ALCOHOL

and

TRAFFIC SAFETY

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Preface

This book came about as the result of a joint decision in 1958 by two units of the Public Health Service—the National Institute of Mental Health and the then Accident Prevention Program (now the Division of Accident Prevention, Bureau of State Services)—to examine the problem of drinking and driving in a series of small working conferences. Originally the intention in convening the working conferences was to provide the Public Health Service with a better integration of the facts in each of several areas of the problem than was available at that time. During the conference planning, we were impressed by the knowledge that, first, many of the "facts" in the alcohol and traffic safety area were by no means settled; and second, several aspects of the problem had not been looked at in a cohesive way from the particular vantage of the Public Health Service's interest—accident prevention. In each working conference, a selected group of people having special competence and background discussed various aspects of the topic over a period of 2 full days. They considered commonly held fallacious and correct opinions, accepted and moot data, controversial subjects, and needed research.

There were five working conferences: Behavioral and Physiological Effects of Alcohol (B. Fox, Chairman); Chemical Testing, Enforcement, and Legal Problems (B. Fox, Chairman); Statistics and Experimental Design (cochaired); Social Psychological Factors (J. Fox, Chairman); and Motivational and Educational Aspects (J. Fox, Chairman). The participants included the invited principals and a few observers who contributed occasionally to the discussion. Both chairmen attended all sessions, participating as regular conferees as well as moderating. The conferences were not expected to deal with all phases of the whole problem of drinking and driving, but it was felt that most major questions in the total problem would receive some attention. For each working conference, a paper was written as a starting point for discussion. The authors were requested to write with due regard for facts, but to present controversial positions, whether the authors agreed with them or not, without reservation.

Following the working conferences, which were intended to provide background information for the Public Health Service, a single conference [1]

[1] The National Conference on Alcohol and Traffic Safety, Pittsburgh, 1961, sponsored by the National Institute of Mental Health and the Division of Accident Prevention, both units of the Public Health Service, U.S. Department of Health, Education, and Welfare.

was planned to provide an appropriate opportunity for bringing to the attention of many interested groups a synopsis of the information and opinions discussed in the working conferences. The original working papers were abridged and edited by the respective authors for this purpose. Additional papers by other authors were requested for presentation at the National Conference on Alcohol and Traffic Safety to fill in certain areas not dealt with in depth by the original papers.

However, a single hearing at the National Conference, with limited distribution of abridged papers, did not seem adequate to inform local and State government officials, the many interested groups who could not be present at the National Conference, and the general public about some of the basic data and the controversial issues in the field. For this reason it is intended that the present book will have wider distribution than the Proceedings of the National Conference. We hope that it will be more useful than those papers alone in presenting a general view of the problem of drinking and driving. It contains papers originally given at the working conferences, later given at the National Conference, and amended for the present book; other papers especially written for the National Conference, also amended for the present purpose; and two chapters especially written for this book.

We hope that the papers will produce discussion and action toward alleviating, in whatever degree possible, the accidental injuries and deaths resulting from drinking and driving. Perhaps enough information and provocation to thought can be found here so that people seeking a background to the problem may refer to this book, among others, for discussion of some of the central issues.

We would like to acknowledge gratefully the contributions of all the people who helped in the many necessary ways to set this book together: the conferees and guests at the working conferences, the speakers and discussion groups who participated in the National Conference, and the members of the Public Health Service who were of such great aid to our thinking. In particular, we would like to acknowledge the bibliographic and technical aid of Virginia Selby and Doris Noll. They have earned our special gratitude for the long hours and unstinting efforts which in a very real sense made this book possible.

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1. American Medical Association, Committee on Medicolegal Problems, R. C. Hill, "Acceptance and endorsement of chemical tests," in *Chemical tests for intoxication manual,* 1959.
2. American Medical Association, *The Journal of the American Medical Association,* W. Haddon, Jr., and Victoria A. Bradess, "Alcohol in the single vehicle fatal accident. Experience of Westchester County, New York," 1959.
3. American Psychological Association, *American Psychologist,* (Psychology in the News), "Automotivational research," 1960.
4. Doubleday & Company, Inc., H. W. Haggard and E. M. Jellinek, *Alcohol explored,* Garden City, N.Y., 1942.
5. Duke University Press, C. H. Patrick, *Alcohol, culture, and society,* Durham, N.C., 1952.
6. National Safety Council, J. J. Beamish and J. L. Malfetti, "A psychological comparison of violator and non-violator automobile drivers in the 16 to 19 year age group," *Traffic Safety Research Review,* 1962.
7. National Safety Council, T. A. Seales, "The drinking driver," *Traffic Safety Research Review,* 1957.
8. Pergamon Press, *Journal of Chronic Diseases,* W. Haddon, Jr., P. Valien, J. R. McCarroll, and C. J. Umberger, "A controlled investigation of the characteristics of adult pedestrians fatally injured by motor vehicles in Manhattan," 1961.
9. Pergamon Press, *Journal of Chronic Diseases,* J. R. McCarroll and W. Haddon, Jr., "A controlled study of fatal automobile accidents in New York City," 1962.
10. *Rocky Mountain Medical Journal,* H. E. Campbell, "Blood alcohol level and highway deaths," 1958.
11. Rutgers Center of Alcohol Studies, *Quarterly Journal of Studies on Alcohol,* H. A. Mulford and D. E. Miller, "Drinking in Iowa. III. A scale of definitions of alcohol related to drinking behavior," 1960.
12. Rutgers Center of Alcohol Studies, *Quarterly Journal of Studies on Alcohol,* J. W. Riley, Jr., C. F. Marden, and Marcia Lifshitz, "The motivational pattern of drinking," 1948.
13. Rutgers Center of Alcohol Studies, *Quarterly Journal of Studies on Alcohol,* W. S. Schmidt and R. G. Smart, "Alcoholics, drinking and traffic accidents," 1959.
14. *The Public Opinion Quarterly,* H. H. Hyman and P. B. Sheatsley, "Some reasons why information campaigns fail," 1947.
15. *The Reporter,* D. P. Moynihan, "Epidemic on the highways," April 30, 1959.
16. Yale University Press, C. I. Hovland, I. L. Janis, and H. H. Kelley, *Communication and persuasion.* New Haven, 1953.

