chairmen: Herb Moskowitz, Herb Barry, Steve Huntley, Paul Hurst, Reg Smart, and Jerry Driessen. Without the efforts of these individuals sitting here at the head table, we would not have had the caliber program that was presented. These men have been extremely cooperative in terms of putting aside other commitments and making space in their very busy programs to survey the literature and prepare the draft reviews in time for distribution at the Symposium. Of course, they may not have fully realized what they were getting into because a great deal of work has yet to be done, namely, preparing the final drafts of the review papers, editing the transcriptions of these discussion sessions, analyzing the results of the many ratings which you all have generously given us, and then putting it altogether in the final report.

We are particularly grateful to our three colleagues who helped fill the drug gap that was caused by the lack of any single individual who could realistically survey the vast spectrum of drug research. Therefore, that area was subdivided and treated by the three panelists who generously responded to our pleas; we were fortunate to have had such a productive panel consisting of Tony Carpenter, Paul Hurst, and Herb Moskowitz, with Jim Nichols serving as moderator.

Finally, my very special personal thanks and appreciation go to that group without whom we would have been completely lost: the Project ABETS staff and spouses. I am especially grateful to each one of them: the graduate students, the research assistants, the secretaries, and the spouses who either joined us here and pitched right in or stayed at home and at least did not prevent their spouses from being with us this weekend. It is truly amazing to see all the staff activities here in the conference room and next door in the secretariat, and then go upstairs later and see the same pleasant faces hosting the Open House, or to see them outside demonstrating the instrumented car, or late into the night seeing many of these same, more tired faces doggedly coding and punching in the data from all the ratings. If you think you had agonies in doing the ratings and just having to make a little circle on a slip of paper, think of the compounded agonies that the data processing staff have had, and have endured with unbelievably good spirit, even though some of them are half asleep now from sheer fatigue. Nevertheless, the ABETS staff has made it possible to experience what I feel has been a very memorable and relatively flawless Symposium. I would like to thank them again very much for their help and for their loyal persistence.

It would seem appropriate in closing to read a portion of the original proposal concerning the expected significance of this Symposium at a point in time when it was no more than a paper plan. Perhaps a review of these earlier expectations now will provide a vantage point for viewing what we have accomplished here during these three days and what lies ahead in the near future. Let me just read a page from the proposal.

EXPECTED SIGNIFICANCE OF THE SYMPOSIUM

"As a bare minimum, the proposed Symposium itself would provide an effective means by which experts in the areas of alcohol, drugs, and driving could convene, interact, and interchange ideas on research issues and priorities. Although even this minimum by itself would be sufficient reason to conduct such a Symposium, the following benefits are also expected.

1. Publication of the invited reviews and Symposium proceedings would make available, under one cover, a reference work which would include: critical reviews of the research literature on alcohol, drugs, and driving; summaries and discussions of these reviews by recognized authorities; a catalog of current knowledge in terms of a matrix structured by relevant parameters; ratings of the relative adequacy of our knowledge in each cell of this matrix; and ratings of each cell's relative priority for research, demonstration, and action.

2. The published reviews and proceedings would thus be the definitive work on behavioral aspects of alcohol, drugs, and driving and would systematically synthesize knowledge in the area for the first time.

3. The published reviews and proceedings would provide highly synthesized information and consensual guidelines to a special audience, including: scientists, legislators, judges, attorneys, law enforcement officials, private institutions (such as the National Safety Council, or the Insurance Institute for Highway Safety), and federal agencies (such as NIAAA, or especially NHTSA and its involvement in such countermeasure efforts as the Alcohol Safety Action Program).

4. The published reviews and proceedings (as well as actual participation in the Symposium by the attendees) should serve as a stimulating basis for future research and countermeasure developments in the area of alcohol, drugs, and driving.

5. Attendance at the Symposium should stimulate the research and countermeasure activities of the participants, as well as forming a firm basis for continuing contacts and interchange of ideas among them.

6. Specialists working in the area of alcohol, drugs, and driving thoughout the world would be greatly encouraged in their professional efforts by

the visible demonstration of active support for such a project and Symposium by the relevant federal agencies.

7. If the proposed matrix, ratings, reviews, and Symposium are as productive as they seem capable of being, they may well serve as the model for similar projects in the future."

With this view toward a possible Sugarbush II or a Big Sur II at some time in the future, I would like to bring my part of the Symposium to a close and ask Bob Voas if he wishes to say a few words.

VOAS: Yes, just a few words, thank you. It seems appropriate that on the part of the sponsoring agency and I think for the members around the room here, Bud, I should take the lead by complimenting you on your efforts in putting this whole Symposium together. Of course, being the contractor, I always hold out the carrot until we see the published report. But I do think it is appropriate now that I should express the feeling I have that this has been very useful and very productive and that much of that is due to your very hard efforts.

RATING RESEARCH PRIORITIES

Chapter 11

11. RATINGS OF PRESENT KNOWLEDGE AND RELATIVE PRIORITIES FOR BASIC AND APPLIED RESEARCH

ABSTRACT

The 35 invited participants at the Vermont Symposium rated 176 keyword topics on three dimensions of alcohol, drug, and driving problems: (1) the extent of present knowledge, (2) relative priority for basic research in terms of informational yield, and (3) relative priority for applied research in highway safety. These rating efforts provide the first quantified evaluations of specific aspects of these problems. The results of the keyword ratings were summarized separately for each of the eight symposium sessions which represent subdivisions of the major approaches to these problems.

A comprehensive overview of all keyword ratings was constructed (with certain methodological misgivings) in an attempt to provide an after-the-fact integration of ratings across sessions. This overview focused on the ratings by the "specialists" within each session (for certain technical reasons); it also focused on the two sets of research priority ratings, such that only the three highest rated keywords from each session were selected for consideration in the overview.

The keywords having the highest priorities for basic alcohol research in terms of informational yield were organized into three general categories, namely, alcohol influences: (1) upon basic neurophysiological activities (central and autonomic nervous systems); (2) upon the psychological processes of perception (dynamic visual acuity and visual search), attention (intensive, selective, and divided), and cognition (risk taking and decision making); and (3) in combination with other conditions of the driver (emotion, mood, and stressors other than alcohol, such as fatigue, noise, other drugs, etc.). The highest priorities for basic drug research were essentially the same as those for alcohol. The highest priority ratings for applied research in highway safety were very similar to those for basic research, especially for alcohol and to a slightly lesser extent for other drugs. Thus, there was a high level of agreement between the alcohol specialists and the drug specialists concerning which aspects of behavior should be rated highest on priorities for both basic and applied research in the two respective areas.

Highest priorities for applied research on the epidemiology of drugs in highway safety were given to the incidence and prevalence studies necessary in the exploratory stage of investigating a new problem (specifically, risk contribution of both hallucinogenic and psychoactive drugs to accidents, and extent of hallucinogenic drug use among drivers and pedestrians). Highest priorities on epidemiologic aspects of alcohol in highway safety were given to the interaction between alcohol and drugs, which is also a new problem area. High priorities for epidemiologic research on the drinking and driving problem were also given to the study of individual differences, especially those variables for which past behavior can serve as a predictor of future behavior (alcohol consumption pattern, and driving history).

Since none of the keywords concerning drug countermeasures received above average priority ratings, it was concluded that more incidence and prevalence studies are necessary to define the nature and scope of the drug and highway safety problem

before any countermeasure programs can be undertaken. Highest priorities for alcohol countermeasure research were given to a very traditional approach (enforcement by police surveillance) which seemed to be in great need of systematic evaluation and to a very new and promising approach (rehabilitation by behavior modification).

11.0 BACKGROUND AND METHODOLOGICAL CONSIDERATIONS

M. W. Perrine [1]

11.0.1 INTRODUCTION

The Vermont Symposium on Alcohol, Drugs, and Driving had three specific aims: to assess the status of present knowledge and to consider relative priorities for both basic and applied research in those areas germane to its theme. An attempt to determine the extent of present knowledge in any field is necessarily constrained by the state of the art at the moment. In turn, any consideration of research priorities is constrained by the very extent of knowledge. More specifically, it is difficult enough to attempt to establish priorities for investigating topics we know that we don't know much -- or anything -- about (the so-called "known unknowns"), but it is logically impossible to do so for those topics about which we know absolutely nothing (the so-called "unknown unknowns"). Thus, since the Vermont Symposium was compelled to work within the limits of present knowledge, it seemed desirable first to sketch and to rate those limits, especially in these relatively young problem areas.

11.0.1.1 Alcohol and highway safety. As a research area, alcohol and highway safety is less than forty years old. Despite a number of conferences, articles, and reports during the first twenty-five or thirty years of its history, the first major reviews have only appeared during the last five years. Thus, as recently as 1966-1967, it was possible for a few leading specialists to review the whole body of literature in the area and publish a comprehensive, definitive assessment of the status of current knowledge at the time (Alcohol and Highway Safety, 1968). At approximately the same time, a similar but slightly more technical review was prepared by a larger group of leading specialists representing a broader spectrum of disciplines (Alcohol and the Impaired Driver, 1968). Another review, which included more of the European literature, was prepared by a very small group of specialists in the Netherlands at the same time as the two American reviews (Griep, 1969). These three reviews clearly reflect the Zeitgeist of the mid-sixties, a point in time at which the persistent efforts of a relatively small number of individuals and organizations culminated in official action being taken on the drinking-and-driving problem, e.g., the 1966 Highway Safety Act in the United States, the 1967 Road Safety Act in Great Britain, etc. All three reviews represented independent attempts by different groups of individuals to assess the status of knowledge at that particular point in time by pulling the information together from the very widely scattered sources. All three publications were doubtless written in response to the same need, namely, to fill the gap caused by the absence of any single review and assessment of the field.

[1] The writer wishes to acknowledge with great gratitude the diligent assistance of Mary Anne Freedman, Robert A. Lubin, and Phillip M. Zunder in collecting, reducing, and analyzing the enormous amount of data reported in this chapter.

Since the mid-sixties, the body of literature concerning the role of alcohol in highway safety has expanded enormously, yet no recent assessment of our current knowledge is known to have been published. The Vermont Symposium originated as a response to a similar need, namely, to fill the gap caused by the lack of any comprehensive review since the late 1960s, but in addition, the status of current knowledge would be evaluated by means of rating procedures.

Only one previous study is known in which some attempt was made to rate the adequacy of current knowledge in the area of alcohol and highway safety; however, it was only a small part of a much broader survey, such that alcohol was but one of a great many factors examined. This study was sponsored by the Automobile Manufacturers Association and was conducted in 1965-66 by Arthur D. Little, Inc. who prepared a state-of-the-art review of all factors affecting traffic safety (i.e., human, environmental, vehicular, loss-limiting, and regulatory and legal factors). Alcohol was treated as one of four medical factors (along with diseases, physiological impairments, and drugs and chemical agents), which in turn was listed as one of six human factors (biographical factors, driving as a skill, medical factors, personality factors, driver education, and pedestrians). All factors were rated on two dimensions: knowledge and importance. No technical details concerning the rating procedure were provided in the report, and the following description is therefore based upon inferences made from the scant bit of text which accompanies the results of the ratings as presented in Figure 2 of the A. D. Little report (1966, pp. 10-11). The purpose of the ratings was stated as, "Figure 2 is intended to provide the reader with an overview of our general understanding of the state of existing knowledge on traffic safety (Little, 1966, p. 11)." Concerning the two dimensions for the ratings, it was stated that,

> "By knowledge, we mean extent to which there is factual information indicating the manner and degree to which the factor contributes to the present accident loss situation....The importance rating indicates our estimate of the degree to which changes in the factor in question contribute to the present overall accident and resulting loss situation. The validity of each such rating is naturally dependent upon the knowledge rating. Thus, where knowledge is rated as good, the importance rating can be considered to be a fairly accurate estimate. Where knowledge is rated as poor, the importance rating can only be our own subjective estimate (Little, 1966, p. 11)."

Knowledge of the factors was rated on five-point scales which were apparently labeled as: none or speculative, poor, fair, good, and excellent. Importance of the factors was rated on five-point scales, apparently labeled as: none or freak, minor, moderate, major, and critical. The number of raters was apparently somewhere between one and fourteen. In any case, the relevant results were that the A. D. Little "chart states that our knowledge on alcohol as a contributing factor is fair and that alcohol is a critical factor (1966, p. 11)."

Two previous studies are known in which an attempt was made to estimate the priority of research on the role of alcohol in highway safety (Hahn, 1968; Havelock, 1971; 1973). However, as with the A. D. Little study, the question of alcohol research priorities was but a very small part of large-scale surveys. The first attempt (Hahn, 1968) was a project sponsored by the Insurance Institute for Highway Safety and conducted by the American Institutes for Research. (The final report has apparently never been cleared for general distribution, which probably accounts for the fact that its contents are not very well known in the field.) The purpose of the project was to prepare recommendations for a research program to investigate human-factors aspects of driving and highway safety. Of the 24 "research program modules" that were developed and evaluated, only two involved alcohol ("drinking and driving in a total community setting," and "interaction effects of combined alcohol/drugs/tobacco"). Although the specific results should be considered as proprietary, it can be stated that both these modules were rated as average in urgency and above average in significance. Of greater relevance for the present study, however, is the unique and imaginative approach which the AIR investigators used to aid them during the preparation of their recommendations. As one part of the project, they surveyed "seventy-nine individuals who had demonstrated interest in highway safety research in one form or another (Hahn, 1968, p. 116)." In response to the initial letter from AIR, "replies either in the form of letters or phone calls, or personal visits were received from about one-half of those asked (Hahn, 1968, p. 116)." Regarding alcohol, "fourteen suggestions were received concerning some aspect of the alcohol problem and its relationship to traffic safety (Hahn, 1968, p. 120)." Thus, the researchers surveyed had responded more or less extensively to a fascinating, open-ended set of questions posed in the original letter from AIR; the responses were then processed by AIR staff and reduced to the 24 "research program modules," which were then rated by AIR project staff on the dimensions of significance (direct, semi-direct, and indirect), urgency, relation to other programs, and other dimensions of project relevance. The ratings produced by the AIR project staff were then submitted to a number of mini-max analyses. (For further details, the interested reader is referred to Clifford T. Hahn, American Institutes for Research, 8555 16th Street, Silver Spring, Maryland, 20910.)

A more recent attempt to estimate priority highway safety items was made as part of a large-scale survey conducted to investigate the national problem-solving system, consisting of highway safety researchers and decision makers (Havelock, 1971; 1973). The survey was conducted by the Institute for Social Research at the University of Michigan, apparently in 1969, and was sponsored by the National Highway Traffic Safety Administration. Of principal relevance for the present study was one open-ended question which asked, "What other area, if any, in addition to the above deserves top priority rating?" (The previous question had included a list of ten "activities which might be supported by the safety dollar"; and requested that the respondents "please rank in order THREE areas which you think should be of highest priority for receiving funds in 1970.") Usable responses were obtained from 15 alcohol-research opinion leaders, 105 highway safety researchers from a national sample, 48 decision makers from an alcohol conference, and 164 decision makers from a general sample (Havelock, 1971, p. 105). The verbatim responses concerning alcohol priorities were presented in Appendix D, where they have been separated according to whether they were recommended by decision makers or by researchers and then dichotomized (within each type of respondent) into responses that recommended "research and development" approaches or "action" approaches. Simple frequency distributions were determined which showed "a tendency for researchers to see priorities more in research terms. However, for the alcohol area, this paradigm does not hold. Here more researchers seem to be agreeing with decision makers that action strategies are necessary (Havelock, 1971, p. D-1)."

One recommendation which emanated from his analysis of the data was to "go all out on development of countermeasures for the alcohol problem (Havelock, 1971, p. 161)." Of particular relevance, however, were the recommendations which concerned improving the linkage between and among researchers and decision makers: (1) "support annual conferences with published proceedings on critical topics," and (2) "consider the suggestions of the researchers and decision makers themselves on improving linkage between them," with "more meetings and conferences" being by far the most popular recommendation of the researchers and one of the most popular of the decision makers (Havelock, 1971, pp. 162-163). Thus, the Vermont Symposium was inadvertently very consistent with the results and recommendations of the Michigan survey, which was a particularly happy coincidence since the existence of the Havelock report did not come to the attention of the present writer until the spring of 1973.

11.0.1.2 Other Drugs and Highway Safety. Active concern with this area of research activity has only developed during the last decade. Indeed, the three major reviews of this area have only appeared during the past three years (Kibrick & Smart, 1970; Milner, 1972; Nichols, 1971). Furthermore, no previous attempt to rate extent of current knowledge or research priorities in the area of other drugs and highway safety is known.

11.0.1.3 Advantages of the present study. A number of refinements and advances were achieved in the present study.

1. The ratings were obtained during the actual course of a task-oriented conference of leading researchers and decision makers.

2. Each set of ratings was obtained on specific clusters of topics or keywords which were germane to the extensive discussion which had immediately preceded the rating tasks themselves.

3. The particular keywords themselves had been selected and pretested by a small group of specialists representing each of the Symposium areas before being submitted to the larger audience of participants.

4. Certain refinements of rating procedures were possible in this face-to-face group situation which would be completely impractical in a mail or telephone survey.

5. By virtue of the group situation in a remote location, it was possible to achieve virtually 100% returns from these rating tasks.

These considerations, in addition to the high degree of specificity of the topics which were rated, should maximize the utility of the obtained results.

11.0.2 METHOD

11.0.2.1 Judges. The rating tasks were performed by the 35 invited participants attending the Vermont Symposium (see Appendix E). Prior to the first session of the symposium, all participants completed a biographical data questionnaire on which each person indicated his primary involvement in terms of one of four possible categories: (1) alcohol administrator, (2) alcohol researcher, (3) drug administrator, or (4) drug researcher. Then, if significantly involved in any other area, each participant was encouraged to check any or all of the same four categories listed in a subsequent question. These self-classifications were subsequently used for grouping purposes in conducting data analyses. Also, strictly for the purposes of analysis, each participant was subsequently rated by all session chairmen as either "expert/specialist" or "non-expert/nonspecialist" in terms of knowledge of the research and literature within each individual session. These various groupings were used in the analyses and tables presented below.

11.0.2.2 Procedure. The keywords to be rated at the end of each session served to identify the particular topics of relevance within the scope of that particular session. The keywords were selected prior to the symposium by the chairman of each session and were then carefully reviewed and pretested where possible by the symposium staff. A total of 176 keywords (or phrases) was used, and ranged in number from 9 in Session 3 to 44 in Session 8 (see Table 11-1.5 for Ns). A list of the keywords for each session is presented in the tables which are included in each of the specific subsections of the results section below, but complete versions of each (including parenthetical material) are in Appendix C.

The participants were seated at pre-assigned places located in alphabetic order along the outside edge of an open rectangle formed by a number of banquet tables pushed together. A coded manila envelope containing all the necessary materials was delivered to each place prior to each session. A copy of the rating instructions and an alphabetical list of the session-specific keywords was available to each participant at the beginning of each session, but the material for the rating task itself remained in the large envelopes until the end of the particular session, at which time the instructions were reviewed verbally and all participants performed the rating task concurrently.

Four separate rating tasks were required, and instructions for each are presented below:

1. Between "no knowledge" and "total knowledge", as represented on the following scales, where do you think we are today (circle the appropriate number)?

2. Circle the number corresponding to the priority for basic research in terms of informational yield.

3. Circle the number corresponding to the priority for applied research in traffic safety.

4. Circle the number corresponding to your own qualifications in judging this area, a rating of 7 being comparable to the person most knowledgeable in this particular area, and a rating of 1 being comparable to a person just entering the area (e.g., a first-year graduate student).

It should be noted that the task referred to above as Instruction 2 was omitted from Sessions 5, 6, and 8 on the assumption that basic-research ratings were not applicable.

Fifteen minutes prior to the scheduled conclusion of each session, the discussion was terminated and the ratings started. In addition to a review of the rating mechanics, supplemental verbal instructions were also given. For the alcohol sessions (1, 2, 3, 4, 5, and 8), the participants were instructed to perform the rating tasks on the assumption that the research was being conducted with human subjects at medium blood alcohol concentrations which were explicitly defined as being between 50 and 100 mg%. For the drug sessions (6 and 7), they were instructed to perform the rating tasks on the assumption that the research was being conducted with human subjects dosed to medium levels. The participants then opened the packets which contained four smaller envelopes, each of which contained one of the four different instructions, as well as a set of all the keywords for that particular session. Each keyword was printed on a separate slip of paper along with the scale which was appropriate for that particular task. Examples of the scales are presented on the following page.

Task 1

Visual field		
NO KNOWLEDGE		TOTAL KNOWLEDGE
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	

Tasks 2, 3 and 4

Visual field						
LO						HI
1	2	3	4	5	6	7

The four rating tasks were performed in a random order, with the exception that Task 4 (i.e., judging one's own qualifications) was always performed last in the series. Furthermore, the keyword slips in each of the smaller envelopes were in random order, and the participants were instructed not to hold any keyword aside for consideration at the end of the series, but rather to judge each keyword at it appeared in the pack.

The rating tasks were performed during the first two days of the Symposium, with two sessions scheduled each morning and each afternoon (see Appendix A for details). In order to provide data in time for presentation during the session summaries on the morning of the third day, a remote terminal was installed at Sugarbush Inn which enabled us to use the University of Vermont Computer Center for the preliminary analyses. Accordingly, the symposium staff diligently began reducing and entering the rating data as soon as available after each session. In view of the large number of entries and the relatively slow output of the terminal, several very loyal staff members worked through the nights to meet the scheduled deadline.

Following the Forum Discussion on the afternoon of the third day of the symposium, the participants were asked to complete a symposium evaluation questionnaire, which is presented and discussed in Appendix D.

11.0.3 RESULTS

Although the summary interpretations of the results of the rating tasks in each session were prepared individually by each session chairman and are presented separately below, a few comments on the data processing common to the results of all sessions would perhaps aid in understanding the subsequent subsections.

First, it might aid in understanding the sheer magnitude of the data processing task if the total amount of raw data were summarized. Assuming that all 35 participants rated each of the 176 keywords on the 4 different tasks (but omitting the 79 keywords from the basic research ratings which were deliberately not required in Sessions 5, 6, and 8), the total number of ratings obtained at the Symposium would be 21,875.

Means, medians, and standard deviations were calculated for each keyword using each of the following different groupings of participants: (1) all participants together, (2) grouped by area of activity, i.e., either alcohol (whether administration or research) or drug (whether administration or research), and (3) grouped on the basis of the chairmen's ratings of each participant as being "expert/specialist" or "non-expert/non-specialist." With the exception of the first grouping of all participants, only the data from those participants for whom the general topic of the session was deemed relevant were included in the analysis of that particular session. For example, in Sessions 6 and 7, the ratings of individuals who had classified themselves as "alcohol administration" or "alcohol research" and had not indicated even secondary involvement in drug administration or research were excluded from the analyses. In the tables presented below, the column heading Alcohol Professionals (or Drug Professionals) includes all those participants who classified themselves as alcohol (or drug) administration or research (regardless of whether primary or significant secondary area of involvement), whereas the column headings of Specialist and Non-specialist are based on the groupings determined from the ratings by the combined session chairmen.