Introduction

Our purpose here is to present a multifaceted view of the drinking-and-driving problem in hopes of stimulating thought, interest, research, and action within the various problem areas. In certain portions of the subject—physiological and psychophysical responses or chemical measurement—a moderately representative selection of data is presented, incomplete to be sure, but containing a minimum of doubt as to technical correctness. In other areas, it is well recognized that the "facts" may not be completely worthy of that label; that the opinions are subject to disagreement, amendment, and verification; and that the suggestions for dealing with various aspects of the problem range from the uniformly acceptable to the highly controversial.

We believe that one important value of this publication is to relate little- and well-known facts on alcohol to driving. Carpenter describes representative relevant studies on psychophysical and behavioral functions as affected by alcohol, and relates them to driving. Schmidt and Smart examine survey studies on drinking and driving. Dubowski describes some background facts on physiological considerations in blood- and breath-alcohol testing. Vester gives some theoretical background on special biochemical questions. He also presents some hypotheses as to the way in which alcohol, acting on brain cells, brings about some well-known mood and other gross behavioral changes. (Recent evidence bears on the matter.) This topic is under active investigation in several quarters. When research finally resolves the question, future findings may have additional relevance to the explanation of recently observed joint effects of some modern drugs and alcohol. The direct application of the whole topic to driving is obvious. Borkenstein, Trubitt, and Lease give a brief history of alcohol as related to transportation, discuss problems of enforcement and the legal environment, and describe some breath-testing instruments. Cisin's discussion is based on his own observations and some well-known background data in motivation and social psychology. His chapter is also important because, within this psychological framework, it relates drinking to driving. The same can be said of Cahalan's discussion of mass education. J. Fox describes the question in the context of the public health approach and outlines some problems faced by those who must *do* rather than *ask*. B. Fox's discussion, though not centered in any discipline, examines certain old and new notions and data and sets them forth in the drinking-driving context in an attempt to come to a comfortable logical position about them. His discussions probably have greater value in orienting viewpoints than in conveying information.

Two years have passed since the National Conference on Alcohol and Traffic Safety. Many developments have taken place. Some of them were already in progress at that time; others began since then and are still in progress. A few examples are: action by States relating to chemical tests, particularly the implied consent laws; movement in foreign countries toward change in regulations, e.g., the British point of view; refinement of older methods of measuring blood alcohol; wider success in applying new methods of blood-alcohol measurement, e.g., chromatography; progress in development of other successful breath-testing tools, e.g., the Kitagawa-Wright instrument; several new studies on the interaction of alcohol and drugs; and new studies on the measurement of alcohol in samples of accident-involved and other road users. No single publication source can hope to cover all such developments completely, since so many are occurring so rapidly. The literature on alcohol is not small. Journals of at least three nationalities are devoted to the subject exclusively (*5, 33, 34*) and several contain frequent articles on the subject (e.g., *9, 21, 22*). These changes, however, show the concern of many about the problem of drinking and driving, and the nature of the movement toward its alleviation.

A few illustrations of the kinds of progress taking place will give something of the flavor of this movement.

Chromatographic methods (*12, 30*) are being applied to alcohol detection. Just as with earlier workers who were examining other methods, the people who are developing and refining these methods are solving problems of specificity, reliability, and technique. One looks for considerable improvement in this attack on measurement and detection.

In the area of blood-alcohol measurement by breath instruments, series of further Breathalyzer blood-breath correspondences have been carried out by Begg (*3*), Lereboullet et al. (*27*), Monnier and Ruedi (*29*), and Vidoni and Redenti (*39*), among others. Fox et al. (*16*) examined and reduced many sources of variation in the Breathalyzer having to do with machine operation and a few relating to machine design. Coldwell and Grant (*7*) did work showing little change with variation of most chemical and physical factors affecting Breathalyzer readings. Contrary to some (*8*) but consistent with other (*7*) findings, Fox (*15*) found that variability of breath measures using the Breathalyzer increased with level of blood alcohol. He could show this because he had reduced variability to about one-third that of Coldwell and Smith.

Alcohol affects nystagmic eye movement. Some developments beyond those mentioned by Carpenter have taken place. For example, Klose (*26*) showed that gaze nystagmus appeared in some fatigued as well as some alcoholized people. Goldberg and associates (*18*) showed that drugs with alcohol influence positional nystagmus. Fox et al. (*17*) were not able to show that latency of caloric nystagmus is affected by alcohol, since it has such high variability.