An analysis of differences between the ratings of the specialists and the non-specialists in terms of central tendency effect and usage of the extreme scale values has been conducted by Lubin, Zunder, and Perrine and is presented below in Subsection 11.9. On the extent of present knowledge ratings, they found an increase in usage of extreme scale values and a decrease in the central tendency effect by the alcohol specialists relative to the alcohol non-specialists.

Regarding the organization of the eight subsections (each of which is devoted to one of the eight Symposium sessions), it should be noted that a series of four similar tables is presented in each subsection. They have been numbered and ordered consistently to aid in location and comparison. Accordingly, the first number following the dash refers to the session number (1-8), whereas the numbers 1, 2, and 3 following the decimal point refer to the rating-task instruction number. However, the number ".4" does not refer to the fourth rating task since the ratings of one's own qualifications are not being presented in this report. Rather, all tables in the .4 series present the correlations between Specialists' ratings of each keyword in the particular session according to the first three rating tasks. Any additional tables within a given subsection are specific to that subsection and are designated .5, .6, etc. All tables referred to in a given subsection are located together following the end of the subsection text.

Finally, it should be noted that the texts of the summary interpretations of the keyword rating tasks have each been prepared by the particular session chairman. All necessary tables were prepared by the symposium staff and sent to the chairman who at an earlier meeting had reached consensus on guidelines to be followed in preparing these summaries. Nevertheless, the resulting summaries show some remarkable individual differences.

11.1 KEYWORD RATINGS IN SESSION 1: ALCOHOL INFLUENCES UPON NEUROPHYSIOLOGICAL, NEUROMUSCULAR, AND SENSORY ACTIVITIES

M. W. Perrine

11.1.1 KEYWORDS

A total of 15 keywords was rated for extent of present knowledge, as well as for basic and applied research priorities (as described above). These keywords ranged from extremely general topics (e.g., central nervous system) to extremely specific topics (e.g., muscle strength, or critical flicker fusion). The 15 keywords were drawn from the three areas of activities reviewed in Session 1, and were distributed (unevenly) within these three areas as follows: 2 neurophysiological, 4 neuromuscular, and 9 sensory keyword topics (see Table 11-1.1 for the specific listings). Although all 15 keywords were presented to the participants as a randomly mixed set for rating purposes, they are more meaningfully organized under the three areas of behavioral aspects for purposes of discussion.

11.1.2 JUDGES

The keywords in this session were rated by all participants, but the data were organized on the basis of three different combinations for purposes of analysis and reporting (as described above in section 11.0.2.1). Thus, the group labeled "Alcohol Professionals" in the following tables (Table 11-1.1 through Table 11-1.4) consisted of the 32 participants who had classified themselves on the initial questionnaire as "alcohol researchers" and/or "alcohol administrators" in terms of either primary involvement or significant additional involvement. This larger group was subsequently subdivided for purposes of analysis into two sub-groups, such that 11 individuals were designated as "expert/specialist" and 21 individuals were designated as "non-expert/non-specialist" by ratings obtained from all session chairmen. The three column headings used in the following tables refer to these three different groupings.

One obvious question concerns the extent to which the ratings of the specialists differed from those of the non-specialists.[2] Accordingly, correlations between the two sets of ratings were determined by calculating Spearman rho's for the means of the keyword ratings on the three different tasks, with the following results (for the 95% confidence intervals for each of these rho's, as well as those obtained from these correlations in all other sessions, see Table 11-1.5): extent of present knowledge = .90, basic research priority = .81, and applied research priority = .89. Because of the relatively high correlations between these two sub-groups and because of the greater reliability obtained from a larger sample, the following discussion will concentrate on the results obtained

[2] A more extensive methodological approach to this question is reported below by Lubin, Zunder, and Perrine in their comparison of scale usage by the specialists and non-specialists (see Section 11.9).

from the combined group of alcohol professionals (N = 32); however, especially noteworthy differences between the two sub-groups will be specifically mentioned.

11.1.3 EXTENT OF PRESENT KNOWLEDGE

11.1.3.1 Neurophysiological activities. Both the autonomic and the central nervous systems were rated as two of the three lowest keywords in this session, indicating very high agreement on the relative inadequacy of our present degree of knowledge concerning alcohol influences upon these two levels of activity.

11.1.3.2 Neuromuscular activities. A high degree of consensus was obtained for two of the less complex behavioral aspects in this category, namely, manual dexterity and standing steadiness, both of which were rated among the four top keywords in terms of relatively high adequacy of present knowledge. However, there was considerable disagreement on muscle strength (perhaps the least complex of the topics in this category) which was in fifth place in the non-specialist ratings, but in tenth place in the specialists' ratings. However, disagreement even within the latter group was indicated by a relatively large standard deviation (3.17). Walking steadiness, the most dynamic topic in this group, was rated relatively low in adequacy of present knowledge (10th place), but the standard deviation was quite large.

11.1.3.3 Sensory activities. A high degree of consensus was demonstrated for three keywords in this category which were rated in the top third for relatively high adequacy of present knowledge: static visual acuity, critical flicker fusion, and visual field. High consensus was also achieved at the other end of the distribution with dynamic visual acuity, visual after-effects and illusions, and audition being rated relatively very low in adequacy of present knowledge.

11.1.4 BASIC RESEARCH PRIORITIES

11.1.4.1 Neurophysiological activities. Both central and autonomic divisions of the nervous system received the highest ratings for basic research priorities, and an impressive degree of consensus was indicated by the relatively low standard deviations (especially for the specialists' ratings for the central nervous system, which had a standard deviation of 0.69).

11.1.4.2 Neuromuscular activities. Muscle strength brought out the greatest degree of unanimity among the participants; it was consistently rated extremely low in priority for basic research, and the ratings had a very small standard deviation. The remaining three keywords in this category were rated in the middle of the distribution, and thus were apparently not felt to merit strong consideration for basic research activities. The only specific exception was walking steadiness which was in fifth place on the specialists' rank-ordered list of ratings (although it was ninth on the nonspecialists' list).

11.1.4.3 Sensory activities. Dynamic visual acuity received a consistently high priority rating, and was followed closely by visual after-effects and illusions, visual field, and adaptation. Consistently low priority ratings were obtained for color vision, critical flicker fusion, and static visual acuity. The only discrepancy that might be worth noting was obtained in the case of visual adaptation which was in fourth place on the non-specialists' list but in eighth place on the specialists' list; nevertheless, the means in both groups were very similar.

11.1.5 APPLIED RESEARCH PRIORITIES

11.1.5.1 Neurophysiological aspects. As in the case of basic research priorities, the central nervous system received the highest ratings for applied research priority. In contrast, the autonomic nervous system was rated appreciably lower, being in fifth place on the non-specialists' list and in seventh place on the specialists' list.

11.1.5.2 Neuromuscular aspects. The same relations obtained for applied research priorities as were presented above for basic research priorities.

11.1.5.3 Sensory activities. As in the case of basic research priorities, dynamic visual acuity received very high ratings for applied research priorities; and the other keywords in this category were rated in essentially the same fashion as described above under basic research priorities.

11.1.6 DISCUSSION AND CONCLUSIONS

The most important general result is the high degree of consensus between the specialists and non-specialists across all three rating tasks. This result could be due to some combination of the following factors: (1) inadequate criteria for differentiating specialists from non-specialists, (2) no "true" differences between specialists and non-specialists, and/or (3) fundamental agreement between the specialists and non-specialists, despite whatever other differences they may have had. Some support for the latter factor can be found in Havelock's (1971, 1973) study, discussed above. He found a tendency for highway safety researchers and decision makers to be in basic agreement on the topic of alcohol, whereas they differed substantially on other highway safety topics.

In any case, a high degree of consensus was obtained concerning the nervous system. Present knowledge of alcohol influences upon both the central and autonomic nervous systems was rated as relatively very inadequate, whereas the priorities for both basic and applied research concerning alcohol influences upon central nervous system function was the highest of all keywords in this session. The study of alcohol influences upon autonomic nervous system function ran a close second for basic research priorities, but was rated slightly lower for applied research priority.

Regarding alcohol influences upon neuromuscular activities, the consensus seemed to be that we currently have a medium to high level of knowledge, whereas priorities for both basic and applied research are medium to low. Thus, with the possible exception of walking steadiness, not much excitement seemed to be generated by this category of behavioral aspects.

Regarding alcohol influences upon sensory activities, a wide range of ratings was obtained for the nine keywords in this category, although a great deal of consistency was obtained for certain individual keywords. Dynamic visual acuity received relatively very high ratings for both basic and applied research priorities, and was followed closely by visual field, after-effects and illusions, and adaptation. Of these topics, only visual field received relatively high ratings for adequacy of present knowledge.

The apparently high degree of relation between priority ratings for basic research and for applied research can be substantiated for most of the keywords, as indicated by the correlations (Spearman's rho) between the ratings on those two tasks produced by the specialists (see Table 11-1.4, Column 3). The fact that the correlations between present knowledge and research priority ratings were not statistically significant could well be interpreted as an indication that the judges were differentiating selectively and were not simply ascribing a high priority to those keywords for which present knowledge seems to be low.

TABLE 11-1.1

Present Knowledge Ratings of Keywords from Session 1: "Alcohol Influences Upon Neurophysiological, Neuromuscular, and Sensory Activities"

Keywords	Alcohol Professional (N=32)		Specialists (N=11)		Non-Specialists (N=21)	
	Mean	SD	Mean	SD	Mean	SD
Neurophysiological						
Autonomic nervous system	6.50	2.82	6.45	3.30	6.52	2.62
Central nervous system	5.91	2.96	5.36	3.23	6.19	2.84
Neuromuscular						
Manual dexterity and steadiness	9.16	2.23	9.45	2.66	9.00	2.02
Muscle strength	7.91	2.88	7.36	3.17	8.19	2.75
Standing steadiness (static balance)	8.94	3.10	9.64	2.98	8.57	3.17
Walking steadiness (dynamic balance)	7.75	3.25	7.82	4.05	7.71	2.87
Sensory						
Acuity, dynamic	7.00	2.92	6.18	2.52	7.43	3.08
Acuity, static	9.81	2.68	9.64	3.41	9.90	2.30
Adaptation (glare tolerance and recovery)	8.16	2.82	8.36	3.14	8.05	2.71
After-effects and illusions	6.44	2.26	6.91	2.66	6.19	2.04
Color vision	7.78	3.41	7.73	4.22	7.81	3.01
Critical flicker fusion	9.69	3.03	10.00	2.93	9.52	3.14
Retinal sensitivity	8.25	3.45	8.91	4.28	7.90	3.00
Visual field	8.50	2.50	9.27	2.24	8.10	2.59
Audition	7.13	2.98	7.18	3.74	7.10	2.61

TABLE 11-1.2

Basic Research Priority Ratings of Keywords from Session 1: "Alcohol Influences Upon Neurophysiological, Neuromuscular, and Sensory Activities"

Keywords	Alcohol Professional (N=32)		Specialists (N=11)		Non-Specialists (N=21	
	Mean	SD	Mean	SD	Mean	SD
Neurophysiological						
Autonomic nervous system	4.97	1.40	5.36	1.29	4.76	1.45
Central nervous system	5.75	1.22	6.55	.69	5.33	1.24
Neuromuscular						
Manual dexterity and steadiness	3.53	1.57	3.73	1.79	3.43	1.47
Muscle strength	1.78	.79	1.82	.98	1.76	.70
Standing steadiness (static balance)	3.31	1.69	4.18	1.89	2.86	1.42
Walking steadiness (dynamic balance)	3.72	1.55	4.73	1.49	3.19	1.33
Sensory						
Acuity, dynamic	4.72	1.25	4.91	1.04	4.62	1.36
Acuity, static	3.03	1.33	2.91	1.22	3.10	1.41
Adaptation (glare tolerance and recovery)	4.16	1.42	4.00	1.26	4.24	1.51
After-effects and illusions	4.44	1.63	4.91	1.70	4.19	1.57
Color vision	2.72	1.53	2.82	1.33	2.67	1.65
Critical flicker fusion	2.75	1.55	3.55	1.92	2.33	1.15
Retinal sensitivity	3.31	1.67	3.00	1.48	3.48	1.78
Visual field	4.31	1.64	4.45	1.63	4.24	1.67
Audition	3.09	1.73	3.00	1.41	3.14	1.90

TABLE 11-1.3

Applied Research Priority Ratings of Keywords from Session 1: "Alcohol Influences Upon Neurophysiological, Neuromuscular, and Sensory Activities"

Keywords	Alcohol Professional (N=32)		Specialists (N=11)		Non-Specialists (N=21)	
	Mean	SD	Mean	SD	Mean	SD
Neurophysiological						
Autonomic nervous system	4.12	1.58	4.36	1.80	4.00	1.48
Central nervous system	5.19	1.69	5.64	1.43	4.95	1.80
Neuromuscular						
Manual dexterity and steadiness	3.34	1.60	3.91	1.92	3.05	1.36
Muscle strength	1.69	.97	1.91	1.45	1.57	.60
Standing steadiness (static balance)	3.34	1.81	4.18	1.78	2.90	1.70
Walking steadiness (dynamic balance)	3.69	1.60	4.55	1.57	3.24	1.45
Sensory						
Acuity, dynamic	4.59	1.56	5.09	1.22	4.33	1.68
Acuity, static	2.75	1.44	2.73	1.27	2.76	1.55
Adaptation (glare tolerance and recovery)	4.44	1.76	4.73	1.42	4.29	1.93
After-effects and illusions	4.00	1.65	4.64	1.50	3.67	1.65
Color vision	2.75	1.74	2.55	1.92	2.86	1.68
Critical flicker fusion	2.41	1.46	3.09	1.87	2.05	1.07
Retinal sensitivity	3.13	1.88	3.18	2.36	3.10	1.64
Visual field	4.53	1.74	4.64	1.80	4.48	1.75
Audition	3.13	1.93	2.91	1.97	3.24	1.95

TABLE 11-1.4

Correlations between Specialists' Ratings of Each Keyword in Session 1 according to Status of Present Knowledge, Basic Research Priority, and Applied Research Priority (N=11)

Keywords	Spearman's Rho		
	PK-BR	PK-AR	BR-AR
Neurophysiological			
Autonomic nervous system	-.36	-.10	.10
Central nervous system	-.21	.49	.39
Neuromuscular			
Manual dexterity and steadiness	.18	-.32	.69 *
Muscle strength	-.19	.03	.57
Standing steadiness (static balance)	-.50	-.15	.73 *
Walking steadiness (dynamic balance)	-.33	-.40	.70 *
Sensory			
Acuity, dynamic	-.45	-.40	.84 *
Acuity, static	-.51	-.17	.60 *
Adaptation (glare tolerance and recovery	-.32	-.18	.44
After-effects and illusions	-.20	-.17	.96 *
Color vision	-.28	-.09	.83 *
Critical flicker fusion	.27	.09	.87 *
Retinal sensitivity	-.46	-.43	.81 *
Visual field	-.62 *	-.53	.59
Audition	-.39	-.59	.62 *

*($|\hat{\rho}| \geq .60 \rightarrow \rho \neq 0; p < .05$)

Key:

PK = present knowledge
BR = basic research
AR = applied research

TABLE 11-1.5

Number of Specialists, Non-specialists, and Keywords per Session; and Rank Order Correlations between Specialists' and Non-specialists' Mean Ratings of Present Knowledge, Basic Research Priority, and Applied Research Priority

Session	Number			Present Knowledge		Basic Research		Applied Research	
	Spec.	Non-spec.	Keywords	Rho	95% c.i.[a]	Rho	95% c.i.[a]	Rho	95% c.i.[a]
1	11	21	15	.90	.70- .98	.81	.48-.95	.89	.70-.98
2	18	14	15	.87	.67- .97	.92	.73-.98	.82	.48-.95
3	11	23	9	.22	-.60-+.75	.97	.78-.98	.93	.60-.97
4	8	26	22	.83	.58- .94	.83	.58-.94	.89	.75-.96
5	17	17	16	.84	.55- .93	.91	.75-.96	.60	.13-.84
6	6	8	19	.34	-.16-+.65			.91	.59-.92
7	8	6	39	.19	-.13-+.47	.82	.65-.91	.89	.63-.89
8	16	16	44	.84	.70- .90			.62	.40-.79

[a] The 95% confidence interval for each calculation of Spearman's rho.

11.2 KEYWORD RATINGS IN SESSION 2: ALCOHOL INFLUENCES UPON SENSORY MOTOR-FUNCTIONS, VISUAL PERCEPTION, AND ATTENTION

Herbert Moskowitz

In Session 2, a high degree of agreement was found regarding ratings between the rater categories of alcohol researcher, drug researcher, or administrator. This consensus held true for both ratings regarding the state of current knowledge on various topic areas (see Table 11-2.1) and those on the priorities to be assigned these areas for future research of basic and applied character (see Tables 11-2.2 and 11-2.3, respectively).

There appeared only a small negative correlation between ratings regarding our state of knowledge of an area and its priority for future research (see Table 11-2.4). While less well known areas were given a slight preference for research, in general, priorities for research appeared determined more by an evaluation of the importance of that area for driving safety. This is supported by the high correlation found for priority ratings on research topics for basic and applied research (see Table 11-2.4). Areas considered important for driving safety and therefore prime candidates for applied research were also highly rated for basic research, apparently to clarify the mechanisms involved.

Given the closeness of some of the ratings, it appears best to group the results into four groups in regard to priorities for basic and applied research. First position was assigned to future work on selective and divided attention, closely followed by an interest in visual search. As a grouping, the votes suggest that raters felt that prime concern for research in this area of alcohol-related driving accidents should be allocated to the role of perception and information processing capacities under alcohol.

It is therefore not surprising that the second grouping of priorities suggested an emphasis on the topics of visual recognition and identification, visual signal detection, and intensive attention or vigilance.

The third group of priorities was headed by tracking and included visual discrimination, choice reaction time, perceptual suggestion, and oculomotor activities. This group of ratings dealt with a range of issues which differed significantly from each other. The issues had considerably less common interest for the group as a whole.

The final level of priorities were assigned to simple reaction time, depth perception, sensory motor coordination, perceptual constancies, and time perception. The rating values assigned to these topics indicated little serious concern with these topics as of importance for problems related to alcohol-driving accidents.

TABLE 11-2.1

Present Knowledge Ratings of Keywords from Session 2:
"Alcohol Influences Upon Sensory Motor Functions,
Visual Perception, and Attention"

Keywords	Alcohol Professional (N=32)		Specialists (N=18)		Non-Specialists (N=14)	
	Mean	SD	Mean	SD	Mean	SD
Attention, intensive (e.g., vigilance)	8.22	2.56	8.06	2.90	8.43	2.14
Attention, selective and divided	7.75	2.75	8.00	2.87	7.43	2.65
Depth Perception	8.72	3.29	8.67	3.14	8.79	3.60
Oculomotor activities (e.g., coordination and control)	7.87	2.71	7.61	3.03	8.21	2.29
Perceptual constancies (e.g., size, shape, color, brightness, etc.)	7.94	2.98	7.50	3.11	8.50	2.82
Perceptual suggestion (e.g., field dependence, autokinetic effects)	6.91	2.58	6.78	2.51	7.07	2.76
Reaction time, choice	9.09	2.77	9.17	2.73	9.00	2.94
Reaction time, simple	11.44	2.33	11.94	1.63	10.79	2.94
Sensory motor coordination (other than tracking)	8.19	2.71	8.00	3.05	8.43	2.28
Time perception	6.41	3.01	6.11	3.23	6.79	2.78
Tracking (pursuit and compensatory)	9.44	2.58	9.83	2.33	8.93	2.87
Visual discrimination	8.38	2.62	8.00	2.77	8.86	2.44
Visual recognition and identification	7.69	2.29	7.83	2.50	7.50	2.07
Visual search	7.09	2.51	6.83	2.60	7.43	2.44
Visual signal detection	8.59	3.06	8.33	3.09	8.93	3.10

TABLE 11-2.2

Basic Research Priority Ratings of Keywords from Session 2:
"Alcohol Influences Upon Sensory Motor Functions,
Visual Perception, and Attention"

Keywords	Alcohol Professional (N=32)		Specialists (N=18)		Non-Specialists (N=14)	
	Mean	SD	Mean	SD	Mean	SD
Attention, intensive (e.g., vigilance)	4.78	1.54	4.72	1.49	4.86	1.66
Attention, selective and divided	5.88	1.10	5.89	.68	5.86	1.51
Depth Perception	3.41	1.41	3.22	1.31	3.64	1.55
Oculomotor activities (e.g., coordination and control)	4.19	1.55	4.17	1.47	4.21	1.72
Perceptual constancies (e.g., size, shape, color, brightness, etc.)	3.78	1.48	3.72	1.49	3.86	1.51
Perceptual suggestion (e.g., field dependence, autokinetic effects)	4.12	1.60	4.33	1.64	3.86	1.56
Reaction time, choice	4.03	1.98	4.17	2.09	3.86	1.88
Reaction time, simple	2.19	1.28	2.11	1.02	2.29	1.59
Sensory motor coordination (other than tracking)	4.06	1.24	4.22	1.11	3.86	1.41
Time perception	3.53	1.52	3.39	1.24	3.71	1.86
Tracking (pursuit and compensatory)	4.06	1.78	4.06	1.66	4.07	1.98
Visual discrimination	4.28	1.30	4.33	1.28	4.21	1.37
Visual recognition and identification	4.69	1.33	4.61	1.33	4.79	1.37
Visual search	5.13	1.45	5.17	1.25	5.07	1.73
Visual signal detection	4.59	1.72	4.67	1.68	4.50	1.83

TABLE 11-2.3

Applied Research Priority Ratings of Keywords from Session 2: "Alcohol Influences Upon Sensory Motor Functions, Visual Perception, and Attention"

Keywords	Alcohol Professional (N=32)		Specialists (N=18)		Non-Specialists (N=14)	
	Mean	SD	Mean	SD	Mean	SD
Attention, intensive (e.g., vigilance)	5.09	1.49	5.39	1.29	4.71	1.68
Attention, selective and divided	6.16	.95	6.17	.86	6.14	1.10
Depth Perception	3.34	1.60	3.11	1.41	3.64	1.82
Oculomotor activities (e.g., coordination and control)	4.06	1.56	4.06	1.39	4.07	1.82
Perceptual constancies (e.g., size, shape, color, brightness, etc.)	3.41	1.60	2.83	1.38	4.14	1.61
Perceptual suggestion (e.g., field dependence, autokinetic effects)	3.91	1.51	4.11	1.49	3.64	1.55
Reaction time, choice	3.91	1.55	4.11	1.68	3.64	1.39
Reaction time, simple	2.06	1.11	2.06	1.06	2.07	1.21
Sensory motor coordination (other than tracking)	4.00	1.44	3.94	1.21	4.07	1.73
Time perception	3.03	1.51	2.44	1.10	3.79	1.67
Tracking (pursuit and compensatory)	4.75	1.55	4.50	1.65	5.07	1.38
Visual discrimination	4.19	1.42	4.22	1.52	4.14	1.35
Visual recognition and identification	5.22	1.41	5.28	1.18	5.14	1.70
Visual search	5.66	1.31	5.78	1.06	5.50	1.61
Visual signal detection	4.66	1.62	4.28	1.56	5.14	1.61

TABLE 11-2.4

Correlations between Specialists' Ratings of Each Keyword in Session 2 according to Status of Present Knowledge, Basic Research Priority, and Applied Research Priority (N=18)

Keywords	Spearman's Rho		
	PK-BR	PK-AR	BR-AR
Attention, intensive (e.g. vigilance)	-.20	-.09	.65 *
Attention, selective and divided	.21	.17	.69 *
Depth perception	-.46	-.46	.81 *
Oculomotor activities (e.g., coordination and control)	-.11	-.41	.55 *
Perceptual constancies (e.g., size, shape, color, brightness, etc.)	-.21	.18	.55 *
Perceptual suggestion (e.g., field dependence, autokinetic effects)	.02	.19	.47 *
Reaction time, choice	-.51	-.36	.78 *
Reaction time, simple	-.21	-.40	.66 *
Sensory motor coordination (other than tracking)	-.21	-.17	.53 *
Time perception	-.04	.09	.25
Tracking (pursuit and compensatory)	-.39	-.21	.80 *
Visual discrimination	-.57 *	-.40	.67 *
Visual recognition and identification	-.33	-.04	.35
Visual search	-.31	-.41	.79 *
Visual signal detection	-.50 *	-.50 *	.74 *

*($|\hat{\rho}| \geq .47 \rightarrow \rho \neq 0$; $p < .05$)

Key:

PK = present knowledge
BR = basic research
AR = applied research

11.3 KEYWORD RATINGS IN SESSION 3: MOTIVATIONAL AND COGNITIVE EFFECTS OF ALCOHOL

Herbert Barry, III

11.3.1 KEYWORD CLASSIFICATION

The nine keywords in Session 3 can be classified according to whether they designate effects of alcohol primarily on motivation, primarily on cognition, or on a combination of both motivation and cognition. All but one of the keywords can also be grouped into pairs of words which pertain to the same general type of behavior. Table 11-3.5 shows this classification of the keywords. The rank order for basic research priority, obtained from the average ratings by the 34 alcohol professionals, is indicated for each of the nine keywords.

The classifications could be disputed, but they may provide a useful -- although simplified -- frame of reference. For example, learning and problem solving involve both motivation and cognition, but problem solving constitutes a greater preponderance of cognitive factors. Likewise, long term memory involves predominantly cognitive factors, such as those involved in the transition from intoxicated to sober condition; whereas, short term memory is greatly influenced by the immediate motivational factors.

The keywords are mostly self-explanatory. However, special definitions had been given for decision making and risk taking in accordance with discussion in Session 3, immediately prior to the ratings. Decision making was defined as the willingness to accept a subjectively perceived degree of risk, whereas risk-taking was defined as the objective hazard, which is influenced by the motivational factor of decision to accept the risk and by any cognitive discrepancy between real and perceived hazard.

The keyword learning was followed by the following parenthetical statement: "e.g., acquisition rate, state-dependency, etc." It is evident that the differentiation between intoxicated and sober states also involves long term memory. Indeed, memory failure is the principal indication of state-dependency. Learning of differential behavior in the different states is a less commonly recognized feature of state-dependency and thus was pointed out in the keyword list.

11.3.2 BASIC RESEARCH PRIORITIES

The nine keywords were well differentiated from each other with respect to average rated priority for basic research (see Table 11-3.2). Verbal performance received by far the lowest rating, and indeed this effect of alcohol seems potentially important only as an indicator or correlate rather than as a cause of traffic accidents. The pairs of keywords pertaining to the same type of behavior were adjacent in priority. Table 11-3.5 shows that the highest priorities were given for the types of behavior which include a keyword expressing motivational effects (decision-making, motivation). Lower priorities were given for the types of behavior which include a keyword expressing cognitive effects (problem solving, long term memory).

A more general observation about the different types of behavior (Table 11-3.5) is that high priority for basic research was assigned to those which often show a stimulant or disinhibitory effect of alcohol. Thus, bold actions and aroused motivations are prominent effects of intoxication and were associated with high-rated priorities. By contrast, alcohol has predominantly depressant effects on the other types of behavior, indicated by stupid actions, forgetting, and misuse of language. These types of alcohol effect are represented by keywords with low priority. These differential priority ratings suggest that the stimulant or disinhibitory actions of alcohol were considered to be more interesting and promising for basic research than were the depressant or sedative actions. This is an inference which should be tested by direct questions, but the available data provide interesting suggestions about how the participants viewed the effects of alcohol.

11.3.3 APPLIED RESEARCH PRIORITIES

The priorities for applied research were closely similar to the priorities for basic research. However, some suggestive differences can be detected. The average ratings showed a greater range of variation among the nine keywords for applied than for basic research priorities (see Table 11-3.3). This was probably due to better consensus among the raters for applied research priorities, indicated by lower standard deviation values among the raters for applied research priorities in the case of eight of the nine keywords. Another difference is that the applied research priorities were rated relatively higher for the keyword which represents both motivation and cognition (Table 11-3.5) than for the keyword which represents the same type of behavior, but is limited to the motivational or cognitive aspect. This suggests the reasonable conclusion that the more complex functions which combine motivational and cognitive factors should be emphasized in applied research, whereas the more simple functions should be emphasized in basic research.

11.3.4 ADEQUACY OF PRESENT KNOWLEDGE

The average ratings of present knowledge showed smaller variation among the nine keywords than the average ratings of research priorities in spite of the more expanded 15-point scale for present knowledge (see Table 11-3.1). Lack of consensus among the raters in this measure is indicated by the fact that the standard deviation scores were substantially higher for the ratings of present knowledge than of research priority. The highest rating of knowledge was for verbal performance, which had the lowest rating of research priority. With this exception, there was no consistent correlation between ratings of knowledge and of research priority (see Table 11-3.4). The keywords which represent both motivation and cognition were given higher ratings of present knowledge than the keywords which represent only the motivational or cognitive aspect of the same type of behavior. This suggests that the more complex effects of alcohol are those which are judged to be better known, in addition to being given higher priorities for applied than basic research.

11.3.5 COMPARISON OF SPECIALISTS AND NON-SPECIALISTS

Some differences have also been found between the 11 specialists and 23 non-specialists for the Session. Basic research priority was consistently rated higher by the specialists than by the non-specialists (see Table 11-3.2). The same tendency was found for applied research priority, but three keywords were rated lower by specialists than by non-specialists: problem solving, long term memory, and verbal performance (see Table 11-3.3). These differences indicate that the specialists made greater differentiation between basic and applied research priorities. A greater range of average ratings among the nine keywords and lower standard deviations among raters of the same word were found for the applied research priorities rated by specialists, compared with the same measure rated by non-specialists and also with the basic research priorities rated by specialists . This difference indicates that the ratings were best differentiated and most consistent when made by specialists rather than by non-specialists, on applied rather than basic research priorities. Therefore, analysis of ratings by the subgroup of experts may be advantageous. Also, the measure of applied research priorities may be superior to the measure of basic research priorities.

In contrast to the higher ratings of research priority by specialists than by non-specialists, present knowledge was consistently rated lower by specialists than by non-specialists (see Table 11-3.1). A lack of consensus among specialists with respect to ratings of knowledge is indicated by higher standard deviations among specialists than non-specialists for all but one of the nine keywords. Comparisons among the keywords in average ratings of present knowledge show that emotion and mood was rated highest by the specialists and lowest by the non-specialists, whereas ratings of long term memory, learning, and verbal performance were substantially lower for the specialists than for the non-specialists. Therefore, the specialists differed substantially from the non-specialists in relative judgments of the nine keywords with respect to present knowledge. This is reflected by a rank-order correlation of only +.22 between specialists and non-specialists for the nine words (see Table 11-1.5). However, the specialists and non-specialists agreed closely in their relative judgments of basic and applied research priorities. This is reflected by rank-order correlations above +.90 for the nine words (see Table 11-1.5).

11.3.6 DISCUSSION

In general, the foregoing analyses and comparisons provide only partial information about the judgements of the participants concerning effects of alcohol on motivation and cognition. Each keyword is a label associated with a variety of other labels and more abstract concepts. The ratings provide information about the quantitative positions of this limited number of labels on a small number of the possible dimensions. However, any increase in our information is likely to be helpful. An understanding analysis of the data may contribute useful additions to our knowledge about how the participants perceived the relationships of these labels to each other and to more abstract concepts. We can thereby improve our understanding of present labels for alcohol effects and develop a superior set of labels for future use. The sophisticated quantitative comparisons of different rating measures and different subgroups of participants may greatly enhance the value of the information obtained.

TABLE 11-3.1

Present Knowledge Ratings of Keywords from Session 3: "Motivational and Cognitive Effects of Alcohol"

Keywords	Alcohol Professional (N=34)		Specialists (N=11)		Non-Specialists (N=23)	
	Mean	SD	Mean	SD	Mean	SD
Decision making	6.74	2.78	6.27	3.20	6.96	2.60
Emotion and mood	7.15	2.86	7.64	3.78	6.91	2.37
Learning (e.g., acquisition rate, state-dependency, etc.)	7.82	2.70	6.64	3.26	8.39	2.25
Memory, long-term	6.88	3.09	5.73	2.94	7.43	3.07
Memory, short-term	7.85	2.96	7.55	3.36	8.00	2.81
Motivation	6.88	2.97	6.45	4.06	7.09	2.37
Problem solving	6.94	2.85	6.55	3.27	7.13	2.69
Risk taking	7.32	3.15	6.73	3.88	7.61	2.79
Verbal performance	8.21	3.23	7.18	4.19	8.70	2.62

TABLE 11-3.2

Basic Research Priority Ratings of Keywords from Session 3: "Motivational and Cognitive Effects of Alcohol"

Keywords	Alcohol Professional (N=34)		Specialists (N=11)		Non-Specialists (N=23)	
	Mean	SD	Mean	SD	Mean	SD
Decision making	5.53	1.54	6.09	1.14	5.26	1.66
Emotion and mood	4.79	1.49	5.45	1.69	4.48	1.31
Learning (e.g., acquisition rate, state-dependency, etc.)	4.12	1.51	4.82	1.40	3.78	1.48
Memory, long-term	3.24	1.65	4.00	1.79	2.87	1.49
Memory, short-term	3.88	1.74	4.36	1.57	3.65	1.80
Motivation	4.97	1.60	5.36	1.80	4.78	1.51
Problem solving	4.41	1.67	4.64	1.50	4.30	1.77
Risk taking	5.85	1.26	6.36	.92	5.61	1.34
Verbal performance	2.26	1.38	2.45	1.51	2.17	1.34

TABLE 11-3.3

Applied Research Priority Ratings of Keywords from Session 3: "Motivational and Cognitive Effects of Alcohol"

Keywords	Alcohol Professional (N=34)		Specialists (N=11)		Non-Specialists (N=23)	
	Mean	SD	Mean	SD	Mean	SD
Decision making	5.68	1.20	5.91	.94	5.57	1.31
Emotion and mood	5.00	1.26	5.64	1.03	4.70	1.26
Learning (e.g., acquisition rate, state-dependency, etc.)	3.85	1.46	4.09	1.51	3.74	1.45
Memory, long-term	2.59	1.33	2.55	1.29	2.61	1.37
Memory, short-term	4.00	1.65	4.64	1.43	3.70	1.69
Motivation	4.88	1.30	5.36	1.21	4.65	1.30
Problem solving	3.74	1.42	3.64	1.50	3.78	1.41
Risk taking	6.06	1.18	6.27	.90	5.96	1.30
Verbal performance	1.97	1.03	1.91	.70	2.00	1.17

TABLE 11-3.4

Correlations between Specialists' Ratings of Each Keyword in Session 3 according to Status of Present Knowledge, Basic Research Priority, and Applied Research Priority (N=11)

Keywords	Spearman's Rho		
	PK-BR	PK-AR	BR-AR
Decision making	-.50	-.43	.68 *
Emotion and mood	.43	.32	.61 *
Learning (e.g., acquisition rate, state-dependency, etc.)	-.40	-.10	.51
Memory, long-term	-.29	.45	.28
Memory, short-term	-.01	-.33	.63 *
Motivation	.16	.55	.76 *
Problem solving	-.46	-.06	.29
Risk taking	.00	.15	.90 *
Verbal performance	.27	-.12	-.02

*($|\hat{\rho}| \geq .60 \rightarrow \rho \neq 0$; $p < .05$)

Key:

PK = present knowledge
BR = basic research
AR = applied research

TABLE 11-3.5

Session 3 Keywords Arranged According to Type of Behavior Expressed and Contributions of Motivation, Cognition, or Both

Type of Behavior	Motivation	Motivation and Cognition	Cognition
Bold or cautious	Decision making (2)	Risk taking (1)	
Aroused or sedated	Motivation (3)	Emotion and mood (4)	
Intelligent or stupid		Learning (6)	Problem solving (5)
Remembering or forgetting		Memory, short term (7)	Memory, long term (8)
Language use or misuse		Verbal performance (9)	

Note: The number in parentheses under each keyword shows the rank-order rating of basic research priority, averaged for the 34 alcohol professionals.

11.4 KEYWORD RATINGS IN SESSION 4: ALCOHOL INFLUENCES UPON CLOSED-COURSE DRIVING PERFORMANCE

M. Stephen Huntley, Jr.

In Session 4, the 22 keyword research areas were rated by alcohol specialists and non-specialists with regard to "extent of present knowledge", "basic research priorities", and "applied research priorities". The means and standard deviations of these ratings are shown in Tables 11-4.1, 11-4.2, and 11-4.3, respectively However, prior to attending to these tables, several features that the ratings have in common across the three tables should be examined. This will aid in the interpretation of the rating data and in the assessment of the relative importance of the differences in the means of the ratings illustrated.

Table 11-4.5 shows the range of the rating scales employed, the percent of the scale represented by this range, and means and mean standard deviations of the ratings assigned to the keyword areas by each of the three rating combinations. Note that the three rating combinations are not independent, as the Alcohol Professionals are comprised of the 26 non-specialists and the 8 specialists.

It can be seen that the raters employed a relatively narrow band of scale values in their ratings on each of the three rating tasks. The location on the scale of the values employed is a classical example of the central tendency effect found in most judgmental data and is not surprising. The narrowness of the bands (considerably less than 50% of the scale in all three cases), however, was unexpected and may be interpreted in several ways. It may indicate: (a) an unwillingness to differentiate between the keywords, (b) an inability to make the instructed discriminations, (c) the similarity of the areas in terms of the properties evaluated, and/or (d) widely disparate within-group responses. The magnitude of the means of the rating standard deviations certainly lends some support to the last notion.

Since the raters agreed to the rating task in the first place, it is not likely that they were unwilling to differentiate between the keywords. More probably, the strong central tendency effect was due to a combination of (b) and (c) and certainly to some extent (d), since standard deviations approaching 50% of the scale ranges that were actually employed certainly indicates considerable disagreement among the professions regarding the relative status of the keywords. Therefore, the meaning of the positions of the keywords when ranked according to the mean ratings shown in Tables 11-4.1, 11-4.2, and 11-4.3 must be determined with a great deal of care.

It can be seen from these first three tables that the ratings of the specialists and the non-specialists are not in perfect agreement. However, as summarized in Table 11-4.5, some concordance is present, as rather high coefficients of correlation having been obtained between the two groups of raters on each of the three tasks. However, the fact that differences exist indicates that the two groups may have different opinions regarding the most appropriate rankings. The question then becomes, which set of ranking is potentially the most useful. Since it is reasonable that the specialists would be most knowledgeable in the field, it would be logical to attend mostly their rankings.

However, two things argue against this approach. First, as indicated by the means of the standard deviations of the ratings, consensus among the members of the groups appears worse for the specialists. This means that if there is some basic "best" set of rankings, the specialists appear no better equipped to see it than the non-specialists.

Secondly, there is a relatively small number of raters in the specialists group, a condition which reduces the potential representativeness of their decisions. A second option would be to use the rankings of the non-specialists as representing the best, i.e. the most useful, sets of rankings; and the third option would be to use the ratings resulting from the combined efforts of these two groups of professionals. Since the results of each of the two groups provide no reason for assuming that either had provided ratings with greater utility, and the rankings of the two groups were significantly correlated, it was decided to utilize the ratings of the composite group for purposes of the following discussion. This approach takes advantage of the potentially higher representativeness of the results of 34 vs. 26 or 8 raters. Accordingly, the remaining discussion will be based upon the rankings provided by the combined ratings of the specialist and non-specialist groups, i.e. the ratings of all of the Alcohol Professionals (N = 34).

The usefulness of the ratings in the three tables of ratings would be increased if commonalities among items sharing similar ratings could be identified and, as a result, some generalities made concerning themes employed by the raters when assigning values to the keyword areas. Unfortunately, no such themes are apparent in the tables. Rather, it appears that each area was evaluated on its own merit without consideration of it as a member of a larger area of research such as vision, psychomotor performance, or cognition.

Nevertheless, some weak tendencies toward clustering do appear. Thus, in Table 11-4.1 there is some tendency for keywords representing more complex and driving related items to be rated below the mean rating of 6.75. In addition, there is also a tendency for those items rated high in Table 11-4.1 to be rated lower in Tables 11-4.2 and 11-4.3. Spearman rho's calculated between Tables 11-4.1 and 11-4.2 and between Tables 11-4.1 and 11-4.3 revealed significant ($p < .05$), but small (-.47 and -.40 respectively) inverse correlations in both cases, indicating a real tendency for items rated low in present knowledge to be ranked high in research priorities.

However, despite these correlations, the items which seemed to cluster low in the present knowledge ratings did not move up as a group in the applied priority ratings. For example, driving related items which are rated low in terms of present knowledge are also rated low regarding research priorities. On the other hand, keywords representing non-driving-identified complex phenomena (i.e., complex in terms of multi-dimensionality or involving cognition) which were rated low on present knowledge received high basic and applied research priority ratings. For example, "decision making", "individual differences", "effect of alcohol in combination with other stressors", and "risk-taking" were all rated below the mean in Table 11-4.1 and above the mean in Tables 11-4.2 and 11-4.3. In fact, "effects of alcohol in combination with other stressors" and "risk-taking" received first and second rankings respectively in both basic and applied research priorities. Furthermore, the rankings of these two areas had lower standard deviations than any of the remaining twenty areas, indicating not only that on the average, raters felt that knowledge in these areas was potentially useful in reducing alcohol associated crashes, but also that the consensus among the raters regarding these priorities was relatively high.

Conversely, it was felt that control response time, visual field, and control response accuracy were areas about which present knowledge was above the mean rank, and apparently were therefore rated as relatively low regarding basic and applied research priorities. In contrast, visual search, which was ranked high in terms of present knowledge, was also rated high in terms of both research priorities. Apparently, it was felt that although much was known about visual search, the potential payoff of knowledge in this particular area was sufficient to warrant further work. The opposite was the case with the study of patterns of automobile control use. Apparently, it was felt that although little was known in this area, it was not important enough to justify a high research priority.

A Spearman rank-correlation coefficient calculated between the basic and applied research priority ratings of the Alcohol Professionals produced a rho of .97, indicating that the two sets of ratings are almost identical. This high correlation was unexpected, since the goals of applied and basic research are quite different. However, perhaps it should not be too surprising inasmuch as basic research in an applied area, such as automobile driving, probably may not be too dissimilar from applied research in the same area.

Because of the lack of overall rating themes, it is difficult to qualitatively summarize the group ratings. However, some rather general conclusions can be drawn. First, the statistically significant agreement between the two specialist groups comprising the Alcohol Professionals regarding the rankings of the research areas in the three rated tasks indicates that both specialists and non-specialists are in agreement with respect to the present knowledge and relative importance of the keyword areas (see Table 11-1.5).

Second, there was a significant tendency for the areas being indicated as relatively low in terms of present knowledge to be ranked higher in terms of basic and applied research priorities and vice versa. In the absence of any other obvious trends, this may indicate that with some exceptions, lack of knowledge in an area is reason enough for a relatively high research priority. Conversely, the assignment of areas ranked high in present knowledge to low research priority rankings may indicate that what was known in these areas was of little potential use in reducing driving fatalities and, therefore, information about phenomena that we know little about is most needed. Consistent with this explanation, basic and applied research ratings were very highly correlated.

Third, regarding specific keyword areas, for the most part, the wide variations in ratings among the individual professionals, and the lack of large differences in the resultant mean ratings preclude a definitive ranking of the 22 areas with respect to priorities.

However, because of the relatively small standard deviations of ratings for "effects of alcohol in combination with other stressors" and "risk-taking" and the assignment of the highest priority ratings to these two keywords, it is clear that they are preferred as representing areas that should receive additional research.

In contrast, with the exception of "control-use in emergency situation," the strong tendency for keywords directly related to automobile manipulation to receive low research priority ratings indicates the low regard in which an understanding of the psychomotor aspects of driving is held concerning its potential for reducing alcohol associated highway fatalities.