A new breath-measuring instrument based on the Kitagawa tube (*24*) has been made by Kitagawa and Wright (*25*), using more uniform tubes and an ingenious breathing apparatus. It shows considerable promise and is now under more intensive investigation as to blood-breath correspondence (*4*) than in the preliminary study (*25*).

The current status of implied consent legislation is being followed closely in many places. New legislation of this kind is regularly reported (e.g., *1, 38*) and seems to be spreading rapidly throughout the country.

A study is now being conducted by Borkenstein's research group (*6*) which examines the relation of personality, background, drinking behavior, and blood alcohol level in accident and nonaccident groups. In this work an attempt is being made to avoid sampling difficulties similar to those cited by Schmidt and Smart (see ch. II) concerning such studies. The results should be available soon.

Interaction of alcohol and drugs is a most important topic because of the widespread regular use of drugs, both old and new. Joint action of drug and alcohol may be extremely dangerous for on-the-road conditions. Certainly it is useful to get prior indications of danger if that is the case. For example, recent work on drug-alcohol interaction, not relating to traffic, has been done by Forney et al. (*14;* eight drugs); Tipton et al. (*37;* chlorpromazine); Wallgren (*40;* acetylcholine analogues); Kawi (*23*; sodium amytal); and Hughes et al. (*19;* benzquinamide). Simulator studies are being planned in South Dakota and California.

We recognize that many of the topics which were presented have been discussed, at least briefly, elsewhere. Some portions of the chapters, however, such as Carpenter's material on behavior and response, have not been collected in just this convenient way. Work done before 1940 in his particular area of interest has been evaluated (*20*), but since 1940 no good discussion has appeared. Other topics have not been discussed previously in a unified way. However much confidence one might have in basic data on sensory-motor responses, the common sources of collected literature do not examine them in detail as they relate to traffic safety. It is important to show this relationship, and attempts have been made to do so here. In some cases, a subject has been mentioned here only as an aspect of a larger topic or as a highlight (e.g., B. Fox's discussion of one facet of legal philosophy in relation to traffic safety). The legal question as a whole has not been given a chapter by itself. At first we felt it should have at least this much coverage, even though it would be an abridgment and concentration of adequately detailed material presented elsewhere. When the matter was more thoroughly considered, however, we decided that one cannot do complete justice to the topic in a single chapter.[2] In addition, a new book on courtroom aspects of drunk-driving cases has recently appeared (*13*).

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[2] Our thanks to Edward C. Fisher for an illuminating discussion of some questions of drinking, driving, and the law. For a detailed accounting of the legal aspects of the problem in the United States, see Donigan and later supplements (*10*).

Among other subjects not discussed in depth in this book are acute medical and neurophysiological effects of alcohol,[3] detailed physiology and pharmacology of alcohol effects on various housekeeping bodily organs,[3] alcohol as a cultural phenomenon in other countries,[4] recent comparative international events, and general developments within the last 2 years.

Recent publications of a general nature are all useful in providing a background picture (e.g., *2, 32, 35*). Each stresses certain aspects of the general problem and leaves out others. None can do justice to the complexities of the total situation.

The editors and the Public Health Service are aware of the unsettled state of the many issues in this problem, both as to facts and to possible ways of dealing with them. In particular recognition of this situation, the writers were urged to present material provoking discussion, as well as basic data.

We look forward to increased interest, increased research and program action, and a gradual recognition by the public that accidental injury and death due to drinking and driving can be reduced.

References

1. *AAMVA Bulletin.* American Association of Motor Vehicle Administrators, Washington, D.C.
2. *Alcohol and road traffic.* Proceedings, 3d International Conference on Alcohol and Road Traffic, London, 1962. London: British Medical Association, 1963.
3. Begg, T. B. (Atheroma Research Unit, Western Infirmary, Glasgow W. 1., Scotland.) Personal communication.
4. Begg, T. B., Hill, I. D., and Nickolls, L. C. A statistically planned comparison of blood and breath alcohol methods. In *Alcohol and road traffic.* Proceedings, 3d International Conference on Alcohol and Road Traffic, London, 1962. London: British Medical Association, 1963.
5. *Blutalkohol.* Verlag Deutsche Polizei GMBH, Hamburg, Germany.
6. Borkenstein, R. F. The role of the drinking driver in traffic accidents. Research Grant No. AC–16, Division of Accident Prevention, Public Health Service, Department of Health, Education, and Welfare, awarded Jan. 1, 1962.
7. Coldwell, B. B., and Grant, G. L. An investigation affecting the accuracy of the Breathalyzer reading. *Proc. Canad. Soc. forensic Sci.,* 1962, 1, 6.
8. Coldwell, B. B., and Smith, H. W. Alcohol levels in body fluids after ingestion of distilled spirits. *Canad. J. Biochem.,* 1959, **37**, 43–52.
9. *Deutsche Zeitschrift für die gesamte gerichtliche Medizin.* Springer-Verlag, 1 Berlin 31 (Wilmersdorf), Heidelberger Platz 3, Berlin, Germany.
10. Donigan, R. L. *Chemical tests and the law* (edited by E. C. Fisher). Evanston, Ill.: The Traffic Institute, Northwestern University, 1957.
11. Elbel, H., and Schleyer, F. *Blutalkohol.* (Blood alcohol.) (2d ed.) Stuttgart: Georg Thieme Verlag, 1956.