TABLE 11-4.1

Present Knowledge Ratings of Keywords from Session 4: "Alcohol Influences Upon Closed-Course Driving Performance"

Keywords	Alcohol Professional (N=34)		Specialists (N=8)		Non-Specialists (N=26)	
	Mean	SD	Mean	SD	Mean	SD
Control-response accuracy (precision of single control movements)	7.50	2.72	6.25	3.15	7.88	2.52
Control-response time (choice reaction time)	8.47	2.42	8.38	2.00	8.50	2.57
Control-use coordination	6.50	3.22	5.13	3.23	6.92	3.16
Control-use in emergency situations	4.94	2.44	4.12	2.10	5.19	2.51
Control-use patterns (as reflected by control-posit. spectral dens. functions)	5.41	2.87	3.88	2.42	5.88	2.88
Decision making	5.97	2.79	4.50	2.98	6.42	2.63
Depth perception	6.82	3.32	4.25	2.66	7.62	3.13
Driving-task analysis	5.53	2.65	4.62	2.88	5.81	2.58
Effects of alcohol in combination with other stressors (e.g., fatigue)	5.18	2.59	4.25	2.43	5.46	2.61
Individual differences	6.00	2.91	4.62	2.20	6.42	3.01
Lateral tracking accuracy	7.62	2.76	6.25	1.67	8.04	2.92
Risk-taking	6.50	2.95	6.25	3.33	6.58	2.89
Speed adaptation	7.03	2.79	6.12	2.95	7.31	2.74
Time-sharing (divided attention)	6.79	2.63	7.50	2.98	6.58	2.53
Track configuration	6.00	2.88	4.87	3.04	6.35	2.80
Velocity estimation	6.97	2.89	6.25	3.88	7.19	2.56
Vigilance	6.65	2.71	6.12	2.64	6.81	2.76
Visual acuity, dynamic	7.68	3.31	7.13	3.94	7.85	3.16
Visual field	8.09	2.53	7.50	2.73	8.27	2.49
Visual recognition and discrimination	7.38	2.26	6.88	2.59	7.54	2.18
Visual search	7.65	2.86	7.25	2.49	7.77	3.00
Visual signal detection	7.85	2.55	6.75	2.71	8.19	2.45

TABLE 11-4.2

Basic Research Priority Ratings of Keywords from Session 4: "Alcohol Influences Upon Closed-Course Driving Performance"

Keywords	Alcohol Professional (N=34)		Specialists (N=8)		Non-Specialists (N=26)	
	Mean	SD	Mean	SD	Mean	SD
Control-response accuracy (precision of single control movements)	3.32	1.43	3.75	1.67	3.19	1.36
Control-response time (choice reaction time)	3.53	1.54	3.50	1.41	3.54	1.61
Control-use coordination	2.85	1.33	2.63	1.60	2.92	1.26
Control-use in emergency situations	5.06	1.39	5.25	1.16	5.00	1.47
Control-use patterns (as reflected by control-posit. spectral dens. functions)	3.79	1.84	4.62	1.85	3.54	1.79
Decision making	5.24	1.78	4.38	1.77	5.50	1.73
Depth perception	2.59	1.48	2.63	1.30	2.58	1.55
Driving-task analysis	5.06	1.70	5.13	1.73	5.04	1.73
Effects of alcohol in combination with other stressors (e.g., fatigue)	5.94	1.07	5.88	1.13	5.96	1.08
Individual differences	5.00	1.83	4.87	1.55	5.04	1.93
Lateral tracking accuracy	3.79	1.43	4.38	.92	3.62	1.53
Risk-taking	5.88	.91	5.63	.92	5.96	.92
Speed adaptation	3.91	1.58	4.38	1.19	3.77	1.68
Time-sharing (divided attention)	4.88	1.63	5.13	1.46	4.81	1.70
Track configuration	2.94	1.50	3.00	2.00	2.92	1.35
Velocity estimation	3.47	1.48	3.50	1.20	3.46	1.58
Vigilance	4.41	1.64	4.38	1.60	4.42	1.68
Visual acuity, dynamic	3.56	1.65	3.13	2.10	3.69	1.52
Visual field	3.68	1.41	3.62	1.77	3.69	1.32
Visual recognition and discrimination	4.18	1.47	4.50	1.77	4.08	1.38
Visual search	4.76	1.48	5.50	1.60	4.54	1.39
Visual signal detection	4.12	1.61	4.25	1.83	4.08	1.57

TABLE 11-4.3

Applied Research Priority Ratings of Keywords from Session 4: "Alcohol Influences Upon Closed-Course Driving Performance"

Keywords	Alcohol Professional (N=34)		Specialists (N=8)		Non-Specialists (N=26)	
	Mean	SD	Mean	SD	Mean	SD
Control-response accuracy (precision of single control movements)	3.35	1.45	3.50	1.60	3.31	1.44
Control-response time (choice reaction time)	3.71	1.71	4.12	1.81	3.58	1.70
Control-use coordination	2.88	1.37	3.00	1.77	2.85	1.26
Control-use in emergency situations	5.41	1.37	5.37	1.51	5.42	1.36
Control-use patterns (as reflected by control-posit. spectral dens. functions)	3.85	1.64	4.38	1.77	3.69	1.59
Decision making	5.24	1.46	5.13	1.55	5.27	1.46
Depth perception	3.03	1.49	2.87	1.81	3.08	1.41
Driving-task analysis	4.94	1.58	5.50	1.60	4.77	1.56
Effects of alcohol in combination with other stressors (e.g., fatigue)	6.03	1.17	5.88	1.13	6.08	1.20
Individual differences	5.15	1.42	5.25	1.28	5.12	1.48
Lateral tracking accuracy	4.12	1.55	4.87	1.36	3.88	1.56
Risk-taking	6.03	1.00	6.00	.53	6.04	1.11
Speed adaptation	4.00	1.26	4.00	1.31	4.00	1.26
Time-sharing (divided attention)	5.32	1.25	5.63	1.30	5.23	1.24
Track configuration	3.50	1.58	3.75	1.39	3.42	1.65
Velocity estimation	3.82	1.27	3.37	1.30	3.96	1.25
Vigilance	4.38	1.61	4.25	1.28	4.42	1.72
Visual acuity, dynamic	3.62	1.69	3.25	2.25	3.73	1.51
Visual field	3.85	1.28	4.12	1.55	3.77	1.21
Visual recognition and discrimination	4.09	1.50	4.50	1.93	3.96	1.37
Visual search	5.15	1.37	5.50	1.85	5.04	1.22
Visual signal detection	4.50	1.52	4.38	1.85	4.54	1.45

TABLE 11-4.4

Correlations between Specialists' Ratings of Each Keyword in Session 4 according to Status of Present Knowledge, Basic Research Priority, and Applied Research Priority (N=8)

Keywords	Spearman's Rho		
	PK-BR	PK-AR	BR-AR
Control-response accuracy (precision of single control movements)	.12	.17	.96 *
Control-response time (choice reaction time)	-.20	-.07	.94 *
Control-use coordination	.64	.42	.82 *
Control-use in emergency situations	.27	-.03	.65
Control-use patterns (as reflected by control-posit. spectral dens. functions)	.29	.22	.76 *
Decision making	.02	-.39	.75 *
Depth perception	.37	.55	.77 *
Driving-task analysis	-.37	-.14	.80 *
Effects of alcohol in combination with other stressors (e.g., fatigue)	-.38	-.33	.90 *
Individual differences	-.12	.06	.94 *
Lateral tracking accuracy	.32	.52	.73 *
Risk-taking	.01	.07	.86 *
Speed adaptation	-.02	.15	.71 *
Time-sharing (divided attention)	.06	.11	.70
Track configuration	.46	.15	.80 *
Velocity estimation	-.20	.15	.89 *
Vigilance	.37	.70	.84 *
Visual acuity, dynamic	-.18	-.24	.89 *
Visual field	.13	.32	.85 *
Visual recognition and discrimination	-.10	-.06	.80 *
Visual search	.43	.51	.79 *
Visual signal detection	-.10	.01	.79 *

*($|\hat{\rho}| \geq .71 \rightarrow \rho \neq 0;\ p < .05$)

Key:

PK = present knowledge
BR = basic research
AR = applied research

TABLE 11-4.5

Summary and Comparison Statistics of Ratings by the Three Combinations of Raters on Each of the Three Rating Tasks

Statistic	Present Knowledge			Basic Research			Applied Research		
	Spec.	Non-Spec.	Alc.Prof.	Spec.	Non-Spec.	Alc.Prof.	Spec.	Non-Spec.	Alc.Prof.
Number of raters	8	26	34	8	26	34	8	26	34
Range of ratings employed	4.50	3.31	3.52	3.25	3.38	3.35	3.13	3.23	3.12
Percent of rating scale employed	30	22	24	46	48	48	45	46	45
Mean SD of ratings	2.77	2.73	2.78	1.52	1.51	1.51	1.53	1.41	1.43
Mean rating	5.86	7.03	6.75	4.27	4.15	4.18	4.48	4.34	4.36
rs between specialist and non-specialist ratings	.75			.84			.86		

11.5 KEYWORD RATINGS IN SESSION 5: EPIDEMIOLOGICAL ASPECTS OF ALCOHOL IN DRIVER CRASHES AND CITATIONS

Paul M. Hurst

In Session 5, means and standard deviations were obtained on each of 16 keyword topics for the entire group of 34 alcohol researchers/administrators, and then separately for the 17 "specialists" and the 17 "non-specialists".

With respect to extent of present knowledge, as shown in Table 11-5.1, the keyword means showed a range of about 4 to 12 regardless of whether specialists, non-specialists, or the composite group was tabulated. Spearman's rho between specialists and non-specialists was 0.84. With 17 in each group, the 95% confidence limits are 0.55 - 0.93 (see Table 11-1.5).

Since no external criterion is available to answer the question of whether the specialists' ratings should be given greater credence than those of the non-specialists, one must try to find guide lines from tests of internal consistency. If the specialists were found to agree more closely with each other than the non-specialists agreed with each other, then one might infer that there was a higher signal-to-noise ratio in their results. One may test this by comparing the averages (RMS) of the standard deviations of keywords within groups. The results were:

Group	Average S.D.
Specialists	2.84
Non-specialists	2.62
Alcohol Professionals	2.75

With respect to applied research priority, the means of the composite group (Alcohol Professionals) had a total range of 2.06, or only about 1/3 of the total 7-point (6 interval) scale (see Table 11-5.3). The specialists had a still shorter range of means, and the non-specialists a longer one, being slightly over half of the scale range. Spearman's rho between specialists and non-specialists on mean priorities assigned to research topics was 0.60, the 95% confidence interval being 0.13 - 0.84 (see Table 11-1.5). The averages (RMS) of the standard deviations of keyword research topics within groups were:

Group	Average S.D.
Specialists	1.37
Non-specialists	1.38
Alcohol Professionals	1.40

Once again, there was little support on grounds of internal consistency to assume that the specialists should be given greater credence than the non-specialists. This result, together with the foregoing result on present knowledge, could mean that specialists agree on the truth to the same extent that non-specialists share the same fallacies. However, it could also mean that semi-objective indices used by the chairmen for assignment of specialist status (publications in the relevant area, etc.) are not sufficiently relevant to the present purpose. We shall consider the composite groups' (Alcohol Professionals) ratings, which can be summarized fairly briefly:

1. Tolerance to combinations of alcohol and (other) drugs is something that we know very little about, and about which it would be most useful to know more. The results don't tell us how we would apply this new knowledge, beyond educational efforts aimed at drivers and the medical profession. It would seem difficult to devise statutory rules in terms of blood concentrations. Perhaps, if legal and/or illegal drug use continues to increase, we must fall back on direct measures of behavioral impairment.

2. There are several topics (alcohol consumption time, pattern, and site; purchase site; and drinking antecedents) that one may choose to subsume under the heading of "drinking-driving logistics." Present knowledge mean ratings ranged from about 7 to 10, and so, as a group, could be considered "medium-high." As to research priority, the members of this group ranged in importance from second to sixteenth. However, with the exclusion of "purchase site," the range of mean ratings was 4.06 to 5.15. Thus, although the topic was perceived as having been fairly well researched, it was judged sufficiently important to be given a medium priority for filling such gaps as still exist.

3. Other keyword topics varied considerably in present knowledge ratings, viz., motives in alcohol fatal crashes = 5.47, biographical variables = 8.09. There was somewhat less differentiation in the applied research priority ratings given them; even allowing for scale differences, they essentially fell between 4 and 5. A difference between any two means of 0.7 would be significant at the 0.05 level if prior hypotheses were involved. If the reader had any such hypotheses, he may therefore be guided accordingly.

One qualitative inference is possible, and that is that the participants were indeed responding to research priorities rather than topic importances. Note, for example, the relatively low rankings on research priority for seat belt availability and usage as a function of BAC, and for post-crash medical treatment. Most participants would probably have agreed that these are important sources of variance in crash morbidity/mortality. Nevertheless, they do not believe there is as great payoff in further researching them, compared to some pre-crash factors. Perhaps this is because "present knowledge" is rated fairly high, in the case of medical treatment. The role of seat belts, however, is ranked 14th in present knowledge. Why, then, is it not more urgent to know more about this factor? Is it because we feel that whatever more is found out, it won't help in getting drinking drivers and passengers to wear their seat belts, since we can't seem to increase their usage even when people are sober?

In conclusion, it would appear that the consensus of participants achieved some modest differentiation of research topics on the extent of present knowledge, but perhaps a less-than-modest differentiation on applied research priorities. It might be possible to build on these results in a follow-up study in which new ratings were taken after discussion sessions aimed at pinpointing the sources of disagreement (as, those topics with highest standard deviations). Nevertheless, we must also face the possibility that no strong differentiation of research priorities is to be effected in the immediate future; that research efforts will have to continue to emulate the shotgun rather than the rifle. Concerning epidemiology of alcohol and drugs in highway crashes, it is obvious that we don't know very many of the "answers." There appears reason to believe that we also don't know what questions most need to be asked.

TABLE 11-5.1

Present Knowledge Ratings of Keywords from Session 5:
"Epidemiological Aspects of Alcohol in Driver Crashes and Citations"

Keywords	Alcohol Professional (N=34)		Specialists (N=17)		Non-Specialists (N=17)	
	Mean	SD	Mean	SD	Mean	SD
Alcohol consumption pattern	8.18	2.50	7.94	2.84	8.41	2.18
Alcohol consumption site	8.15	2.81	7.76	3.29	8.53	2.27
Alcohol consumption time	9.85	2.81	9.24	2.95	10.47	2.60
Alcohol purchase site	7.56	3.03	7.06	3.45	8.06	2.54
Biographical Variables	8.09	3.08	8.24	2.97	7.94	3.27
Cause of crash as a function of severity	7.06	2.76	7.29	2.73	6.82	2.86
Characteristics of passengers	5.79	2.60	5.24	2.02	6.35	3.04
Drinking antecedents	6.85	2.71	6.24	2.75	7.47	2.60
Driving history	7.76	3.21	7.29	3.29	8.24	3.15
Motives in alcohol involved fatal crashes	5.47	2.89	5.24	3.17	5.71	2.66
Post crash medical treatment	7.91	2.98	7.82	3.41	8.00	2.57
Seat belt availability and use as a function of BAC	5.50	2.83	5.06	2.59	5.94	3.07
Time of crash	12.12	2.10	12.29	1.76	11.94	2.44
Tolerance to alcohol, long term	7.24	2.64	7.71	2.82	6.76	2.44
Tolerance to alcohol, short term	7.06	2.91	7.00	2.85	7.12	3.06
Tolerance to combination of alcohol and drugs	3.91	1.85	3.88	1.76	3.94	1.98

TABLE 11-5.3

Applied Research Priority Ratings of Keywords from Session 5:
"Epidemiological Aspects of Alcohol in Driver Crashes and Citations"

Keywords	Alcohol Professional (N=34)		Specialists (N=17)		Non-Specialists (N=17)	
	Mean	SD	Mean	SD	Mean	SD
Alcohol consumption pattern	5.06	1.15	5.35	1.27	4.76	.97
Alcohol consumption site	4.06	1.30	4.47	1.23	3.65	1.27
Alcohol consumption time	4.74	1.46	4.76	1.35	4.71	1.61
Alcohol purchase site	3.62	1.65	4.65	1.37	2.59	1.23
Biographical Variables	4.76	1.42	4.94	1.60	4.59	1.23
Cause of crash as a function of severity	5.03	1.49	5.24	1.30	4.82	1.67
Characteristics of passengers	3.97	1.57	4.35	1.66	3.59	1.42
Drinking antecedents	5.15	1.52	4.82	1.67	5.47	1.33
Driving history	5.00	1.23	5.35	1.22	4.65	1.17
Motives in alcohol involved fatal crashes	4.82	1.68	4.65	1.66	5.00	1.73
Post crash medical treatment	4.41	1.67	4.29	1.65	4.53	1.74
Seat belt availability and use as a function of BAC	4.15	1.23	4.06	1.20	4.24	1.30
Time of crash	4.06	1.46	3.88	1.11	4.24	1.75
Tolerance to alcohol, long term	4.88	1.17	4.59	1.28	5.18	1.01
Tolerance to alcohol, short term	4.65	1.25	4.59	1.18	4.71	1.36
Tolerance to combination of alcohol and drugs	5.68	.91	5.59	.94	5.76	.90

TABLE 11-5.4

Correlations between Specialists' Ratings of Each Keyword in
Session 5 according to Status of Present Knowledge, Basic
Research Priority, and Applied Research Priority
(N=17)

Keywords	Spearman's Rho		
	PK-AR	PK-SR	AR-SR
Alcohol consumption pattern	-.36	.18	.28
Alcohol consumption site	-.20	-.16	-.14
Alcohol consumption time	-.28	.35	-.22
Alcohol purchase site	-.11	.28	.19
Biographical variables	.27	.50 *	.52 *
Cause of crash as a function of severity	-.56 *	.49 *	-.17
Characteristics of passengers	-.25	.18	-.15
Drinking antecedents	-.15	.23	.57 *
Driving history	-.04	.47	.42
Motives in alcohol involved fatal crashes	-.08	-.06	.37
Post crash medical treatment	-.09	.17	.42
Seat belt availability and use as a function of BAC	-.37	-.41	-.09
Time of crash	-.14	.49 *	.06
Tolerance to alcohol, long term	-.34	.45	-.34
Tolerance to alcohol, short term	-.51 *	.57 *	.09
Tolerance to combination of alcohol and drugs	.54 *	.23	.30

*($|\hat{\rho}| \geq .48 \rightarrow \rho \neq 0$; $p < .05$)

Key:

PK = present knowledge
BR = basic research
AR = applied research

11.6 KEYWORD RATINGS IN SESSION 6: USE OF PHYCHOACTIVE AND HALLUCINOGENIC DRUGS IN RELATION TO DRIVING RISK

Reginald G. Smart

Keyword ratings for Session 6 are shown in Table 11-6.1 for 19 phrases covering the areas of countermeasures, accident histories, extent of use studies, and accident-risk contribution studies. In general, ratings of present knowledge for these keywords were rather low. The highest is only 5.69, and they range down to 3.71. The average present knowledge ratings are considerably lower than for areas involving alcohol and laboratory studies of drugs (i.e., Sessions 1, 2, 3, and 7). However, they are similar to those for Session 4 (Alcohol Influences upon Closed-Course Driving Performance). It would seem that the area covered by Session 6 was rated as one of the lowest in terms of present knowledge.

When ratings of the entire group are considered, present knowledge is rated highest for certain countermeasures areas, e.g., licence suspensions, imprisonment, presentence investigations, etc. Present knowledge is deemed least adequate in the areas of: (1) risk contribution to accidents for opiates, hallucinogens, and psychoactives; (2) extent of use of hallucinogens among drivers; and (3) legal actions: forced labour. Rather similar sets of ratings were given by self-defined drug researchers and administrators. "Chairman-rated" specialists ranked present knowledge as highest for the same countermeasures areas as the entire group, but also highly rated were "opiate drugs: accident histories and extent of use." However, their ratings for areas of least adequate knowledge are nearly identical to those of the entire group.

The problem of research priorities for Session 6 was attacked somewhat differently than for the other sessions. Basic research priority ratings were not assigned, only applied research priority ratings. The highest research priorities were given by the entire group to studies of: (1) risk contribution; (2) extent of use of hallucinogenic drugs among drivers and pedestrians; and (3) accident histories of drug heavy users. Lowest ratings were given to countermeasures areas such as forced treatment, public education, mandatory chemical tests, etc. However, the differences between the lowest and highest ratings are small ($\bar{x}$ = 4.14 and 5.49). Very similar ratings to these were also given by session specialists and by chairman-selected specialists. The actual ordering of the keywords varies slightly from group to group, but the cluster of most highly rated and least highly rated items is very similar. In general, those areas given highest priority are the areas seen as most deficient in terms of present knowledge. This would be roughly true of all groups.

In summary, several tentative conclusions are possible:

1. Knowledge levels in the area of drug use in relation to driving risk are lower than for almost all areas involving alcohol and driving.

2. Knowledge levels are seen as highest for countermeasures and lowest for risk contribution to accidents and accident histories of users.

3. Applied research priorities are rated highest for those areas where knowledge is low, i.e., the contribution of drug use to accident risk, extent of use of drugs by drivers, and accident histories of users.