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[3] Good reviews have appeared elsewhere, however (*11, 36*).

[4] Alcohol use as a cultural phenomenon has been well described in recent publications by McCarthy (*28*) and Pittman and Snyder (*31*).

12. Enticknap, J. B. Observations on the Swoboda technique for alcohol analysis in dilute aqueous solutions by argon ionization chromatography. In *Alcohol and road traffic.* Proceedings, 3d International Conference on Alcohol and Road Traffic, London, 1962. London: British Medical Association, 1963.
13. Erwin, R. E. *Defense of drunk driving cases.* Albany, N.Y.: Banks & Co., 1963.
14. Forney, R. B., Hulpieu, H. R., and Hughes, F. W. The comparative enhancement of the depressant action of alcohol by eight representative ataractic and analgesic drugs. *Experientia,* 1962, 18, 468–471.
15. Fox, B. H. Unpublished data, 1963.
16. Fox, B. H., Lower, J., and Fox, Mary W. Measurement and reduction of some sources of variation in a breath testing instrument. In *Alcohol and road traffic.* Proceedings, 3d International Conference on Alcohol and Road Traffic, London, 1962. London: British Medical Association, 1963.
17. Fox, B. H., Makowski, W., and Schnall, A. M. Unpublished data, 1962.
18. Goldberg, L. Alcohol, tranquilizers, and hangover. *Quart. J. Stud. Alc.,* 1961, Suppl. 1, pp. 37–56.
19. Hughes, F. W., Forney, R. B., and Gates, P. W. Performance in human subjects under delayed auditory feedback after alcohol, a tranquilizer (benzquinamide), or benzquinamide-alcohol combination. *J. Psychol.,* 1963, **55,** 25–32.
20. Jellinek, E. M., and McFarland, R. A. Analysis of psychological experiments on the effects of alcohol. *Quart. J. Stud. Alc.,* 1940, **1,** 272–371.
21. *Journal of the American Medical Association.* American Medical Association, 535 North Dearborn St., Chicago 10, Ill.
22. *Journal of Forensic Sciences.* Callaghan & Co., 6141 North Cicero Ave., Chicago 46, Ill.
23. Kawi, A. A. Effects of sodium amytal and ethyl alcohol on some psychological and psychomotor functions. *J. Neuropsychiat.,* 1961, **2,** 195–200.
24. Kitagawa, T. The rapid measurement of toxic gases and vapors. Paper read at 13th International Congress of Occupational Health, New York, July 25–29, 1960.
25. Kitagawa, T., and Wright, B. M. A quantitative detector tube method for breath-alcohol estimation. *Brit. med. J.,* 1962, **ii,** 652–653.
26. Klose, Irmela. Einstellnystagmus ohne Alkoholgenuss. (Gaze nystagmus without use of alcohol.) *Blutalkohol,* 1963, **2,** 63–64.
27. Lereboullet, J., Amstutz, C., Leluc, R., and Biraben, J.-N. Dosage de l'alcool dans l'air expiré et alcoolémie. (Measurement of breath alcohol and blood alcohol.) *Rev. Alcool.,* 1961, **7** (unpaged reprint).
28. McCarthy, R. G. (Ed.) *Drinking and intoxication: selected readings in social attitudes and controls.* Glencoe, Ill.: Free Press, 1959.
29. Monnier, D., and Ruedi, W. Etude critique du "Breathalyser" appareil de dosage de l'alcool dans l'haleine. (Critical study of the measurement of breath alcohol by means of the Breathalyzer apparatus.) Published as a separate without editorial indication. (Authors at University of Geneva.)
30. Osterhaus, E., and Johannsmeier, K. Gaschromatische Bestimmung von Alkoholen, Aether und Aceton im Blut und Urin. (Gas-chromatographic determination of alcohols, ether, and acetone in blood and urine.) *Blutalkohol,* 1963, **2,** 65–67.
31. Pittman, D. J., and Snyder, C. R. (Eds.) *Society, culture, and drinking patterns.* New York: Wiley, 1962.
32. *Proceedings of the symposium on alcohol and road traffic.* Bloomington, Ind.: Department of Police Administration, Indiana University, 1959.
33. *Quarterly Journal of Studies on Alcohol.* Rutgers University, 73 Easton Ave., New Brunswick, N.J.
34 *Revue de l'Alcoolisme.* Maisson et Cie, 120 bd. Saint-Germain, Paris 6, France.

35. Symposium—breath alcohol tests. *J. forensic Sci.,* 1960, **5** (4).
36. Thompson, G. N. (Ed.) *Alcoholism.* Springfield, Ill.; Charles C Thomas, 1956.
37. Tipton, D. L., Jr., Sutherland, V. C., Burbridge, T. N., and Simon, A. Effect of chlorpromazine on blood level of alcohol in rabbits. *Amer. J. Physiol.,* 1961, **200,** 2007–2010.
38. *Traffic Digest and Review.* The Traffic Institute, Northwestern University, Evanston, Ill.
39. Vidoni, G., and Redenti, L. La determinazione dell'alcoolemia sull'aria espirata. (Determination of blood alcohol from expired air.) Published as a separate without editorial indication. (Authors at University of Parma.)
40. Wallgren, H. Effects of acetylcholine analogues and ethanol on the respiration of brain cortex tissue *in vitro. Biochem. Pharmacol.,* 1961, **6,** 195–204.

CHAPTER I

Social Psychological Factors in Drinking-Driving

IRA H. CISIN, Ph. D.[1]

Introduction

The purpose of this chapter is to encourage thought and discussion of some of the social and psychological problems associated with driving after drinking. The deplorable record of destruction of life and property attributable to driving under the influence of alcohol is well known and thoroughly documented elsewhere. The failure of the law enforcement agencies and of society to control this menace stands as a disgraceful comment on our value system.

The motor vehicle has become the principal means of transportation in the United States. Daily, millions of Americans drive their cars to and from work; millions of housewives drive to and from the local shopping center or the downtown area; millions of families drive to and from places of recreation; and almost all of this driving is done safely. Both in the operation of their own cars and in their relationships with other drivers, most drivers display the caution and courtesy required to maintain a reasonable balance between getting to one's destination quickly and getting there safely. On a relatively small number of occasions, drivers—through lack of skill, through lack of social responsibility, or for any of a number of other reasons—behave in such a way that accidents occur. One special class of irresponsible behavior—driving after drinking—has been singled out for special attention here. The essential questions are: Why does this particular kind of irresponsible behavior occur? What kinds of people are these drunken drivers? Are they ignorant of the special risks they are taking?

[1] While the author has had the full responsibility for the preparation of this paper, the contributions of the following participants in a preliminary conference held on Sept. 12–13, 1960, are gratefully acknowledged: Selden Bacon, Rutgers Center of Alcohol Studies; John L. Haer, Pomona College; Harold Mulford, State University of Iowa; and Christopher Sower, Michigan State University.

Or don't they care what happens to themselves and to others? Are they indulging in a motorized exhibition of the death wish? Or are they the heroes of a Greek tragedy, propelled by psychological and cultural forces beyond their comprehension and certainly beyond their control?

The reader will not find the answers to these questions in this chapter. Rather, he will find a discussion of the questions in the light of sociological and psychological theory, an attempt to place the questions in the perspective of larger questions, and a review of research findings bearing upon the issues. It is the author's hope that this kind of systematic presentation of the problem will stimulate others to think about the kinds of research that might be done to increase our understanding of driving after drinking and related phenomena. Only if this objective is achieved are we likely to reach the stage where it is possible to speak intelligently about steps which might be taken to control the problem. And it should be clear from the outset that understanding is not enough; the ultimate goal is control, and no amount of descriptive or analytic research will contribute to the solution of the problem unless the increased understanding can be converted into practical, realistic control measures. It is in this spirit, then, that we begin our inquiry into the social psychological variables that work for and against driving under the influence of alcohol.

What Is Driving After Drinking?

How much alcohol is required before normal driving skill is impaired? If a precise answer to this question were required, there would be little time for consideration of any of the other problems associated with driving after drinking. The question is a trap; we do not have a test by which normal driving skill can be unequivocally rated. We can test behavior patterns which are assumed to be reasonably related to driving skill; we can measure reaction times, visual and other perceptual abilities, even the intrinsically complex psychological phenomena of risk-taking, attitudes, and judgment. But we cannot integrate these tests into a single meaningful score that can be called driving skill, because we do not know how they interact in the process of summation. Furthermore, we do not know what kinds of weights to apply to compensatory mechanisms through which increases in one kind of skill can make up for decreases in another kind of skill. Obviously, if we cannot evaluate normal driving skill, the job of estimating decreases in driving skill attributable to some specific stimulus is hopeless.

Fortunately, we do not have to answer the question of how much alcohol is required for impairment of normal driving skill. It is generally conceded that virtually any discernible amount of alcohol in the blood will be accompanied by a decrease in competence in the operation of a motor vehicle; and, for our purposes, we may not have to specify the mechanism by which the decrease in competence is accomplished, nor face up to the insurmountable problem of measuring the decrease. It may be sufficient, for the moment at least, to agree that *any* drinking impairs driving.

Although this kind of evasion of the measurement problem may be supportable for the researcher whose primary interest is in motivation and the control of motives, it should be noted that the task of the law enforcement authorities is not quite so easy. Driving under the influence of alcohol is outlawed almost everywhere, and thus it has fallen upon the legislators, the law enforcement agencies, and the courts to define the illegal act. It is not surprising, therefore, to find that the definition universally evades the difficult problem of measuring driving skill and demonstrating its impairment. Rather the illegal act is defined as driving under the influence of alcohol; then, depending on the jurisdiction, either a specified proportion of alcohol in the blood is accepted as prima facie evidence or the judgment of a police officer or a court is accepted as evidence that the driving is sufficiently impaired to be unsafe.