TABLE 11-6.1

Present Knowledge Ratings of Keywords from Session 6: "Use of Psychoactive and Hallucinogenic Drugs in Relation to Driving Risk"

Keywords	Drug Professional (N=14)		Specialists (N=8)		Non-Specialists (N=8)	
	Mean	SD	Mean	SD	Mean	SD
Countermeasures-legal actions: fines (varying amounts)	5.86	4.11	6.88	5.30	5.00	2.67
Countermeasures-legal actions: forced labor	4.57	2.56	3.88	2.75	4.75	2.31
Countermeasures-legal actions: forced treatment	6.00	3.09	4.75	2.60	6.50	3.38
Countermeasures-legal actions: imprisonment (varying periods)	5.93	3.79	6.25	5.31	5.75	2.05
Countermeasures-legal actions: license suspensions & revocations	6.86	4.11	6.38	4.63	6.75	3.45
Countermeasures-legal actions: mandatory chemical tests	5.57	2.65	4.25	2.71	6.25	2.25
Countermeasures-legal actions: presentence investigation	6.64	3.54	6.12	4.02	6.50	3.16
Countermeasures-legal actions: vehicle impoundment	5.57	3.92	5.37	4.78	5.13	2.75
Countermeasures-public education: drug effects on the individual	5.93	3.27	5.75	3.58	5.75	3.06
Countermeasures-public education: drug problems on the highway	5.36	3.13	4.75	3.11	5.37	3.16
Hallucinogenic drugs: accident hist. of heavy users and dependent users	5.21	3.02	5.25	3.15	4.38	3.02
Hallucinogenic drugs: extent of use among drivers and pedestrians	3.93	1.94	3.62	2.39	3.75	1.49
Hallucinogenic drugs: risk contribution to accidents	3.29	2.30	3.75	2.82	2.87	1.46
Opiate drugs: accident histories of heavy users and dependent users	5.29	3.10	6.75	3.33	3.75	2.05
Opiate drugs: extent of use among drivers and pedestrians	5.79	3.64	6.62	4.10	5.13	3.52
Opiate drugs: risk contribution to accidents	4.86	2.63	5.88	2.70	4.00	2.67
Psychoative drugs: accident hist. of heavy users and dependent users	5.79	2.86	6.12	3.00	5.00	2.73
Psychoactive drugs: extent of use among drivers and pedestrians	5.36	2.62	5.63	2.92	4.75	2.12
Psychoactive drugs: risk contribution to accidents	3.57	1.74	3.50	2.07	3.25	1.39

TABLE 11-6.3

Applied Research Priority Ratings of Keywords from Session 6: "Use of Psychoactive and Hallucinogenic Drugs in Relation to Driving Risk"

Keywords	Drug Professional (N=14)		Specialists (N=8)		Non-Specialists (N=8)	
	Mean	SD	Mean	SD	Mean	SD
Countermeasures-legal actions: fines (varying amounts)	3.50	1.61	4.12	1.89	3.13	.99
Countermeasures-legal actions: forced labor	3.21	1.93	3.37	2.26	2.75	1.39
Countermeasures-legal actions: forced treatment	4.93	1.21	5.25	.89	4.62	1.41
Countermeasures-legal actions: imprisonment (varying periods)	3.29	1.77	2.87	2.17	3.62	.92
Countermeasures-legal actions: license suspensions & revocations	4.21	1.42	4.62	1.51	3.75	1.04
Countermeasures-legal actions: mandatory chemical tests	4.50	1.22	4.50	1.20	4.62	1.30
Countermeasures-legal actions: presentence investigation	4.14	1.51	4.38	1.77	3.88	1.13
Countermeasures-legal actions: vehicle impoundment	3.00	1.57	3.37	1.69	2.75	1.28
Countermeasures-public education: drug effects on the individual	4.79	1.12	4.87	.64	4.62	1.41
Countermeasures-public education: drug problems on the highway	4.71	1.27	5.37	.92	4.00	1.07
Hallucinogenic drugs: accident hist. of heavy users and dependent users	5.29	1.27	5.88	1.13	4.75	1.28
Hallucinogenic drugs: extent of use among drivers and pedestrians	5.57	.85	6.00	1.07	5.13	.64
Hallucinogenic drugs: risk contribution to accidents	5.21	1.58	6.12	.83	4.50	1.69
Opiate drugs: accident histories of heavy users and dependent users	5.43	1.09	5.25	1.49	5.13	.99
Opiate drugs: extent of use among drivers and pedestrians	5.21	1.37	5.37	1.06	4.75	1.58
Opiate drugs: risk contribution to accidents	5.36	1.08	5.37	1.41	4.87	.99
Psychoative drugs: accident hist. of heavy users and dependent users	4.79	1.67	5.13	1.55	4.50	1.69
Psychoactive drugs: extent of use among drivers and pedestrians	5.36	1.15	5.88	.64	4.87	1.25
Psychoactive drugs: risk contribution to accidents	5.43	1.28	6.00	.76	4.87	1.36

TABLE 11-6.4

Correlations between Specialists' Ratings of Each Keyword in Session 6 according to Status of Present Knowledge, Basic Research Priority, and Applied Research Priority (N=8)

Keywords	Spearman's Rho PK-AR
Countermeasures-legal actions: fines (varying amounts)	-.51
Countermeasures-legal actions: forced labor	.16
Countermeasures-legal actions: forced treatment	.33
Countermeasures-legal actions: imprisonment (varying periods)	-.43
Countermeasures-legal actions: license suspensions & revocations	-.71 *
Countermeasures-legal actions: mandatory chemical tests	-.24
Countermeasures-legal actions: presentence investigation	-.37
Countermeasures-legal actions: vehicle impoundment	-.17
Countermeasures-public education: drug effects on the individual	.65
Countermeasures-public education: drug problems on the highway	-.11
Hallucinogenic drugs: accident hist. of heavy users and dependent users	.11
Hallucinogenic drugs: extent of use among drivers and pedestrians	.15
Hallucinogenic drugs: risk contribution to accidents	.11
Opiate drugs: accident histories of heavy users and dependent users	.14
Opiate drugs: extent of use among drivers and pedestrians	-.33
Opiate drugs: risk contribution to accidents	-.26
Psychoactive drugs: accident hist. of heavy users and dependent users	-.37
Psychoactive drugs: extent of use among drivers and pedestrians	.15
Psychoactive drugs: risk contribution to accidents	-.02

*($|\hat{\rho}| \geqq .71 \rightarrow \rho \neq 0; p < .05$)

PK = present knowledge
AR = applied research

11.7 KEYWORD RATINGS IN SESSION 7: DRUG INFLUENCES UPON DRIVING-RELATED BEHAVIOR

Robert A. Lubin

A series of 39 keywords, representing a wide range of research areas and research interests of drug influences upon driving-related behaviors, was rated with regard to: (1) the extent of present knowledge, (2) the priority for basic research, and (3) the priority for applied research.

A post hoc division of the participants' responses was performed on the assumption that the validity of the evaluations would be directly associated with individual participant's session-specific expertise. Specifically, those 14 participants who were self-classified as drug researchers and/or administrators were dichotomized into "specialist" (N = 9) or "non-specialist" (N = 5) groups, according to the ratings of all session chairmen. However, the effectiveness, necessity, and/or legitimacy of this procedure was found to be mute given significantly high correlations obtained in a between-group comparison of keyword evaluations (see Table 11-1.5). Therefore, the following discussion of the data is based on the entire population of the self-designated drug researchers and/or administrators (N = 14).

11.7.1 EXTENT OF PRESENT KNOWLEDGE

An examination of the present-knowledge ratings (Table 11-7.1) reveals that the mean keyword evaluations only range from a high of 8.07 (simple reaction time) to a low of 4.21 (visual search) on the 15-point scale. Furthermore, if one attends to the second highest evaluation (visual field), the range reduces to 2.86 units, a relatively small amount given the number of keywords (N = 39) and the available scale range. Two general conclusions may be drawn, given the extent of usage of the judgmental range, the relatively large standard deviations of the ratings, and the observation that "simple reaction time" was the only keyword rated above the scale midpoint. Firstly, the participants are implicitly in consensus that any prior research has not been markedly productive in obtaining information in these disparate areas. Secondly, in a related conclusion, the participants are presently unable to discriminate differences reliably among these research areas, with regard to the extent of "present knowledge" of drug influences on driving-related behaviors.

It is difficult (if not statistically invalid) to discern "clusters" of research topics which may have been differentially evaluated. Even if such post hoc groupings were established, the large variation in the judgments and the small scale range would probably prevent obtaining statistically significant differences.

11.7.2 RESEARCH PRIORITIES

Symposium participants were further requested to evaluate the keywords (on 7-point scales) with respect to priorities both for basic research and for applied research. Unlike the discriminations with respect to present knowledge, these latter sets of evaluations indicate the participants' abilities to discriminate among the keywords. Furthermore, an increase in usage of the scale range (i.e., 70% and 63% for basic research priorities and applied research priorities, respectively) and a decrease in judgmental variance (in comparison with the evaluations of present knowledge) enable a more valid examination of keyword differences.

The ordering of ratings for basic research priorities indicates the existence of at least two relatively distinct trends (Table 11-7.2). Firstly, it is observed that keywords identifying cognitive functions are evaluated as being of a higher basic research priority than those keywords identifying perceptual or motor functions. Support for this observation is found in Table 11-7.2 which indicates, for example, that of the six most highly rated keywords, five can be considered as directly relevant to cognitive functioning (e.g., attention, risk-taking, decision-making, etc.). Secondly, basic research priority ratings tend to be judged on their relative degrees of complexity (e.g., from high evaluations for central nervous system and attention to low evaluations for critical flicker fusion, reaction time, and muscle strength).

The ratings of priorities for applied research was again a multi-dimensional task, requiring the evaluators to attend to such factors as the probability and functional utility of increased knowledge, and to such research contingencies as the present levels of research technology and pragmatic temporal limitations. However, in a pattern similar to that obtained in the evaluations of basic research priorities, the judgmental responses range from the more complex cognitive and perceptual functions to the less complex sensory and motor functions (see Table 11-7.3). This observed similarity between evaluations of basic and applied research priorities receives statistical support from the significant associations (Spearman's rho, $\rho < .05$) for 22 of 39 keywords (see Table 11-7.4) The obtained associations between basic and applied research priorities for respective keywords may be attributed to the difficult task of systematically and effectively discriminating basic and applied research with regard to the influences of drugs on driving-related behaviors.

Interestingly, the calculation of Spearman rhos between basic or applied research priorities and present knowledge ratings did not indicate any statistically significant associations (see Table 11-7.4). The expectation of obtaining significant inverse correlations between research priority and present knowledge evaluations was not realized, possibly indicating that the relative absence of information concerning a specific issue is not a sufficient condition to necessitate further research.

TABLE 11-7.1

Present Knowledge Ratings of Keywords from Session 6:
"Drug Influences Upon Driving-Related Behavior:
Laboratory, Simulator, and Closed-Course Studies"

Keywords	Drug Professional (N=14)		Specialists (N=9)		Non-Specialists (N=6)	
	Mean	SD	Mean	SD	Mean	SD
Attention, intensive	5.14	2.41	4.56	2.74	5.33	1.86
Attention, selective and divided	5.71	2.49	5.78	2.73	5.83	2.64
Audition	5.07	3.00	5.33	3.67	4.83	1.83
Color vision	4.93	3.10	5.11	3.89	3.33	1.51
Critical flicker fusion	6.43	4.22	7.78	4.41	4.83	3.19
Decision making	4.93	2.34	4.67	2.35	5.50	2.35
Depth perception	5.86	2.57	5.89	3.14	6.00	1.90
Emotion and mood	6.43	3.06	6.22	3.19	6.17	2.32
Learning	4.93	1.82	5.56	1.59	4.00	1.79
Manual dexterity and steadiness	6.50	4.03	6.56	4.45	6.50	3.73
Memory, long term	5.43	2.59	5.22	3.15	5.50	2.07
Memory, short term	5.71	2.55	6.22	2.82	4.50	2.35
Motivation	4.43	1.91	4.11	1.96	5.33	1.86
Muscle strength	6.00	3.46	6.33	3.50	5.83	3.87
Nervous system, autonomic	6.07	3.36	6.67	3.35	5.17	3.13
Nervous system, central	4.64	2.21	4.78	2.44	4.33	1.75
Ocular motor activities	5.64	3.37	4.89	3.30	6.00	2.97
Perceptual constancies	5.14	2.77	5.44	3.13	3.50	1.22
Perceptual suggestion	4.79	2.69	4.22	2.44	5.33	2.42
Problem solving	6.50	2.93	6.56	3.13	6.17	2.64
Reaction time, choice	5.86	2.71	5.78	3.15	6.67	2.42
Reaction time, simple	8.07	3.45	8.67	3.43	7.00	3.41
Retinal sensitivity	5.86	3.61	6.00	4.12	6.17	3.66
Risk taking	4.64	2.47	5.00	2.74	3.83	1.83
Sensory motor coordination	5.50	3.11	5.33	3.28	5.67	3.14
Steadiness, dynamic	6.14	2.88	6.44	3.09	6.00	2.61
Steadiness, standing	6.57	3.52	6.67	4.09	7.17	2.48
Time perception	5.50	2.65	5.67	3.12	5.17	1.94
Tracking	6.14	3.44	7.00	3.54	5.00	2.68
Verbal performance	6.43	3.67	7.11	4.11	5.33	3.44
Visual acuity, dynamic	4.71	2.43	5.11	2.42	4.83	2.56
Visual acuity, static	6.57	3.67	6.78	4.24	7.00	3.16
Visual adaptation	6.21	2.22	6.67	2.50	5.50	1.87
Visual after-effects and illusions	5.14	2.71	5.56	2.96	3.67	2.07
Visual discrimination	5.57	3.08	5.89	3.72	5.00	1.79
Visual field	7.07	3.08	7.67	3.46	6.00	2.68
Visual recog. and identification	4.86	2.14	4.78	2.39	5.33	2.34
Visual search	4.21	2.33	5.11	1.54	3.00	2.53
Visual signal detection	5.86	2.66	6.00	2.74	5.00	2.53

TABLE 11-7.2

Basic Research Priority Ratings of Keywords from Session 7:
"Drug Influences Upon Driving-Related Behavior:
Laboratory, Simulator, and Closed-Course Studies"

Keywords	Drug Professional (N=14)		Specialists (N=9)		Non-Specialists (N=6)	
	Mean	SD	Mean	SD	Mean	SD
Attention, intensive	5.86	1.03	5.44	1.42	5.67	.82
Attention, selective and divided	5.79	1.19	5.89	.93	5.17	1.33
Audition	3.07	1.69	2.44	1.42	3.33	2.25
Color vision	3.07	1.73	2.67	1.58	3.17	2.14
Critical flicker fusion	2.93	1.86	2.56	1.74	3.17	2.14
Decision making	5.29	1.20	5.22	1.20	5.33	1.03
Depth perception	4.00	1.57	3.22	1.56	4.33	1.97
Emotion and mood	5.21	1.31	5.33	1.32	5.00	1.26
Learning	4.21	1.72	3.67	1.73	5.00	1.26
Manual dexterity and steadiness	3.00	1.11	3.00	1.00	3.00	1.26
Memory, long term	4.57	1.16	4.33	1.58	4.50	1.38
Memory, short term	4.50	1.02	4.22	1.20	4.33	1.03
Motivation	5.00	1.24	5.33	1.41	4.83	1.17
Muscle strength	1.93	1.07	1.56	.88	2.00	1.26
Nervous system, autonomic	5.29	1.20	5.00	1.32	5.50	1.05
Nervous system, central	5.86	1.03	6.00	1.00	5.50	.84
Ocular motor activities	4.71	1.38	4.44	1.74	4.33	1.63
Perceptual constancies	3.50	1.34	3.00	1.22	3.67	1.75
Perceptual suggestion	4.64	1.34	4.89	1.17	4.67	1.51
Problem solving	4.29	1.54	4.11	1.45	4.00	1.10
Reaction time, choice	4.64	1.28	4.33	1.41	4.17	1.47
Reaction time, simple	2.86	1.17	2.78	1.20	2.67	1.21
Retinal sensitivity	3.43	1.74	2.78	1.56	3.33	2.25
Risk taking	5.29	1.07	5.22	1.09	5.33	.82
Sensory motor coordination	4.71	.99	4.33	1.41	4.67	.82
Steadiness, dynamic	3.43	1.22	3.78	1.20	2.83	.98
Steadiness, standing	3.00	1.18	3.22	1.30	2.83	.98
Time perception	4.00	1.84	3.44	1.74	4.50	1.64
Tracking	4.36	1.50	3.89	1.45	4.50	1.64
Verbal performance	2.71	1.07	2.11	.93	3.00	1.10
Visual acuity, dynamic	4.14	1.92	4.00	1.50	4.33	2.07
Visual acuity, static	3.43	1.22	3.11	1.45	3.50	1.22
Visual adaptation	3.86	1.17	3.56	1.51	3.50	1.38
Visual after-effects and illusions	3.93	1.64	3.56	1.01	4.00	1.79
Visual discrimination	4.50	1.70	4.00	1.94	4.50	1.38
Visual field	4.00	1.41	3.44	1.24	4.17	1.72
Visual recog. and identification	5.71	.99	5.22	1.56	5.33	1.03
Visual search	5.21	1.53	4.89	1.69	4.83	1.60
Visual signal detection	5.21	1.31	4.44	1.67	5.17	1.47

TABLE 11-7.3

Applied Research Priority Ratings of Keywords from Session 7: "Drug Influences Upon Driving-Related Behavior: Laboratory, Simulator, and Closed-Course Studies"

Keywords	Drug Professional (N=14)		Specialists (N=9)		Non-Specialists (N=6)	
	Mean	SD	Mean	SD	Mean	SD
Attention, intensive	6.00	1.18	5.78	1.64	5.33	1.37
Attention, selective and divided	5.79	1.42	6.22	.83	4.67	1.51
Audition	3.07	1.59	2.33	1.22	3.67	2.07
Color vision	3.07	1.64	2.67	1.32	3.50	1.97
Critical flicker fusion	2.50	1.70	2.33	1.50	2.67	1.97
Decision making	5.14	1.10	5.11	.93	4.83	.98
Depth perception	3.71	1.90	3.11	2.09	3.67	2.16
Emotion and mood	4.86	1.17	5.11	.78	4.33	1.51
Learning	3.71	1.68	3.67	1.58	4.00	1.67
Manual dexterity and steadiness	3.14	1.10	3.44	1.01	3.00	1.10
Memory, long term	3.43	1.70	3.11	1.76	3.50	1.87
Memory, short term	3.93	1.49	3.78	1.56	3.67	1.63
Motivation	5.14	1.29	5.11	1.36	5.00	.89
Muscle strength	1.71	.73	1.56	.73	1.83	.75
Nervous system, autonomic	4.21	1.63	4.22	1.48	3.83	1.83
Nervous system, central	4.64	1.74	4.33	1.94	4.50	1.52
Ocular motor activities	4.43	1.50	4.33	1.32	4.17	2.04
Perceptual constancies	4.29	1.44	4.11	1.69	3.67	1.63
Perceptual suggestion	4.29	1.49	4.33	1.22	4.17	1.83
Problem solving	3.79	1.42	3.78	1.30	3.67	1.63
Reaction time, choice	4.29	1.38	4.22	1.30	3.50	1.52
Reaction time, simple	2.57	1.34	2.78	1.39	2.17	1.17
Retinal sensitivity	3.14	1.99	2.56	1.67	3.33	2.66
Risk taking	5.50	1.09	5.33	1.22	5.67	.52
Sensory motor coordination	4.57	1.28	4.89	1.17	3.83	1.33
Steadiness, dynamic	3.29	.99	3.56	1.01	2.67	.52
Steadiness, standing	2.79	.97	3.22	.97	2.17	.75
Time perception	3.71	1.77	3.00	1.50	3.83	1.94
Tracking	4.50	1.56	4.33	1.32	4.17	1.83
Verbal performance	2.00	.68	2.11	.78	2.00	.63
Visual acuity, dynamic	4.64	1.65	4.33	1.66	3.83	1.83
Visual acuity, static	2.93	1.33	2.89	1.69	2.33	1.03
Visual adaptation	4.36	1.28	4.22	1.48	3.83	1.72
Visual after-effects and illusions	4.21	1.72	3.78	1.30	4.17	1.83
Visual discrimination	4.93	1.54	4.56	1.51	4.33	1.86
Visual field	4.64	1.74	4.56	1.88	4.00	1.55
Visual recog. and identification	5.14	1.61	4.78	1.64	4.67	1.75
Visual search	5.43	1.65	5.22	1.72	4.50	2.07
Visual signal detection	4.93	1.94	4.44	2.19	4.83	1.60

TABLE 11-7.4

Correlations between Specialists' Ratings of Each Keyword in Session 7 according to Status of Present Knowledge, Basic Research Priority, and Applied Research Priority (N=9)

Keywords	Spearman's Rho		
	PK-BR	PK-AR	BR-AR
Attention, intensive	.28	.03	.85 *
Attention, selective and divided	-.22	-.43	.89 *
Audition	-.00	.15	.83 *
Color vision	.50	.52	.91 *
Critical flicker fusion	.48	.34	.89 *
Decision making	.07	.37	.33
Depth perception	-.45	.04	.77 *
Emotion and mood	.62	.37	.72 *
Learning	.15	.29	-.35
Manual dexterity and steadiness	.06	-.47	.55
Memory, long term	.28	.51	.50
Memory, short term	.11	.48	.36
Motivation	-.22	-.17	.75 *
Muscle strength	-.26	.20	.53
Nervous system, autonomic	.21	-.09	.49
Nervous system, central	-.07	.33	.54
Ocular motor activities	-.45	-.27	.70 *
Perceptual constancies	-.47	-.10	.81 *
Perceptual suggestion	-.10	-.20	.77 *
Problem solving	-.60	-.29	.52
Reaction time, choice	-.26	-.37	.96 *
Reaction time, simple	-.01	-.09	.75 *
Retinal sensitivity	-.30	-.35	.94 *
Risk taking	.31	.18	.45
Sensory motor coordination	-.00	-.04	.90 *
Steadiness, dynamic	.42	.31	.53
Steadiness, standing	-.04	-.02	.16
Time perception	-.43	-.53	.63
Tracking	.43	-.47	.36
Verbal performance	.29	.18	.54
Visual acuity, dynamic	.12	.02	.98 *
Visual acuity, static	.31	-.42	.87 *
Visual adaptation	.49	.40	.75 *
Visual after-effects and illusions	-.32	-.29	.68 *
Visual discrimination	.02	-.20	.74 *
Visual field	-.18	-.13	.37
Visual recognition and ident.	-.25	-.44	.87 *
Visual search	.19	.47	.69 *
Visual signal detection	.29	-.38	.55

*($|\hat{\rho}| \geq .67 \rightarrow \rho \neq 0;\ p < .05$)

PK = present knowledge
BR = basic research
AR = applied research

11.8 KEYWORD RATINGS IN SESSION 8: ALCOHOL COUNTERMEASURES

Gerald J. Driessen

The quantification of judgments of present knowledge and research priorities in relation to the various items was a worthwhile effort. The bulk of the results are directly apparent in the tables. Only the extreme values (top and bottom five items) will be discussed.

11.8.1 PRESENT KNOWLEDGE RATINGS

The present knowledge ratings for the alcohol professionals (Table 11-8.1) show that the five countermeasures judged to be high, i.e., about which we know a good deal include: breath testers (9.44), police surveillance (8.78), maximum BAC (8.72), fines (8.66), and direct observation of erratic behavior (8.56). The five countermeasures rated lowest are: interagency exchange (4.84), sniffer devices (4.78), alcohol questions on license applications (4.72), self-testing for BAC (4.16), and tagging license plates of problem drinker-drivers (3.62).

When the "specialists" (as designated by session chairmen) judged the knowledge factors (Table 11-8.1), the top five countermeasures shifted somewhat: maximum BAC (9.38), breath testers (9.00), implied consent laws (8.25), police surveillance (8.13), and "other testing devices" (7.87). The bottom five overlap in four cases with the combined alcohol professionals: self-testing for BAC (4.25), visits to emergency room (not rated lowest in other group), (4.06), alcohol question on license application (3.94), interagency exchange (3.88), and the tagging of license plates (3.25).

Finally, the "non-specialists" (Table 11-8.1) gave the highest present knowledge ratings to: breath testers (9.87), fines (9.50), police surveillance (9.44), direct observation of erratic behavior (9.88), and imprisonment (9.12). The lowest ratings in this group were assigned to: sniffer devices (5.19), forced labor (5.06), educational program for attorneys and other specialists (4.94), self-testing for BAC (4.06), and tagging plates (4.00).

Table 11-8.5 shows the above results in summary form.

11.8.2 APPLIED RESEARCH PRIORITIES

On the basis of a 7-point scale, (Table 11-8.3) shows the highest priorities as judged by the alcohol professionals to be: police surveillance (5.41), enforcement by selective police surveillance (5.37), special educational programs for attorneys and other specialists (5.25), public education of legal alcohol limits (5.13), and the use of roadblocks (5.00). The items given lowest priorities are: medical advisory boards (2.94), imprisonment (2.91), alcohol questions on driver license applications (2.78), visits to alcoholic wards (2.56), and forced labor (2.31).

The specialists' ratings (Table 11-8.3) show an essentially similar pattern, with one exception in both the highest and lowest ratings. The specialists rated rehabilitation by behavior modification (5.50) among the top five, in place of educational programs for attorneys. Among the bottom five, visits to emergency rooms (2.94) replaced medical advisory boards.

Table 11-8.6 shows the above results in summary form.

11.8.3 RANK ORDER CORRELATIONS

The Spearman rank order correlations (Rho) between specialists and non-specialists were significant at the .01 level for both present knowledge and applied research priorities, having values of .84 and .62, respectively (see Table 11-1.5).