Apparently, our society is not willing to pay the price of absolute safety, and it appears that some decrement in driving skill is tolerable. So it becomes necessary to define in absolute terms a decrement in driving skill that is to be considered criminal. Since driving skill cannot be measured directly, the measurement of blood alcohol is used as an indicator of decrement in skill. There have been attempts to define a specific level of blood alcohol as prima facie evidence of intolerable decrement in driving skill. Some feel that one of the magic solutions to the problem of driver intoxication lies in legislation reducing the amount of alcohol in the blood that will be acceptable as prima facie evidence. All are familiar with the arguments for and against this proposition. It can only be pointed out here that, from a social point of view, the use as prima facie evidence of such a test will not necessarily receive unanimous public approval. It is known that there are individual differences in alcohol tolerance and that the reliability of the test can be called into question. Probably a clever defense attorney could elicit public support against such prima facie evidence. And when it comes to jury trials, one should not be surprised that juries are extremely reluctant to convict drunken drivers except in the most blatant cases. A learned California judge made a wise comment on this difficulty. He pointed out that when an accused burglar faces a jury, it is extremely unlikely that he is looking at 12 unconvicted burglars. But when a man is accused of drunken driving, it is quite likely that some or all of the jurors are saying: "There but for the grace of God go I." Driving after drinking is not deviant behavior in our society. It is not known how many have been guilty of driving after drinking; but it is extremely likely that the apparent ambivalence in public attitudes toward driving after drinking stems from at least a modicum of experience. It would be well to remember, in the search for control mechanisms, that a great many persons have had the experience of driving after drinking, and of doing so without accident.

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Thus, we may be dealing with behavior that has been reinforced, or at least behavior that has gone unpunished in the past.

Where blood tests are used, the fact that driving under the influence is defined in terms of a specified proportion of alcohol in the blood is apparently an attempt to strike a balance between two sets of facts: On the one hand, the presence of virtually any discernible amount of alcohol in the blood will decrease driving skill; on the other hand, some decrease in driving skill is tolerable, and a perfectly arbitrary point must be chosen on this continuum to define an illegal act. The point selected is not only necessarily arbitrary, but, in addition, it ignores individual differences in driving skills and individual differences in the effects of given proportions of alcohol. Washburne (*20*) points out that, even if alcohol is assumed to have certain invariant or fixed physiological effects (a questionable assumption at best), we ought not to ignore the important social and psychological variables which influence behavior in drinking situations and which account for wide differences in reaction to moderate amounts of alcohol, since personal and social factors can affect the physiological system in just as real a way as chemicals. Haggard and Jellinek have phrased this neatly in *Alcohol Explored* when, in commenting on behavior under the influence of alcohol, they stated:

> Many observations suggest that an element of control plays a part in the reaction to alcohol. It may also play a part in what is known as habituation to alcohol, the change by which a man becomes accustomed to alcohol and appears to get less intoxicated or not intoxicated at all on quantities which at one time made him feel drunk. This element of control means that the drinker has become familiar with his usual reactions to alcohol; he has lost his bewilderment over these effects, and therefore it no longer exaggerates his reactions. He comes to know and anticipate the effects and consciously or unconsciously compensates for them. . . . [This does not] imply that there are no definite limits to this control over intoxication. Even the best-controlled man gets drunk if he drinks beyond a certain amount. (*4*, pp. 120–121.)

Thus, our earlier evasion of the difficulties of measuring driving skill and evaluating its impairment may be brought into question. For the behavioral scientist interested only in understanding driving after drinking, it may be sufficient to assume that any amount of alcohol will decrease driving skill; but, since our interest is ultimately and principally in the control of undesirable behavior, and since one of the principal means of available control is through legal proceedings, the social scientist is forced to share with the law enforcement agencies the dilemma involved in defining a tolerable decrease in skill and the even greater difficulty of defining driving skill and in measuring its decline attributable to alcohol. We cannot refute the claim that some people who are legally under the influence of alcohol can drive more efficiently than some other licensed drivers who have never had a drink. Clearly what is needed in this area is further analysis of the skills involved in driving, their integration into a usable single measure of driving competence, and tests which will discriminate between those with an acceptable level of competence and those without, recognizing that individual differences require us, in all fairness, to define as illegal behavior the incompetent operation of a motor vehicle because of drinking rather than the possession of some arbitrary proportion of alcohol in the blood. It is not just the need for fairness that impels this suggestion; as pointed out in a later section of this chapter, the problem of driving after drinking may be regarded as a special case of incompetent or below-standard driving (implying that the comparative standard should not be the offender's own nondrinking driving ability but some tolerable safety standard approved by the community) and that a broader perspective requires us to address ourselves not only to the prevention of driving under the influence of alcohol but also to the prevention of incompetent driving from whatever cause. Such a goal may not be entirely practical, but increased effort toward the construction and standardization of tests of driving skill could do much toward the accomplishment of this larger objective.

How Does Drinking Affect Driving?

Although we may not be able to specify all the component skills that go to make up driving competence, and although we do not know how to integrate these components into a single measure of driving skill, a great deal of work has been done to demonstrate the effect of alcohol on the various perceptual and psychomotor skills involved in driving. In general, this work has been atomistic, developing more and more refined techniques in an attempt to draw more exact curves of decrement in function as blood alcohol was increased. Some crude beginnings toward overall ratings of driving skill have been made, and some ambitious estimates of proportionate decrease in skill have been attempted—with no recognition, however, that expression of decrease in proportionate terms requires a ratio scale with an absolute zero that obviously does not exist for driving skill.

Several lessons are to be gained from a review of the literature on the relationship between alcohol and driving skill. (See ch. III.) First of all, it seems obvious that even small quantities of alcohol impair driving skill, whether that skill is somehow judged globally or whether it is measured in terms of presumably relevant components. This impairment stands out as a conclusion even though each individual study can be criticized methodologically for the kinds of faults that Jellinek and McFarland pointed out in 1940 (*7*), and which Carpenter notes in chapter III. Even very recent studies commit the grievous error of reporting proportionate decrement in tests for which no zero point exists. But the weight of evidence is too great, so that even the methodological purist must strain to withstand it.

Second, it is interesting to note the trend in psychological research in the area of drinking and driving. Early studies tended to concentrate on presumably elemental characteristics like reaction time; most recently the trend has been toward evaluation of what might be called the whole driving skill, using simulators and actual total driving tests. There seems to be no middle ground in which behaviors which are more complex than the simple psychomotor tests and yet less complex than the total driving skill are studied.

Third, and perhaps most important for the social psychologist, there seems to be a remarkable paucity of literature dealing with the strictly psychological concepts as distinct from the psychomotor concepts. The social psychologist is accustomed to thinking of behavior in terms which emphasize its motivation and its effects on interpersonal behavior. Thus driving may be thought of as a kind of risk-taking behavior, and the effects of alcohol on driving efficiently may be economically studied through investigation of its more general effect on the total class of risk-taking behaviors. Similarly, strikingly infrequent in the literature are references to the effect of alcohol on the relief of inhibitions, its effect on self-perception and self-confidence, its effect on attitudes, values, and judgments. The kinds of concepts mentioned here are as important in the understanding of driving behavior as the psychomotor concepts; and without an understanding of the effect of alcohol on these strictly psychological phenomena, tests of global driving skill become virtually meaningless. It is strongly suggested that the attention of social psychologists be invited to this virtually unexplored area of the effects of alcohol. For those of us who are interested in the control of drinking-driving, and who are not too optimistic about the possibility of completely eliminating it, such work might provide an alternative avenue toward control. If, for example, we knew more about the effect of alcohol on risk-taking behavior (an effect to which most card players will testify), and if we knew more about compensatory mechanisms employed by drivers who are aware of the fact that their psychomotor responses are slowed down, it might be possible to reduce the effects of driving after drinking through a campaign designed to modify risk-taking behavior and to encourage employment of the compensatory mechanisms. In any case, there is a lack of information on the very kinds of psychological phenomena that seem most amenable to modification through education and propaganda.

How Big Is the Problem?

It may be sufficient to say that the problem is big enough and important enough so that something must be done about it. We can point to the available statistics to demonstrate that it accounts for considerable losses of life and property, not to mention the untold misery associated with these losses. On the other hand, it may be argued that society tolerates, and apparently must tolerate, some losses of this type, and that at least some part of these losses would have occurred even if no driver ever had any alcohol in his blood. Yet, it seems obvious that the losses from driving after drinking have long since passed the undefined tolerable limit set by our society. Laws against it are not unpopular laws; no one steps forth to say a good word.

In our zeal to control the problem, however, we assume two important kinds of risks. The first is a kind of scientific risk involving the drawing of conclusions from inadequate data. This is not a plea for decreased emphasis on the problem; rather, it is an attempt to point out the need for information that would help to clarify its size and nature, and perhaps provide some guide to its solution. We know that a great deal of economic loss, human suffering, and death can be attributed to driving after drinking; and yet the devil's advocate might argue that we have not demonstrated beyond all doubt that the intoxicated driver accounts for significantly more than his share of this loss. Berry in 1940 (*1*) pointed out the great variation in statistics showing the part alcohol has played in traffic accidents: "The reported frequency of drinking violations on the part of drivers involved in fatal accidents, based on 1939 summary reports from States, varies from as low as 0 percent to as high as 24.9 percent. For pedestrians, the variation was from 0 percent to as high as 30 percent." Efforts on the part of the National Safety Council to standardize accident-reporting forms presumably have helped to remedy this situation, but there is undoubtedly still considerable variation in the probability of attribution. (See ch. II.) But even if it were possible to decide unequivocally whether or not alcohol is involved in any given accident, since we do not know at any moment how many drivers are on the road under the influence of alcohol, we cannot clearly reject the hypothesis that intoxicated drivers account for no more than their proportionate share of accidents. The hypothesis can, of course, be put in more palatable form: Through a relatively inexpensive survey of the alcohol concentration in a sample of drivers in a small number of communities, we could find out how much more than their share the intoxicated drivers contribute to the accident statistics.

The other risk is that of an overly narrow perspective. Since we want to curtail driving after drinking, we concentrate on it as our problem and we do not choose to see it as one of a class of problems which are worthy of our attention. There are those who would argue that this problem is trivial in comparison to the problem of national survival in an atomic age—but that kind of argument can be used to kill off any research idea except the most universal and basic. Assuming national survival, we have many problems that are worthy of our scientific as well as our patriotic attention. Somewhere between our most global perspective and our narrowest perspective, perhaps driving after drinking can be seen in a kind of middle perspective, as a special case of incompetent driving—and perhaps we can address ourselves to research on the causes of incompetent driving. It is conceivable that some of the other causes which have not been investigated account for more economic loss than this problem. It is even conceivable that in this slightly broader perspective, we may stumble upon means of control that could apply to driving under the influence as well.