The reader can examine the rhos for each keyword under the present knowledge and applied research priority column in Table 11-8.4 to determine which are significantly correlated. Any absolute value of .50 or higher is significant at the .05 level. Thus, the rho for "Driver Education" is -.55 which is statistically significant, i.e., the measured degree of association between ratings for present knowledge and applied research priority (negative, in this case) is not likely to be due to chance factors, but represents a real association of the two rank orders. On the basis of the value presented in Table 11-8.4 showing rhos for each keyword, it is not possible to tell whether the present knowledge rating was high and the applied research priority rating was low, or the reverse. Further data processing would clarify this relationship.

TABLE 11-8.1

Present Knowledge Ratings of Keywords from Session 8:
"Alcohol Countermeasures: Solid Rock and Shifting Sand"

Keywords	Alcohol Professional (N=32)		Specialists (N=16)		Non-Specialists (N=16)	
	Mean	SD	Mean	SD	Mean	SD
Alc question on license app.	4.72	3.28	3.94	3.09	5.50	3.39
Alternative transportation	6.19	3.24	6.12	3.14	6.25	3.44
Direct obs. of erratic behav.	8.56	3.12	7.75	3.42	9.38	2.66
Driver education	7.59	3.90	6.56	3.83	8.62	3.81
Ed program for attorneys, etc.	5.00	2.78	5.06	2.26	4.94	3.30
Enforcement by selective police surv	7.13	3.10	6.75	3.00	7.50	3.25
Instrumentation: anti-start devices	5.56	3.21	5.13	3.32	6.00	3.14
Instrumentation: breath testers	9.44	3.68	9.00	3.98	9.87	3.42
Instrumentation: other testing dev.	7.97	3.59	7.87	4.29	8.06	2.86
Instrumentation: sniffer devices	4.78	2.67	4.38	3.05	5.19	2.26
Insurance actions	5.97	3.60	5.75	3.61	6.19	3.69
Interagency exchange	4.84	2.85	3.88	1.82	5.81	3.39
Knowledge of effects	6.16	3.23	5.94	3.84	6.38	2.60
Legal actions: chem tests	8.09	2.90	7.69	3.05	8.50	2.78
Legal actions: fine	8.66	3.06	7.81	3.08	9.50	2.90
Legal actions: forced labor	4.87	3.67	4.69	4.14	5.06	3.26
Legal actions: forced treatment	6.34	2.66	5.88	2.50	6.81	2.81
Legal actions: implied consent laws	8.47	3.16	8.25	3.26	8.69	3.16
Legal actions: imprisonment	8.38	3.41	7.63	3.59	9.12	3.14
Legal actions: lic. susp. & revoc.	7.75	2.86	7.13	2.94	8.38	2.73
Legal actions: max BAC	8.72	3.13	9.38	2.92	8.06	3.30
Legal actions: presentence inv.	6.28	2.90	6.56	2.94	6.00	2.92
Legal actions: rest. or sales	7.59	3.71	6.06	3.30	9.12	3.56
Legal actions: tagging plates	3.62	1.96	3.25	1.91	4.00	2.00
Legal actions: veh. impoundment	4.94	3.11	4.31	2.89	5.56	3.29
Med advisory boards	5.84	3.29	6.06	3.30	5.63	3.38
Physiological tests	5.78	2.60	5.31	2.75	6.25	2.44
Police surveillance	8.78	3.07	8.13	2.87	9.44	3.20
Pre-arrest test	5.63	3.11	4.50	3.01	6.75	2.86
Psychological tests	7.56	2.49	7.44	2.73	7.69	2.30
Public ed. of legal alcohol limits	6.81	3.07	7.25	2.98	6.38	3.20
Public ed. of alcohol effects on ind.	6.09	2.89	6.38	2.73	5.81	3.10
Public ed. of alc probs on highway	5.97	2.87	5.88	3.14	6.06	2.67
Reduce per capita consumption	5.91	3.74	4.69	2.85	7.13	4.21
Rehab. by AA	8.16	3.75	7.44	4.44	8.88	2.87
Rehab. by behavior modification	5.69	2.32	5.19	1.87	6.19	2.66
Rehab by drug therapy	7.03	2.81	6.31	2.44	7.75	3.04
Rehab by industrial alcohol programs	6.78	3.31	6.38	3.54	7.19	3.12
Rehab by psychotherapy	6.69	2.55	6.56	2.22	6.81	2.90
Responsible host behavior	4.87	3.39	4.38	3.10	5.37	3.69
Roadblocks	8.31	3.23	7.50	3.50	9.12	2.80
Self testing for BAC	4.16	2.46	4.25	2.79	4.06	2.17
Visits to alcoholic wards	4.91	3.62	4.50	4.12	5.31	3.14
Visits to emergency room	4.94	3.54	4.06	3.00	5.81	3.90

TABLE 11-8.3

Applied Research Priority Ratings of Keywords from Session 8:
"Alcohol Countermeasures: Solid Rock and Shifting Sand"

Keywords	Alcohol Professional (N=32)		Specialists (N=16)		Non-Specialists (N=16)	
	Mean	SD	Mean	SD	Mean	SD
Alc question on license app.	2.78	1.68	2.87	1.78	2.69	1.62
Alternative transportation	4.75	1.87	4.56	2.06	4.94	1.69
Direct obs. of erratic behav.	3.91	1.96	3.88	2.16	3.94	1.81
Driver education	4.47	1.68	4.38	2.00	4.56	1.36
Ed program for attorneys, etc.	5.25	1.68	5.06	1.95	5.44	1.41
Enforcement by selective police surv	5.37	1.10	5.69	1.01	5.06	1.12
Instrumentation: anti-start devices	3.69	1.99	3.88	1.96	3.50	2.07
Instrumentation: breath testers	4.38	1.68	4.25	1.98	4.50	1.37
Instrumentation: other testing dev.	3.94	1.66	3.62	1.67	4.25	1.65
Instrumentation: sniffer devices	4.56	1.81	4.75	1.91	4.38	1.75
Insurance actions	4.47	1.90	4.62	1.75	4.31	2.09
Interagency exchange	4.19	1.49	4.12	1.54	4.25	1.48
Knowledge of effects	4.62	1.64	4.19	1.68	5.06	1.53
Legal actions: chem tests	4.31	1.69	4.06	2.02	4.56	1.31
Legal actions: fine	3.56	1.81	3.62	1.93	3.50	1.75
Legal actions: forced labor	2.31	1.38	1.94	1.12	2.69	1.54
Legal actions: forced treatment	4.50	1.61	4.81	1.64	4.19	1.56
Legal actions: implied consent laws	3.91	1.42	4.12	1.45	3.69	1.40
Legal actions: imprisonment	2.91	1.65	2.56	1.36	3.25	1.88
Legal actions: lic. susp. & revoc.	4.44	1.76	4.31	1.74	4.56	1.82
Legal actions: max BAC	4.50	1.57	4.69	1.74	4.31	1.40
Legal actions: presentence inv.	4.66	1.68	4.69	1.89	4.62	1.50
Legal actions: rest. or sales	3.13	1.95	3.88	1.67	2.37	1.96
Legal actions: tagging plates	4.31	1.87	4.19	2.10	4.44	1.67
Legal actions: veh. impoundment	4.03	1.89	4.12	1.75	3.94	2.08
Med advisory boards	2.94	1.52	3.31	1.62	2.56	1.36
Physiological tests	4.25	1.44	4.19	1.80	4.31	1.01
Police surveillance	5.41	1.29	5.50	1.21	5.31	1.40
Pre-arrest test	4.31	1.84	4.44	1.97	4.19	1.76
Psychological tests	4.41	1.50	4.75	1.65	4.06	1.29
Public ed. of legal alcohol limits	5.13	1.31	5.13	1.15	5.13	1.50
Public ed. of alcohol effects on ind.	4.69	1.47	4.62	1.54	4.75	1.44
Public ed of alc probs on highway	4.06	1.72	4.00	1.67	4.12	1.82
Reduce per capita consumption	3.16	1.99	4.12	2.09	2.19	1.33
Rehab. by AA	3.75	1.27	3.69	1.30	3.81	1.28
Rehab. by behavior modification	4.81	1.47	5.50	1.21	4.12	1.41
Rehab by drug therapy	4.09	1.84	5.13	1.36	3.06	1.69
Rehab by industrial alcohol programs	4.00	1.34	4.31	1.35	3.69	1.30
Rehab by psychotherapy	4.19	1.77	5.00	1.55	3.37	1.63
Responsible host behavior	4.28	1.78	4.44	1.67	4.12	1.93
Roadblocks	5.00	1.61	5.13	1.82	4.87	1.41
Self testing for BAC	4.34	1.66	4.19	1.91	4.50	1.41
Visits to alcoholic wards	2.56	1.64	2.31	1.70	2.81	1.60
Visits to emergency room	3.09	1.75	2.94	1.77	3.25	1.77

TABLE 11-8.4

Correlations between Specialists' Ratings of Each Keyword in Session 8 according to Status of Present Knowledge, Basic Research Priority, and Applied Research Priority (N=16)

Keywords	Spearman's Rho
	PK-AR
Alc question on license app.	.15
Alternative transportation	-.26
Direct obs. of erratic behav.	-.01
Driver education	-.55 *
Ed program for attorneys, etc.	.22
Enforcement by selective police surv.	-.15
Instrumentation: anti-start devices	.34
Instrumentation: breath testers	-.43
Instrumentation: other testing dev.	-.03
Instrumentation: sniffer devices	-.11
Insurance actions	-.29
Interagency exchange	.37
Knowledge of effects	-.49
Legal actions: chem. tests	.20
Legal actions: fine	-.17
Legal actions: forced labor	.54 *
Legal actions: forced treatment	-.07
Legal action: implied consent laws	-.20
Legal actions: imprisonment	.20
Legal actions: lic. susp. & revoc.	-.46
Legal actions: max. BAC	.19
Legal actions: presentence inv.	-.11
Legal actions: rest. of sales	-.01
Legal action: tagging plates	-.08
Legal actions: veh. impoundment	-.20
Med. advisory boards	-.38
Physiological tests	-.38
Police surveillance	-.17
Pre-arrest test	-.10
Psychological tests	.13
Public ed. of legal alcohol limits	-.07
Public ed. of alcohol effect on ind.	-.14
Public ed. of alcohol problems on highway	-.07
Reduce per capita consumption	.18
Rehabilitation by AA	.12
Rehabilitation by behavior modification	-.05
Rehabilitation by drug therapy	-.23
Rehabilitation by ind. alcohol pgms.	.12
Rehabilitation by psychotherapy	.24
Responsible host behavior	-.13
Roadblocks	-.15
Self testing for BAC	-.20
Visits to alcoholic wards	.03
Visits to emergency room	-.14

$*(|\hat{p}| \geq .50 \rightarrow p \neq 0; p < .05)$

PK = present knowledge
AR = applied research

TABLE 11-8.5

Present Knowledge of Alcohol Countermeasures:
Highest and Lowest Mean Ratings by Various Groups[a]

Keywords	Alcohol Professionals (N=32)	Specialists[b] (N=16)	Non-Specialists[b] (N=16)
Highest items			
Breath testers	9.44	9.00	9.87
Police surveillance	8.78	8.13	9.44
Maximum BAC	8.72	9.38	c
Fines	8.66	c	9.50
Direct obs. of erratic behavior	8.56	c	9.88
Implied consent laws	c	8.25	c
Other testing devices	c	7.87	c
Imprisonment	c	c	9.12
Lowest items			
Interagency exchange	4.84	3.88	c
Sniffer devices	4.78	c	5.19
Alc. question on license app.	4.72	3.94	c
Self-testing for BAC	4.16	4.25	4.06
Tagging plates	3.62	3.25	4.00
Visits to emergency room	c	4.06	c
Forced labor	c	c	5.06
Ed. program for attorneys	c	c	4.94

TABLE 11-8.6

Applied Research Priorities:
Highest and Lowest Mean Ratings by Various Groups[a]

Keywords	Alcohol Professionals (N=32)	Specialists[b] (N=16)	Non-Specialists[b] (N=16)
Highest items			
Police surveillance	5.41	5.50	5.31
Enf. by selective police surv.	5.37	5.69	5.06
Ed. program for attorneys, etc.	5.25	c	5.44
Public ed. of legal alc. limits	5.13	5.13	5.13
Roadblocks	5.00	5.13	c
Rehab. by behavior modification	c	5.50	c
Knowledge of effects	c	c	5.06
Lowest items			
Medical advisory boards	2.94	c	2.56
Imprisonment	2.91	2.56	c
Alc. question on license app.	2.78	2.87	2.69
Visits to alcoholic wards	2.56	2.31	c
Forced labor	2.31	1.94	2.69
Visits to emergency rooms	c	2.94	c
Restriction of sales	c	c	2.37
Reduce per capita consumption	c	c	2.19

a Based on a 7-point scale.
b As designed by the consensus of the session chairmen.
c Not among the top or bottom five items in the group's ratings.

11.9 INFLUENCE OF EXPERTISE ON RATING-SCALE USAGE PATTERNS

Robert A. Lubin, Phillip M. Zunder, and M. W. Perrine [1]

ABSTRACT

The present study investigated the efficacy of discriminating on a judgmental task between subjects of varying degrees of expertise. Symposium participants were dichotomized with regard to their expertise subsequent to evaluating the state of present knowledge in key research areas. An examination of relative scale usage indicated "experts," being less subject to the central tendency effect, used significantly ($p < .05$) more extreme scale positions. The differential scale usage patterns obtained were discussed as possible indices of expertise.

11.9.1 INTRODUCTION

Variations in confidence can exert an influence on subjective judgment. Individual differences in confidence would therefore be expected to increase response variance within any group of judges. Havelock (1971) differentiated between the responses of researchers and decision makers concerning the relative priorities of various highway safety measures in an attempt to increase the validity of their responses. Havelock found the orientation of the evaluators to be a prime determinant of response. However, the efficacy of this a priori dichotomy was not determined, in that the relative validity of each group consensus was never ascertained.

It was felt that relative validity would be indicated by an analysis of judgmental scaling. The central tendency effect and usage of extreme scale values were expected to produce reciprocal effects. Johnson (1955) indicated that maximum confidence in judgment occurred at the midpoint of any response category. Conversely, minimum confidence in judgment was realized at the thresholds of response categories.

An extension of Johnson's statement regarding response categories to an entire judgmental scale would state that confidence would be minimal at the scale extremes. It is hypothesized that judges with relatively low confidence would avoid such scale extremes, and that, as confidence increases, judges would be less likely to avoid such extremes. Accordingly, specialists who assumedly have more confidence in their judgments, were expected to use the extreme values on the scales more frequently than non-specialists who assumedly have less confidence in their judgments and were thus expected to avoid extreme scale usage. This central tendency effect, more evident in non-specialists, may very well obscure any real scale differences in judgmental data. Considering the possible ambiguity of the keywords used in the rating tasks, the central tendency effect was expected to influence the data markedly.

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[1] The authors thank J. G. Ferguson, who collaborated with us in initiating this experiment and who contributed many helpful ideas.

As a test of this hypothesis, specialists and non-specialists were compared with respect to the distribution of their scale-usage on the task requiring ratings of the adequacy of our present knowledge for each keyword. If the data support the above hypothesis, an evaluation of only the specialists' responses would minimize the central tendency effect. With this effect minimized, real scale differences, which would have been obscured within the entire group, would now appear as significant.

The experimental hypothesis was not examined with respect to the participant's judgments on basic and applied research priorities. Since these responses were considered value judgments, the expectation of realizing significant differences was minimal. In other words, because the decisions involved in the research priority questions were considered value judgments, as opposed to factual judgments, the specialists would be expected to display as large a variability and disagreement in scale usage within individual keywords as the non-specialists. In addition, the non-specialists were expected to have used the extreme scale values increasingly in response to these value judgments. Finally, the present-knowledge question included a greater response range. The expectation of finding significant differences in scale usage in the research-priority questions was therefore considerably less.

11.9.2 METHOD

All relevant aspects of methods and procedures were presented at the beginning of this chapter (see Section 11.0.2).

11.9.3 RESULTS

The experimental hypothesis that the usage of extreme scale values was related to group membership received limited support in the present study. Only in the six combined alcohol sessions were specialists found to respond more frequently with extreme judgments.

For each scale value, (1 through 15), the difference between the mean percent usage by specialists and non-specialists yielded a signed difference score. Support for the experimental hypothesis would be obtained by three like-signed runs.

The mean percent distribution across all eight sessions was the initial test of the experimental hypothesis (See Table 11-9.1). The Wald-Wolfowitz two-sample runs test indicated that the 10 runs obtained were not significant.

An examination of the distribution of each individual session revealed the two drug sessions as highly negatively skewed, while the remaining alcohol sessions approached normal distributions. Since the hypothesis was only deemed appropriate for normally distributed data, the drug sessions were deleted. The Wald-Wolfowitz two-sample runs test, when performed on the data from the alcohol sessions (see Table 11-9.2), indicated that the three runs obtained were significant ($p < .05$).

These results were highly significant in that the ideal case to be tested by the Wald-Wolfowitz two-sample runs test involves two discrete samples (i.e., one run). This test tolerates some inconsistencies when applied to this ideal case. According to the experimental hypothesis, however, the two samples were not discrete (i.e., three runs were predicted). Since three runs were a more probable occurrence than one, few inconsistencies could be tolerated within the .05 level of significance.

11.9.4 DISCUSSION

The results confirm the experimental hypothesis by indicating relative increase in usage of extreme scale values by the specialists, concomitant with a relative decrease in the central tendency effect. The original expectation was to realize an increase in significant differences within the keyword scales by only using the responses of the specialists. Although the group differences were indeed significant, they were not of sufficient magnitude to induce any marked changes in the keyword rankings.

Unfortunately, this study is not a totally adequate test of the efficacy of the experimental hypothesis, since the non-specialists cannot be considered as an appropriate comparison group. Although the non-specialists are not as qualified in the given areas as the specialists, most are nevertheless quite knowledgeable in these areas. The responses of these "almost-specialists" can therefore not be expected to be markedly different from those of the specialists. More support for the experimental hypothesis would probably be found if the comparison group had consisted entirely of the true non-specialists.

TABLE 11-9.1

Mean Percent Usage of Scale Values on Present-knowledge Rating Task According to Specialists and Non-specialists for all Sessions (1-8) Combined

Scale Values	% Specialists	% Non-Specialists	Signed Difference Scores
1	3.52	3.03	+ .49
2	9.27	6.58	+2.69
3	8.67	9.08	- .41
4	11.38	10.15	+1.23
5	10.01	11.70	-1.69
6	8.76	11.26	-2.50
7	8.03	8.42	- .39
8	9.07	10.79	-1.72
9	7.71	7.30	+ .41
10	8.23	9.12	- .89
11	6.38	5.65	+ .73
12	4.30	4.13	+ .17
13	2.44	1.89	+ .55
14	1.34	.41	+ .93
15	.54	.08	+ .46

TABLE 11-9.2

Mean Percent Usage of Scale Values on Present-knowledge Rating Task according to Specialists and Non-specialists for All Alcohol Sessions (1-5, 8) Combined

Scale Values	% Specialists	% Non-Specialists	Signed Difference Scores
1	3.18	1.66	+1.52
2	7.43	3.81	+3.62
3	8.38	6.28	+2.10
4	10.71	8.29	+2.42
5	10.01	11.33	-1.32
6	8.78	10.91	-2.13
7	8.25	8.88	- .63
8	9.77	12.16	-2.39
9	7.77	8.50	- .73
10	9.09	10.92	-1.83
11	6.73	7.30	- .57
12	4.48	5.92	-1.44
13	2.79	2.83	- .04
14	1.68	.66	+1.02
15	.64	.13	+ .51

11.10 SUMMARY AND CONCLUSIONS

M. W. Perrine

11.10.1 INTRODUCTION

Three specific aims of the Vermont Symposium were to assess the status of present knowledge and to consider relative priorities for basic research and applied research in those areas germane to its theme (Alcohol, Drugs, and Driving). Accordingly, the participants were asked to rate a large number of specific topics or keywords on these three dimensions. Any such effort is bound to be arduous, fraught with human and methodological limitations, and constrained by the relative state of the art at the moment; our attempt was certainly no exception. Nevertheless, through the good-hearted diligence of the participants, the results of the many keyword ratings seem to have been worth the effort. In sum, the ratings by this group of leading specialists provide the first quantified evaluations of the major dimensions of alcohol, drug, and driving problems, namely, "What do we know now?" and "What should we know?"

As a research area, alcohol and highway safety is nearly 40 years old, but the first major reviews have only appeared during the past five years. Although the body of literature concerning the role of alcohol in highway safety has expanded enormously since the mid-sixties, no recent assessment of our current knowledge is known to have been published. The Vermont Symposium originated as a response to three interrelated needs: (1) to fill the gap caused by the lack of any comprehensive review since the late 1960s, (2) to evaluate the status of our current knowledge, and (3) to rate relative priorities for basic and applied research on the role of alcohol and drugs in highway safety.

Only one previous study is known in which some attempt was made to rate the adequacy of current knowledge in the area of alcohol in highway safety; however, alcohol was but one of a great many factors examined (A.D.Little, 1966). It was concluded "that our knowledge on alcohol as a contributing factor is fair and that alcohol is a critical factor (A.D.Little, 1966, p. 11)."

Two previous studies are known in which an attempt was made to estimate the priority for research on the role of alcohol in highway safety (Hahn, 1968; Havelock, 1971; 1973). In both studies, however, the question of alcohol research priorities represented but a very small part of large-scale surveys. In the first study, "drinking and drinking and driving in a total community setting" was rated as average in urgency and above average in significance (Hahn, 1968). In the second study, the alcohol area was viewed by both highway safety researchers and decision makers as an area in which action strategies are necessary (Havelock, 1971). Two relevant recommendations which emanated from this study were: (1) to "go all out on development of countermeasures for the alcohol problem," and (2) to "support annual conferences with published proceedings on critical topics" (Havelock, 1971, pp. 161-163).

Regarding other drugs and highway safety, active concern with this area of research activity has developed only during the last decade. Indeed, the three major reviews of this area have appeared only within the past three years.

Furthermore, no previous study is known in which adequacy of current knowledge and/or research priorities in the area of other drugs in highway safety were rated.

A number of methodological refinements and advances were achieved in the present study:

1. The ratings were obtained during the actual course of a task-oriented conference of leading researchers and decision makers.

2. Each set of ratings was obtained on specific clusters of topics or keywords germane to the extensive discussion which had immediately preceded the rating task itself.

3. The particular keywords themselves had been selected and pre-tested by a small group of specialists representing each of the Symposium areas before being submitted to the larger audience of participants.

4. Certain refinements of rating procedures were possible in this face-to-face group situation that would be completely impractical in a mail or telephone survey.

5. By virtue of the group situation in a remote location, it was possible to achieve virtually 100% returns from these rating tasks.

It was felt that these considerations, in conjunction with the high degree of specificity of the topics which were rated, should maximize the utility of the obtained results.

11.10.2 METHOD

11.10.2.1 Judges. The rating tasks were performed by the 35 invited participants attending the Vermont Symposium (see Appendix E). Each participant had initially indicated his primary (and if applicable, his secondary) professional involvement in terms of one of four possible categories: (1) alcohol administrator, (2) alcohol researcher, (3) drug administrator, or (4) drug researcher. These self-classifications were subsequently used for grouping purposes in the data analyses. Also, strictly for the purposes of data analysis, each participant was subsequently rated by all the session chairmen as either "expert/specialist" or "non-expert/non-specialist" in terms of his knowledge of the research and literature within each individual session. These various groupings were used in the analyses and tables presented in this chapter.

11.10.2.2 Procedure. The keywords to be rated at the end of each session served to identify the particular topics of relevance within the scope of that session. A total of 176 keywords was used, and ranged in number from 9 to 44 per session.

Four separate rating tasks were required, and instructions for each are presented below:

1. Between "no knowledge" and "total knowledge", as represented on the following scales, where do you think we are today (circle the appropriate number)?

2. Circle the number corresponding to the priority for basic research in terms of informational yield.

3. Circle the number corresponding to the priority for applied research in traffic safety.

4. Circle the number corresponding to your own qualifications in judging this area, a rating of 7 being comparable to the person most knowledgeable in this particular area, and a rating of 1 being comparable to a person just entering the area (e.g., a first-year graduate student).

It should be noted that the second task above was omitted from Sessions 5, 6, and 8 on the assumption that basic-research ratings were not applicable.

In summary, assuming that all 35 participants rated each of the 176 keywords on the 4 different tasks (but omitting the 79 keywords from the basic-research ratings not required in Sessions 5, 6, and 8), the total number of ratings obtained at the Vermont Symposium would be 21,875.

11.10.3 RESULTS

11.10.3.1 Rationale for constructing an overview of ratings. The texts of the subsections of this chapter represent relatively brief, self-contained summaries of the many analyses of the keyword ratings within each session. Rather than attempt to condense these summaries even further, it seemed more useful to consolidate the most important results from each session and thereby construct a comprehensive overview of all the keyword ratings. This effort was undertaken with full realization that a certain amount of violence is necessarily done to some of the methodological assumptions involved in actually obtaining the ratings. The most important assumption was that the keywords within each session had been rated separately and independently as a closed set, since the judges had been specifically instructed to consider that particular set of keywords strictly in the context of that session's topic, rather than to attempt to integrate relative ratings across the various sessions. This after-the-fact integration of ratings across sessions is therefore an artificial construction, must be consciously viewed as such, and the results interpreted with great caution. In fact, the only justification for attempting this synthesis is that the ratings in each of the sessions were produced by the same pool of judges.

In the process of preparing this overview, it was decided to focus on the ratings by the specialists (rather than on those produced by the entire group of participants) for several reasons, and owing to the importance of this decision, the various comparisons between specialists' and non-specialists' ratings are summarized below in the next subsection (11.10.3.2). Although a high level of agreement was found between the ratings of the non-specialists and the specialists, the latter showed finer and more consistent differentiations. As a group, the specialists typically showed less variance, that is, more agreement or consensus among themselves than did the non-specialists (especially at the high and the low ends of the scale). Furthermore, the individual participants designated as "specialist" for a given session were selected on the assumption that they were relatively more knowledgeable in that particular area than were those participants designated as "non-specialists" (see Section 11.0.2.1).

It was also decided to focus on the two sets of research priority ratings, with a view more toward the future than toward the status of present knowledge.

In order to provide a simple and consistent overview across sessions, the three highest rated keywords from each session were selected and are presented in separate tables according to the rank order of the mean ratings on basic or applied research priorities. Thus, the list in Table 11-10.1 reflects the specialists' ratings of those topics which have the highest priority for basic research in terms of potential informational yield, whereas the list in Table 11-10.2 reflects their ratings of those topics which have the highest priority for applied research in highway safety.

Within the group of specialists, the degree of agreement concerning the rating of each topic is indicated by the magnitude of the standard deviation; therefore, its rank is also presented in the tables. It should be noted that a rank of 1 was assigned to the lowest standard deviation since it reflects the highest degree of agreement. Thus, the ideal case for high agreement on a high priority topic would be represented by a rank of 1 for both the mean and the standard deviation; this combination was found in 7 of the 13 comparisons presented in Table 11-10.1 (basic research priorities) and Table 11-10.2 (applied research priorities). For convenience and reference, the ranks of the mean ratings for extent of present knowledge are also included for the keywords in both these tables. In addition, the total number of keywords in each session is also included so that the reader can easily see the extent of possible ranks within a given session (i.e., in Session 1, "central nervous system" was ranked first out of 15 possible keyword positions; whereas in Session 8, "enforcement by selective police surveillance" was ranked first out of 44 possible keyword positions). The discussions of these rankings are presented below and are separated on the basis of either basic or applied research, either alcohol or drug influences, and epidemiologic and countermeasure aspects of alcohol and drugs (beginning with Subsection 11.10.3.3).

11.10.3.2 Comparisons of ratings by specialists and non-specialists. One obvious question concerns the extent to which the ratings of the specialists differed from those of the non-specialists. Several different approaches to this question were undertaken. In the first, rank-order correlations between specialists' and non-specialists' mean ratings of present knowledge, basic research priority, and applied research priority were determined for each keyword in each session. With only one exception (the extent of present knowledge ratings in Session 3), all the resulting correlations were statistically significant at the .05 level, indicating high general concordance between these two groups of participants (see Table 11-1.5).

In a more extensive methodological approach, the differences between the ratings of the specialists and the non-specialists were analyzed in terms of central tendency effect and usage of the extreme scale values (see Subsection 11.9). It was hypothesized that judges with relatively low confidence in the material to be rated would avoid using the extreme positions on the scale, but that as confidence increased, judges would be less likely to avoid the use of such extreme scale values. Accordingly, specialists who assumedly had more confidence in their judgments were expected to use the extreme values on the scale more frequently than non-specialists who assumedly had less confidence in their judgments and were thus expected to avoid the extreme scale values, which would lead to a central tendency effect or a piling up of ratings in the central portion of the scale. Such a central tendency effect might very well obscure any real differences in the judgmental data. These analyses were deemed most appropriate for the ratings on extent of present knowledge, for which relative expertise was felt to be the relevant variable. It was found that the alcohol specialists (Sessions 1, 2, 3, 4, 5, and 8, combined) significantly increased in usage of extreme scale values and decreased in central tendency effect relative to the alcohol non-specialists ($p < .05$).

Regarding priorities for basic research and applied research, evidence was found to indicate that the specialists made greater differentiations. This difference was taken to indicate that the ratings were best differentiated and most consistent when made by the specialists rather than by the non-specialists on applied rather than basic research priorities (see Section 11.3).

In summary, a sufficiently high degree of general agreement between the specialists and non-specialists was found to warrant combining their responses in order to increase the size, stability, and generalizability of the sample data. Nevertheless, the two groupings of participants did show differences on their ratings of extent of present knowledge, the one dimension on which they could reasonably be expected to differ by virtue of their relative expertise. Compared with the non-specialists, the alcohol specialists tended to use a wider range of the available scale values, with proprotionately less use of the central portion of the scale, which was viewed as an indication of a greater willingness to differentiate and to take more extreme positions. Furthermore, the lowest values for the rank-order correlations were obtained in the comparisons of the specialists' and non-specialists' ratings for the extent of present knowledge.

11.10.3.3 Priorities for basic research on alcohol. The keywords in the alcohol sessions (Session 1 through 4) which were rated by the specialists as having the highest priorities for basic research in terms of informational yield are presented in Table 11-10.1. These keywords can be meaningfully organized into three general categories: (1) alcohol influences upon basic neurophysiological activities, (2) alcohol influences upon psychological processes, and (3) alcohol influences in combination with other conditions of the organism. In the first category, the two traditional divisions of the nervous system (central and autonomic) not only received high priority ratings with high agreement among the specialists, but also were rated lowest on the extent of our present knowledge.

Regarding alcohol influences upon the second category, the psychological processes can be divided into two subcategories: (1) perceptual-attentional, and (2) cognitive. The first subcategory consists of dynamic visual acuity, visual search, and attention (intensive, selective, and divided). These psychological processes are functionally interrelated and involve what has been termed "visual information processing." The second subcategory consists of risk taking and decision making, two cognitive psychological processes which are also functionally interrelated, but are concerned with the actions or behavior resulting from the visual information processing.

Regarding alcohol influences upon the third category, the other conditions of the organism can be divided into two subcategories: (1) emotion and mood, and (2) stressors other than alcohol (e.g., fatigue). The relatively high ratings for both sets of conditions doubtless stem from recognition that any "pure" influences of alcohol can be greatly affected by the condition of the person at the moment. Stressors other than alcohol (such as noise, fatigue, other drugs, emotional upset) when combined with it can either enhance or attenuate the basic influences of alcohol. These overlays of various combinations of stressors and emotional condition were highly rated for basic research priorities, especially in studies of alcohol influences upon driving itself (Session 4).

11.10.3.4 Priorities for basic research on drugs. The three highest rated keywords from Session 7 concerning drug influences upon driving-related behavior are presented in Table 11-10.1. In the case of these drug ratings, the pragmatic decision to list only the three highest keywords has necessarily led to presenting a proportionately incomplete picture of the actual ratings because of the ratio of the three keywords listed to the total keywords rated in the session (i.e., in Session 1, the three top keywords represent 20% of the total of 15 keywords whereas in Session 7, the three highest keywords represent approximately 8% of the 39 keyword total). Accordingly, if the highest 20-25% of the keyword ratings (i.e., the highest 10) are examined (see the specialists' column in Table 11-7.2), a pattern emerges which is essentially the same as that reported for alcohol in the preceding subsection. Thus, for the sake of efficiency, only the three exceptions to that pattern for basic research on alcohol need be mentioned here. The 10 highest rated drug keywords included all those alcohol keywords cited in the preceding subsection and listed in Table 11-10.1, with the following three exceptions: (1) "alcohol effects in combination with other stressors (fatigue)" was not included as a keyword to be rated in the drug session, (2) "dynamic visual acuity" received a mean rating at the midpoint of the drug distribution, and (3) "motivation" was the fourth highest among the drug keywords (as it was in the relevant alcohol session, but it was not listed because it did not fall within the criteria of the highest three ratings). In summary, there was a high level of agreement between the alcohol specialists and the drug specialists concerning which aspects of behavior should be rated highest on priorities for basic research in the two respective areas.

11.10.3.5 Priorities for applied research on alcohol. The keywords in the alcohol sessions (Sessions 1-5, and 8) which were rated by the specialists as having the highest priorities for applied research in highway safety are presented in Table 11-10.2. However, only those sessions concerned with influences of alcohol (Sessions 1-4) are considered in this subsection; Sessions 5 and 8 were concerned with epidemiologic and countermeasure aspects of the alcohol and highway safety problem, and thus are more conveniently treated below in a separate subsection (11.10.3.7).

The keywords from Sessions 1 through 4 can be meaningfully organized in the same general categories as were used above for the ratings on basic research priorities (see Subsection 11.10.3.3): (1) alcohol influences upon basic neurophysiological activities, (2) alcohol influences upon psychological processes, and (3) alcohol influences in combination with other conditions of the organism. As can be seen by comparing the two tables in this section, the alcohol keywords with highest ratings on applied research priority (Table 11-10.2) are essentially the same as those with highest ratings on basic research priorities (Table 11-10.1), with only two differences. On the priority ratings for applied research, "autonomic nervous system" was ranked seventh in Session 1 and was replaced among the top three keywords by "visual adaptation (glare)," and in Session 4, "visual search" was ranked fourth, being replaced among the top three by "time-sharing (divided attention)." Thus, for all practical purposes, essentially the same keyword topics received the highest ratings for both basic and applied research priorities; these keywords were explicitly summarized in the preceding subsection on alcohol (11.10.3.3).

11.10.3.6 Priorities for applied research on drugs. As with the preceding subsection on alcohol, the keywords concerned with influences of drugs upon driving-related behavior (Session 7) are considered here, whereas those keywords concerned with drug epidemiologic and countermeasure activities (Session 6) are treated in the next subsection. Relative to the ratings on basic research priorities, those for applied research emphasized the more attentional and cognitive processes, namely, attention (intensive, selective, and divided) and risk taking; thus showing more pragmatic concern for the information processing and action components of the problem, rather than emphasizing the basic neurophysiological activities since "central nervous system" dropped from first place for basic research priority to 13th place for applied research priority. The other keywords among the top ten concerned with drug influences were again very similar to the keywords receiving the highest ratings for applied alcohol research priorities, with the exception of motivation, sensory motor coordination, visual recognition and identification, and visual field, none of which were found among the highest alcohol keywords.

11.10.3.7 Priorities for applied research on epidemiologic aspects of alcohol and drugs. Comparison of the highest rated epidemiologic aspects of alcohol and driving problems (Session 5) and of drugs and driving problems (Session 6) in Table 11-10.2 reveals some clear differences in orientation which doubtless reflect differences in the respective states of the art. The epidemiology of alcohol and highway safety is at a relatively much more advanced stage of investigation and knowledge than is the epidemiology of other drugs and highway safety, which is still in its infancy. Accordingly, the highest ratings for applied research on the epidemiology of drugs in highway safety were given to incidence and prevalence studies which are necessary in the exploratory stage of a new undertaking to establish the very scope of the problem. More specifically, the highest priority keywords were concerned with the "risk contribution to accidents" of both hallucinogenic and psychoactive drugs, with the "extent of use of hallucinogenic drugs among drivers and pedestrians" receiving the third highest rating. It should be noted that these three keyword topics received the three lowest ratings for the extent of present knowledge.

It was perhaps in recognition of these differences in our knowledge about the older, established menace on the highways -- as opposed to the newer, potential menace -- that the highest rated keyword topic in Session 5 on epidemiologic aspects of alcohol in highway safety concerned the interaction between alcohol and drugs (more specifically, "tolerance to combination of alcohol and drugs"). It should also be noted that this keyword topic not only received the highest priority and greatest agreement, but was also rated the very lowest on extent of present knowledge. Research conducted on this topic would necessarily involve incidence and prevalence studies, which is an additional indication of the need for exploratory research in this area.

Excluding the above consideration of alcohol and other drugs, the highest rated priorities for epidemiologic research on the drinking and driving problem concern two aspects of the problem which can only be meaningfully investigated after a firm basis of incidence and prevalence studies had been established. The two aspects are "alcohol consumption pattern" and "driving history," both of which emphasize the study of individual differences, especially in terms of those variables for which past behavior may serve as a predictor for future behavior. In summary, the multivariate psychometric approach to the two main components of the problem -- drinking and driving -- received high priority ratings for applied research.

11.10.3.8 Priorities for applied research on countermeasures for alcohol and drugs. The priority ratings for applied research on countermeasures provided still further recognition of the differences between alcohol and other drugs in terms of the state of the art. More specifically, none of the keywords concerning drug countermeasures were among the highest rated priorities for applied research. Despite the fact that slightly over half (10 out of 19) of the drug keywords in Session 6 were explicitly labeled as countermeasures (see Appendix C), none of the keywords in the top third of the priority rankings concerned countermeasures, whereas all keywords in the lowest third of priority rankings were countermeasures. One could infer from these results that more incidence and prevalence studies are necessary to define the scope of the drug and highway safety problem before any countermeasure programs can be undertaken.

Regarding countermeasures for the drinking and driving problems (Session 8), it is interesting to note that highest priority ratings for applied research were given to the very new and the very old. "Rehabilitation by behavior modification" refers to a relatively recent but promising development in psychology which could be effective in reducing the number of problem drinkers on the road. Some exploratory research using this approach has already been undertaken, and positive results could represent a very significant advance towards solving a major component of the drinking and driving problem.

As a countermeasure, enforcement by police surveillance represents the most traditional, most readily implemented, but least evaluated of the many possible countermeasure approaches rated in Session 8 (N = 44). The full texts of the two highly rated keyword topics were: "enforcement by selective police surveillance (e.g., site of consumption, accident sites, etc.)" and "enforcement by increased police surveillance on roads." Since both these enforcement topics were rated very high on extent of present knowledge (respectively, 30th and 41st out of the total of 44 possible keyword positions), it can be reasonably inferred that the high priority ratings on applied research represent a strong perceived need to have this traditional and widely used countermeasure evaluated systematically.

TABLE 11-10.1

Keywords with Highest Ratings on Basic Research Priority

Session	Keyword	Rank: Basic research priority Mean[a]	Rank: Basic research priority SD[b]	Rank: Present knowledge Mean[b]	Total keywords N
1	Central nervous system	1	1	1	15
	Autonomic nervous system	2	6	3	15
	Dynamic visual acuity	3	2	2	15
2	Attention, selective & divided	1	1	9	15
	Visual search	2	5	3	15
	Attention, intensive	3	10	10	15
3	Risk taking	1	1	6	9
	Decision making	2	2	2	9
	Emotion and mood	3	7	9	9
4	Alc. effects in combination with other stressors (fatigue)	1	3	4	22
	Risk taking	2	1	13	22
	Visual search	3	11	19	22
7	Central nervous system	1	4	6	39
	Attention, selective & divided	2	2	20	39
	Attention, intensive	3	21	3	39

[a] High value of the statistic is set as 1.
[b] Low value of the statistic is set as 1.

TABLE 11-10.2

Keywords with Highest Ratings on Applied Research Priority

Session	Keyword	Rank: Applied research priority Mean[a]	Rank: Applied research priority SD[b]	Rank: Present knowledge Mean[b]	Total keywords N
1	Central nervous system	1	4	1	15
	Dynamic visual acuity	2	1	2	15
	Visual adaptation (glare)	3	3	9	15
2	Attention, selective & divided	1	1	9	15
	Visual search	2	2	3	15
	Attention, intensive	3	7	10	15
3	Risk taking	1	2	6	9
	Decision making	2	3	2	9
	Emotion and mood	3	4	9	9
4	Risk taking	1	1	13	22
	Alc. effects in combination with other stressors (fatigue)	2	2	4	22
	Attention, divided	3	5	21	22
5	Tolerance to combination alcohol & drugs	1	1	1	16
	Alcohol consumption pattern	2	7	13	16
	Driving history	3	4	9	16
6	Hallucinogenic drugs: risk contribution to accidents	1	4	3	19
	Psychoactive drugs: risk contribution to accidents	2	3	1	19
	Hallucinogenic drugs: extent of use among drivers & pedestrians	3	8	2	19
7	Attention, selective & divided	1	4	20	39
	Attention, intensive	2	28	3	39
	Risk taking	3	10	8	39
8	Enforcement by selective police surveillance	1	1	30	44
	Rehabil'tn by behav. modification	2	4.5	15	44
	Police surveillance	3	4.5	41	44

[a] High value of the statistic is set as 1.
[b] Low value of the statistic is set as 1.

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APPENDIX A: THE SYMPOSIUM PROGRAM[1]

VERMONT SYMPOSIUM
on
ALCOHOL, DRUGS, AND DRIVING

12-15 October 1972

Sugarbush Inn
Warren, Vermont

Sponsored by

Project ABETS, Psychology Department
University of Vermont

and

Psychological Research Foundation of Vermont, Inc.
Burlington, Vermont

in cooperation with

National Highway Traffic Safety Administration
U. S. Department of Transportation

THURSDAY, 12 OCTOBER

4:00 p.m.	*Registration (until 9:00 p.m.)*
6:30 p.m.	*Dinner*
8:30 p.m.	*Reception*

FRIDAY, 13 OCTOBER

8:00 a.m.	*Registration*

[1] This copy of the program is the version that was distributed at the Symposium and therefore does not reflect changes that were made after it went to press.

8:30 a.m.	WELCOME, INTRODUCTION, and PROGRAM COMMENT M. W. Perrine Robert B. Voas
9:00 a.m.	SESSION 1. *Alcohol influences upon neurophysiological, neuromuscular, and sensory activities.* *CHAIRMAN:* M. W. Perrine
10:30 a.m.	*Intermission*
11:00 a.m.	SESSION 2. *Alcohol inflences upon sensory motor functions, visual perception, and attention.* *CHAIRMAN:* Herbert Moskowitz
12:30 p.m.	*Lunch*
2:00 p.m.	SESSION 3. *Alcohol influences upon cognition and motivation.* *CHAIRMAN:* Herbert Barry, III
3:30 p.m.	*Intermission*
4:00 p.m.	SESSION 4. *Alcohol influences upon closed-course driving performance.* *CHAIRMAN:* M. Stephen Huntley, Jr.
5:30 p.m.	*Libatio ad libitum*
7:00 p.m.	*Dinner*
8:30 p.m.	*Open "House"*

SATURDAY, 14 OCTOBER

9:00 a.m.	SESSION 5. *Epidemiologic aspects of alcohol in driver crashes and citations.* *CHAIRMAN:* Paul M. Hurst
10:30 a.m.	*Intermission*
11:00 a.m.	SESSION 6. *Use of psychoactive and hallucinogenic drugs in relation to driving risk.* *CHAIRMAN:* Reginald G. Smart
12:30 p.m.	*Lunch*
2:00 p.m.	SESSION 7. *Drug influences upon driving-related behavior: Laboratory, simulator, and closed-course studies.* (Panel)
3:30 p.m.	*Intermission*

4:00 p.m.	SESSION 8. *Alcohol countermeasures: Solid rock and shifting sand.* *CHAIRMAN:* Gerald J. Driessen
5:30 p.m.	*Libatio ad libitum*
7:00 p.m.	*Banquet*

SUNDAY, 15 OCTOBER

9:00 a.m.	SUMMARIES OF SESSIONS 1, 2, 3, & 4
10:30 a.m.	*Intermission*
11:00 a.m.	SUMMARIES OF SESSIONS 5, 6, 7, & 8
12:30 p.m.	*Lunch*
2:00 p.m.	FORUM DISCUSSION
3:30 p.m.	*Intermission*
4:00 p.m.	CONCLUDING REMARKS AND DEMONSTRATIONS
5:30 p.m.	*Libatio ad libitum*
7:00 p.m.	*Dinner*
8:30 p.m.	*Open "House"*

Symposium conducted
under Contract DOT-HS-265-2-489

Coffee Courtesy of NATIONAL SAFETY COUNCIL

APPENDIX B: THE WRITTEN QUESTIONS SUBMITTED AT EACH SESSION

SESSION 1: "ALCOHOL INFLUENCES UPON NEUROPHYSIOLOGICAL, NEUROMUSCULAR, AND SENSORY ACTIVITIES"

1. Could the speaker briefly summarize the evidence for and against the view that some drinkers are better off after one or two drinks (in terms of impairment).

2. The spatial modulation functions and the temporal modulation functions may be measures of inhibitory losses produced by alcohol.

3. Short duration samples of sensory measurements may inverse the variance?

4. At present, do we know how to modify the effect of alcohol on specific types of neurophysiological and neuromuscular activity?

5. What makes you think that EEG work will make significant contribution to alcohol-drugs-driving research?

6. If our concern is relevance to the real world, and if our concern is with the influence of alcohol on driving behavior, then, what difference does it make whether the effect on behavior is mediated via one or another CNS site?

7. Since attitude and "risk-taking" are viewed as important to the role of alcohol in crashes should not autonomic nervous system studies be more important than indicated in your brief review?

8. In considering these aspects of function are you proposing to limit concern only to identifiable BACs or to the "hangover" phase as well? I would urge that the latter is a largely unexplored area of as yet unknown importance to highway safety.

9. Where would one fit conception of time? I urge another keyword.

10. Are there any lab tasks that can be shown to be capable of producing results useful for real world applications?

11. If research in this area is justified on the basis of the long term model building approach, what is the expected time frame for producing useful countermeasures, i.e., how long is the long road?

12. Both in your presentation and in your paper, which I hurried through, I didn't hear mention of the "light threshold" studies done at Indiana University Optometric Lab, i.e., an object that can be seen dimly in the dark without alcohol will not be seen with alcohol even in such small amounts as 30 to 50 mg%.

13. The correlation of dynamic visual acuity and driving record is quite low (See Burgs data). In driving, visual acuity is probably not used in a dynamic sense. Objects viewed down the road have quite low rates of motion and are viewed focally. High angular velocities occur rather close in to the vehicle for objects that would be viewed off axis, mostly. Based on such considerations, why is dynamic visual acuity an important ability whose alcohol effects we should investigate?

SESSION 2: "ALCOHOL INFLUENCES UPON SENSORY MOTOR FUNCTIONS, VISUAL PERCEPTION, AND ATTENTION"

1. You report a very low impairment threshold for divided attention tasks (0.015% - 0.03%), as opposed to single-channel operations. What are the comparative dose-response curves as BAC is manipulated above this range?

2. Do you believe that choice reaction time (two signals with two corresponding responses) is a complex reaction task? Note that some studies indicate no greater effect of alcohol on choice than single reaction time.

3. Is impairment in time-shared task performance with alcohol a function of the information not getting into the "central processor" or a function of the processor not being able to handle it., i.e., is it an attentional problem or information processing problem?

4. With an eye toward development of countermeasures, do we know anything about how to modify the effect of alcohol on divided-attention tasks?

5. Shouldn't we try to develop a simulator that really simulates rather than using laboratory tasks of possible or probable relevance?

6. Is there a difference in the variance of RT data as a function of blood alcohol?

7. The lack of a "taxonomy of behavior" is critical to alcohol and highway safety research. Do you feel that the McKnight analysis of the driving task will help?

8. The American Institutes for Research has developed a "taxonomy of behavior". Do you know of it? Is it useful?

9. What are the practical implications of these findings -- do they increase our confidence that alcohol causes accidents? Beyond that, do they suggest programs for law, for education, for vehicle design or highway design?

10. It was said that there is no influence of alcohol on the immediate memory system. Does this mean that it is of no use trying to develop ignition lock systems?

11. Do you have any comments concerning attention divided between two tasks, related or unrelated, i.e., Donna Cornsweets' Ph.D. thesis?

SESSION 3: "MOTIVATIONAL AND COGNITIVE EFFECTS OF ALCOHOL"

1. Is the superego soluble in alcohol?

2. Is the inhibition more of that in approach-avoidance conflict rather than that in Pavlov's inhibition of delay?

3. Do you have any ideas about how to measure the risk taking among drinking drivers while on the road?

SESSION 4: "ALCOHOL INFLUENCES UPON CLOSED-COURSE DRIVING PERFORMANCE"

1. What other personality variables should be investigated in respect to alcohol effects?

2. Why did you chose extraversion-introversion scale as your measure?

3. What is the rationale for using instrumented cars under less rigorous controls vs. using laboratory simulators?

4. Your conclusion seems to be that alcohol does affect driving behavior in unknown ways. Surely we already knew that. Is it appropriate to conclude that the total contribution of all the studies you are reviewing to our knowledge is ZERO? If not, what have these studies contributed?

5. Realizing that research conducted in an actual car is the closest approximation to real-world problems, and realizing the shortcomings of past car research, what parameters would you suggest be investigated in the future and how might they best be instrumentized?

6. How do the measures (which you are taking on your revised instrumented car) vary from those available on the original HSR equipment?

7. Didn't someone market a gadget that sounds a buzzer if no steering-wheel reversal occurs within a preset time constant? It might be useful for drunks, sleepy persons, those looking at girls, etc. Has this ever been followed up?

8. What was the placebo? Could the subjects tell whether they were getting alcohol?

9. Have any of these studies used DWI's? If so, with what results?

10. Does the fact that alcohol has little effect on response rate to signal, when this has been emphasized as the important aspect of the test, relate to the notion that the presumed impaired driver has difficulty only when presented with multiple information, which then requires selection or decision?

SESSION 5: "EPIDEMIOLOGICAL ASPECTS OF ALCOHOL IN DRIVER CRASHES AND CITATIONS"

1. Would you comment on the implications of Figure 3 & 5 for alcohol countermeasures?

2. In Figure 3, apparently the safest group, when sober, is the daily drinkers. Why? (I have a hypothesis.)

3. Why are more frequent drinkers involved in fewer collisions?

4. Selection of crash sites for collection of "control" data means that a higher level of alcohol in the exposed but not involved drivers is obtained than if a purely random site is selected (about .86% for random vs. 2.00% for crash sites). How does this effect Figure 5?

5. Presumably the Manhattan Study and the Vermont Study are most similar but appear to be most different. Why?

6. In Figure 3, the "yearly" and "monthly" data for .06 BAC must be based on relatively few cases, therefore is not this rapid rise less reliable than the other data points?

7. What variables other than drinking frequency explain the "Grand Rapids Dip"?

8. Concerning Figure 3: Is there any data which indicates how much daily, 3X, W, M, Y drinkers drink, when they do drink, i.e., is the median for dailies 2.03 or very high or bimodal? Is the median for daily drinkers (2.03) or very high or bimodal, for instance.

9. Has it been verified for all studies mentioned on page 6 of the paper whether the time between the crash and the moment they took the blood-samples was about the same for all groups concerned?

10. Has it been verified whether there were any other differences (except for BAC) between the crash-group and the control group? (We found in the Netherlands that drunken drivers had more accidents also when sober compared to a matched control group of non-drunken drivers.)

<u>SESSION 6</u>: "USE OF PSYCHOACTIVE AND HALLUCINOGENIC DRUGS IN RELATION TO DRIVING RISK".

1. On the studies of arrests for DWI analyzed for BAC in presence or absence of drugs, you note that the average BAC of those arrested is nearly the same whether or not drugs were also present. Yet we feel pretty sure that many of those drugs (e.g., barbs) are at least additive with alcohol regarding impairment in lab studies. One might, therefore, have expected to find a lower mean BAC in those arrested for DWI who also had drugs present. Have you an explanation? I have a hypothesis.

2. Is there any evidence on differential effects of barbituates and alcohol on probability of traffic accidents?

<u>SESSION 7</u>: "DRUG INFLUENCES UPON DRIVING-RELATED BEHAVIOR: LABORATORY, SIMULATOR, AND CLOSED-COURSE STUDIES"

1. Were there indications of potentiation?

2. With regard to amphetamines, did you say there was a positive effect if it involved simple tasks, but that you did not find any improvement for complex tasks?

3. Is there a dependence on the subject's state of fatigue?

<u>SESSION 8</u>: "ALCOHOL COUNTERMEASURES: SOLID ROCK AND SHIFTING SAND"

1. Your text implies that dead DWIs and convicted DWIs are from the same population. Are you sure?

2. Was the Oregon program unique in any important way that might explain its success relative to the other states?

APPENDIX C: THE KEYWORD TOPICS RATED IN EACH SESSION

Listed below by Session are the complete versions of the keyword topics (including any parenthetical material) as they were used in the actual rating tasks.

SESSION 1: "ALCOHOL INFLUENCES UPON NEUROPHYSIOLOGICAL, NEUROMUSCULAR, AND SENSORY ACTIVITIES"

Audition
Color vision
Critical flicker fusion
Manual dexterity and steadiness
Muscle strength
Nervous system, autonomic
Nervous system, central
Retinal sensitivity
Steadiness, standing (static balance)
Steadiness, walking (dynamic balance)
Time
Visual acuity, dynamic
Visual acuity, static
Visual adaptation (glare tolerance and recovery)
Visual after-effects and illusions
Visual field

SESSION 2: "ALCOHOL INFLUENCES UPON SENSORY MOTOR FUNCTIONS, VISUAL PERCEPTION, AND ATTENTION"

Attention, intensive (e.g., vigilance)
Attention, selective and divided
Depth perception
Ocularmotor activities (e.g., coordination and control)
Perceptual constancies (e.g., size, shape, color, brightness, etc.)
Perceptual suggestion (e.g., field dependence, autokinetic effects, etc.)
Reaction time, simple
Sensory motor coordination (other than tracking)
Time perception
Tracking (pursuit and compensatory)
Visual discrimination
Visual recognition and identification
Visual search
Visual signal detection

SESSION 3: "MOTIVATIONAL AND COGNITIVE EFFECTS OF ALCOHOL"

Decision making (willingness to accept a subjectively perceived degree of risk)
Emotion and mood
Learning (e.g., acquisition rate, state-dependency, etc.)

Memory, long-term
Memory, short-term
Motivation
Problem solving
Risk taking (objective hazard)
Verbal performance

SESSION 4: "ALCOHOL INFLUENCES UPON CLOSED-COURSE DRIVING PERFORMANCE"

Control-response accuracy (in terms of the precision of single control movements)
Control-response time (choice reaction time)
Control-use coordination (e.g., as measured by gear clashes)
Control-use in emergency situations
Control-use patterns (e.g., individual profiles as reflected by control-position spectral density functions)
Decision making
Depth perception
Driving-task analysis (including modeling)
Effects of alcohol in combination with other stressors (e.g., fatigue)
Individual differences (e.g., driving experience)
Lateral tracking accuracy
Risk taking
Speed adaptation
Time-sharing (divided attention)
Track configuration
Velocity estimation
Vigilance
Visual acuity, dynamic
Visual field
Visual recognition and discrimination
Visual search
Visual signal detection

SESSION 5: "EPIDEMIOLOGICAL ASPECTS OF ALCOHOL IN DRIVER CRASHES AND CITATIONS"

Alcohol consumption pattern
Alcohol consumption site
Alcohol consumption time (e.g., day of week, time of day, etc.)
Alcohol purchase site
Biographical variables
Cause of crash as a function of severity
Characteristics of passengers
Drinking antecedents (e.g., psychological stress, family conflicts, job loss, etc.)
Driving history
Motives in alcohol involved fatal crashes (e.g., suicidal)
Post crash medical treatment
Seat belt availability and use as a function of BAC
Time of crash
Tolerance to alcohol, long-term
Tolerance to alcohol, short-term
Tolerance to combination of alcohol and drugs

SESSION 6: "USE OF PSYCHOACTIVE AND HALLUCINOGENIC DRUGS IN RELATION TO DRIVING RISK"

Countermeasures - Legal actions: fines (varying amounts)
Countermeasures - Legal actions: forced labor
Countermeasures - Legal actions: forced treatment (e.g., driver training, therapy, etc.)
Countermeasures - Legal actions: imprisonment (varying periods)
Countermeasures - Legal actions: license suspensions & revocations (varying periods)
Countermeasures - Legal actions: mandatory chemical tests
Countermeasures - Legal actions: presentence investigation (recording previous alcohol or drug related offenses)
Countermeasures - Legal actions: vehicle impoundment
Countermeasures - Public education: drug effects on the individual
Countermeasures - Public education: drug problems on the highway
Hallucinogenic drugs: accident histories of heavy users and dependent users
Hallucinogenic drugs: extent of use among drivers and pedestrians
Hallucinogenic drugs: risk contribution to accidents
Opiate drugs: accident histories of heavy users and dependent users
Opiate drugs: extent of use among drivers and pedestrians
Opiate drugs: risk contribution to accidents
Psychoactive drugs: accident histories of heavy users and dependent users
Psychoactive drugs: extent of use among drivers and pedestrians
Psychoactive drugs: risk contribution to accidents

SESSION 7: "DRUG INFLUENCES UPON DRIVING-RELATED BEHAVIOR: LABORATORY, SIMULATOR, AND CLOSED-COURSE STUDIES"

Attention, intensive (e.g., vigilance)
Attention, selective and divided
Audition
Color vision
Critical flicker fusion
Decision making
Depth perception
Emotion and mood
Learning (e.g., acquisition rate, state-dependency, etc.)
Manual dexterity and steadiness
Memory, long-term
Memory, short-term
Motivation
Muscle strength
Nervous system, autonomic
Nervous system, central
Ocular motor activities (e.g., coordination and control)
Perceptual constancies (e.g., size, shape, color, brightness, etc.)
Perceptual suggestion (e.g., field-dependence, autokinetic effects, etc.)
Problem solving
Reaction time, choice
Reaction time, simple
Retinal sensitivity
Risk taking
Sensory motor coordination (other than tracking)
Steadiness, dynamic (dynamic balance)

Steadiness, static (static balance)
Time perception
Tracking (pursuit and compensatory)
Verbal performance
Visual acuity, dynamic
Visual acuity, static
Visual adaptation (glare tolerance and recovery)
Visual after-effects and illusions
Visual discrimination
Visual field
Visual recognition and identification
Visual search
Visual signal detection

SESSION 8: "ALCOHOL COUNTERMEASURES: SOLID ROCK AND SHIFTING SAND"

Alcohol question on driver license application
Alternative transportation (e.g., mass transit, taxi, police, buddy driving, etc.)
Detection by direct observation of erratic behavior (driving or walking)
Detection by interagency exchange of alcohol offense information
Detection by physiological tests to diagnose problem drinkers
Detection by psychological tests to diagnose problem drinkers
Enforcement by increased police surveillance on roads
Enforcement by roadblocks
Enforcement by selective police surveillance (e.g., sites of consumption, accident sites, etc.)
High school driver education
Instrumentation: anti-start devices (e.g., phys-tester, etc.)
Instrumentation: breath testing devices
Instrumentation: other testing devices (e.g., blood, urine, saliva, etc.)
Instrumentation: "Sniffer" devices (remote electrochemical sensing device)
Insurance actions (e.g., cancellation, rate increase, preferred rates for non-drinking, etc.)
Knowledge of effects (subject drinks of a measured 100 mg% BAC)
Legal actions: fines (varying amounts)
Legal actions: forced labor
Legal actions: forced treatment (e.g., driver training, therapy, etc.)
Legal actions: implied consent laws
Legal actions: imprisonment (varying periods)
Legal actions: license suspensions and revocations (varying periods)
Legal actions: mandatory chemical tests
Legal actions: maximum allowable BAC (100-150 mg%)
Legal actions: presentence investigation (recording previous alcohol related offenses)
Legal actions: restriction of alcohol sales (e.g., time, place, age, amount, concentration, etc.)
Legal actions: tagging of license plates
Legal actions: vehicle impoundment
Medical advisory boards
Public education of alcohol effects on the individual (e.g., effects of number and types of drinks on driving, synergistic effect of alcohol and drugs, alcohol effects in young and old drivers, safe drinking practices, etc.)
Public education of the alcohol problems on the highway
Public education of the legal alcohol limits and sanctions

Reduction of per capita consumption
Rehabilitation by Alcoholics Anonymous
Rehabilitation by behavior modification
Rehabilitation by drug therapy (e.g., tranquilizers, Antabuse, Temposil, etc.)
Rehabilitation by industrial alcohol programs
Rehabilitation by psychotherapy (individual and group)
Responsible host behavior (e.g., coffee, lodging, transportation, etc.)
Self testing for BAC
Visits to alcoholic wards
Visits to emergency rooms

APPENDIX D: THE EVALUATION QUESTIONNAIRE

The purpose of the evaluation questionnaire was simply to provide a structured medium through which we could obtain quantifiable feedback from each participant concerning the value of each identifiable aspect of the Symposium to him. During the final 20 minutes of the Forum Discussion (and, for that matter, of the Symposium itself), the remaining 29 participants were asked to evaluate each component of the Vermont Symposium by completing a 25-item questionnaire, a copy of which is presented below. These ratings were performed semi-anonymously, i.e., an elected representative of the participants (Prof. Buikhuisen) was entrusted with a code-sheet that identified the evaluators. This procedure allowed the individual participants to remain anonymous, yet allowed analyses to be performed according to the previously mentioned groupings (alcohol researchers and administrators, and drug researchers and administrators).

The results are presented below in the summary form of means and standard deviations of the ratings for each component (see Table D-1). No attempt has been made at complex interpretations of these results; they are simply being reported for informational purposes. It might be noted that the three highest rated components (across all three combinations of participants) were:

1. The value of the type of setting for the Symposium. (#13)
2. The value of the informal discussions. (#12)
3. The overall value of the Symposium. (#14)

The three lowest rated components were:

23. The value of the keyword ratings in general. (#5)
24. The value of the keyword ratings on priority for basic research. (#7)
25. The value of the summaries of the sessions (i.e., the third morning). (#10)

TABLE D-1

Means and Standard Deviations of Responses on the Symposium Evaluation Questionnaire According to Participants Grouped as Alcohol or Drug Researchers and Administrators (or Combined)

The value of:	Alcohol (N=28)		Drug (N=11)		Entire Group (N=29)	
	Mean	SD	Mean	SD	Mean	SD
1. Written drafts of the literature review papers	4.39	1.71	5.18	1.47	4.48	1.74
2. Reviewer-chairmen's oral summary at start of session	4.46	1.37	5.09	1.14	4.55	1.43
3. Discussion periods in general	4.86	1.48	4.73	1.85	4.93	1.51
4. Submission of written questions for consideration	3.89	1.50	4.18	1.40	3.93	1.49
5. Keyword ratings in general	3.64	1.77	3.45	1.51	3.76	1.84
6. Keyword ratings on present knowledge	3.75	1.62	4.00	1.55	3.86	1.71
7. Keyword ratings on priority for basic research	3.43	1.81	3.82	1.89	3.55	1.90
8. Keyword ratings on priority for applied research	3.79	1.79	3.73	1.90	3.90	1.86
9. Ratings of your own qualifications	3.86	1.76	3.45	2.07	3.97	1.82
10. Summaries of the sessions	2.93	1.59	2.82	1.66	3.07	1.73
11. Forum discussion	4.04	1.88	3.91	2.02	4.14	1.92
12. Informal discussions	5.86	.89	5.73	.79	5.86	.88
13. Type of setting for the Symposium	5.93	1.21	6.09	.94	5.97	1.21
14. Symposium to you (overall)	5.39	1.23	5.27	1.42	5.45	1.24
15. Symposium to the federal agencies (overall)	4.36	1.59	4.18	1.66	4.41	1.59
16. Session 1 (overall)	3.75	1.65	4.00	1.84	3.86	1.73
17. Session 2 (overall)	4.25	1.80	4.91	2.02	4.34	1.84
18. Session 3 (overall)	4.43	1.57	4.82	1.40	4.52	1.62
19. Session 4 (overall)	4.11	1.62	4.18	1.72	4.21	1.68
20. Session 5 (overall)	5.00	1.31	4.91	1.51	4.86	1.62
21. Session 6 (overall)	4.04	1.69	3.91	1.97	4.10	1.70
22. Session 7 (overall)	4.18	1.49	4.18	1.40	4.24	1.50
23. Session 8 (overall)	4.86	1.48	4.73	1.68	4.93	1.51
24. Obtaining written papers one month in advance	5.29	2.64	5.18	2.75	5.34	2.61
25. Having papers and proceedings published	3.64	2.74	3.64	2.94	3.76	2.76

TABLE D-2

Exact Copy of the Evaluation Questionnaire as Distributed to All Participants at the Conclusion of the Vermont Symposium

Identification______

Evaluation Questionnaire

On each of the following, circle the number corresponding to your feelings:

1. The value of the written drafts of the literature review papers.

low value	1	2	3	4	5	6	7 high value

2. The value of the reviewer-chairmen's (20-minute) oral summary at the beginning of each session.

low value	1	2	3	4	5	6	7 high value

3. The value of the discussion periods in general.

low value	1	2	3	4	5	6	7 high value

4. The value of the whole procedure involving the submission of written questions for priority consideration in the discussion periods.

low value	1	2	3	4	5	6	7 high value

5. The value of keyword ratings, in general.

low value	1	2	3	4	5	6	7 high value

6. The value of keyword ratings of present knowledge.

low value	1	2	3	4	5	6	7 high value

7. The value of keyword ratings on the priority for basic research in terms of informational yield.

low value	1	2	3	4	5	6	7 high value

8. The value of keyword ratings on the priority for applied research in traffic safety.

low value	1	2	3	4	5	6	7 high value

9. The value of the ratings of <u>your own qualifications</u>.

low value							high value
	1	2	3	4	5	6	7

10. The value of the <u>summaries of the sessions</u>, which emphasized the analyses of the ratings.

low value							high value
	1	2	3	4	5	6	7

11. The value of the <u>forum discussion</u> (Sunday afternoon).

low value							high value
	1	2	3	4	5	6	7

12. The value of the <u>informal discussions</u> (e.g., at the Open Houses).

low value							high value
	1	2	3	4	5	6	7

13. The value of the type of <u>setting</u> for the Symposium (i.e., remote & rural vs. metropolitan)

low value							high value
	1	2	3	4	5	6	7

14. The overall value of the Symposium to you.

low value							high value
	1	2	3	4	5	6	7

15. The probable overall value of the Symposium to the federal government agencies responsible for alcohol and drug programs.

low value							high value
	1	2	3	4	5	6	7

16. The overall value of Session 1 for you.

low value							high value
	1	2	3	4	5	6	7

17. The overall value of Session 2 for you.

low value							high value
	1	2	3	4	5	6	7

18. The overall value of Session 3 for you.

low value							high value
	1	2	3	4	5	6	7

19. The overall value of Session 4 for you.

1 low value 1 2 3 4 5 6 7 high value

20. The overall value of Session 5 for you.

low value 1 2 3 4 5 6 7 high value

21. The overall value of Session 6 for you.

low value 1 2 3 4 5 6 7 high value

22. The overall value of Session 7 for you.

low value 1 2 3 4 5 6 7 high value

23. The overall value of Session 8 for you.

low value 1 2 3 4 5 6 7 high value

24. The value of obtaining written papers one month in advance.

low value 1 2 3 4 5 6 7 high value

25. The value of having papers and proceedings published.

low value 1 2 3 4 5 6 7 high value

APPENDIX E: LIST OF PARTICIPANTS

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