Earlier in this chapter, it has been noted that a body of literature demonstrates rather conclusively that alcohol in the bloodstream results in an impairment of functions which are clearly related to driving skill. It may have occurred to the reader that virtually identical results could have been produced if the experimental variable had been fatigue rather than alcohol. And yet we have no laws against driving while tired, and we do not contemplate any major effort to determine how many people are on the road when they are too tired to drive efficiently, or to discourage them from doing so. Similarly, we might observe very similar effects if our experimental variable were frustration—either momentary frustration such as we frequently feel in traffic jams at rush hour, when it is easy to observe the clearly unsafe driving practices of those to whom the frustration is intolerable, or the cumulative frustration that follows a particularly difficult series of experiences. Certainly, detrimental effects on driving skill would be observed if the experimental variable were any of a class of "miracle" drugs, including those specifically intended to tranquilize or those with demonstrated physiological and psychological side effects detrimental to driving skill. To say that these effects are tolerable while those attributed to driving after drinking are intolerable is to isolate only one of the causes of incompetent driving. Our true goal, of course, is the prevention of automobile accidents, and it is suggested here that, without diminishing our efforts to control drinking-driving as a cause of accidents, we might well devote some of our research and control effort to some of the other obvious causes.

We might even be tempted, in this more general approach to the problem of automobile accidents, to examine some of the other causes of incompetent driving—including the licensing laws which, in at least some cases of automatic renewal, grant a lifetime privilege to operate a motor vehicle on the basis of tests whose validity is open to serious question. We might even look into the allegation that automobile design has something to do with driving competence and investigate the frequently leveled charge that driving has been made so comfortable and easy that the driver is no longer required or encouraged to exercise the appropriate caution and responsibility.

Thus, a broad-gauged program designed to prevent automobile accidents, or at least designed to reduce their frequency and their effects, would call for research aimed at the understanding and the ultimate control of driving incompetence, including those factors which affect driving competence temporarily (of which alcohol is perhaps the most important one). Such a broad-gauged program might not have the dramatic appeal of a program designed to curb the presumably easily identified and unpopular drunken drivers, and, of course, it may be argued that research should proceed from the smaller problem to the larger one. It is not our intention to pursue this argument, so it will be assumed in the remainder of this chapter that the area of principal interest is driving after drinking, and that progress toward the abatement of that problem is a required first step toward an approach to the larger problems of automobile accidents and incompetent driving.

Who Are the Drinking Drivers?

Except for information gained from occasional police roadblock traffic checks and information gathered from arrest and conviction records, there are very few descriptive data on the intoxicated driver. What manner of person is he; does he come from a particular stratum of society; does he tend to be alone or in company? Where is he going and whence has he come? The kind of spot-check survey mentioned earlier might yield these kinds of data; but without such a survey, one can only guess at the answers.

The police roadblock traffic checks may provide a preliminary answer to estimating the number of drinking drivers on the road, although customarily in such traffic checks, tests are not systematically given to all drivers; only those who appear to the inspecting officer to be clearly under the influence of alcohol are cited. These checks are customarily scheduled on holiday weekends, and have the multiple purpose of curbing drinking-driving and detecting mechanical failures.

During the July 4, 1960, weekend, the police of Berkeley, Calif., observed 766 vehicles in a roadblock traffic check. Of these, 652 were stopped for closer inspection (*13*). A total of 134 citations were made, of which 1 was for drunken driving, 102 for improper lights, 14 for invalid operators' licenses, 7 for improper registration, and 10 for mechanical defects. Three drivers who had apparently been drinking were issued warning citations.

In 11 neighboring communities during the same weekend, over 23,000 vehicles were observed in traffic checks, and almost 10,000 of these were stopped for closer inspection. Over 1,000 citations were issued, 5 persons were arrested for drunken driving, and 26 were warned for drinking while driving. The number of citations for mechanical defects far exceeded the number for drunken driving.

The purpose in giving these statistics is not to say that we should be devoting ourselves to other problems rather than to driver intoxication. The fact that other factors, including mechanical defects, fatigue, tranquilizers and other medication, may increase accident hazards even more than alcohol merely defines larger targets for future consideration. In this chapter concern is directed toward what can be done about drivers who have been drinking.

These sparse records on traffic checks provide little information on the characteristics of the intoxicated drivers. The police records simply do not record the kind of information that would be of interest here. The rates of arrests for drunken driving in the traffic checks were approximately the same, although the communities involved were quite varied in their composition. This kind of gross comparison, however, does not provide the type of data necessary for study, and there would be much to be learned from the participation of social scientists in similar checks in the future.

Similarly, the arrest records offer only the most imperfect data for the study of the characteristics of the intoxicated driver. It is frequently alleged that arrests for drunken driving are selective—that in certain neighborhoods involving certain social strata, the police are more lenient about this offense than they are in those neighborhoods which generally offer them more trouble. Thus, it would be extremely difficult, even if more information were gathered on arrested offenders, to make comparisons between intoxicated drivers and the general population. If a bias exists in the tendency to arrest for this offense, such a comparison could merely reflect the bias rather than the truth. To avoid this bias, and to study the unique characteristics of the crime of drunken driving, Jacobsen, in Belgium during 1956, made a comparison between 207 persons convicted of drunken driving and 1,046 persons convicted of other crimes (*5*). Comparisons were made on place of residence, age, marital status, education, social class, income level, and drinking habits. Of the variables studied, only drinking habits successfully differentiated the two groups. Those who were arrested for drunken driving were "characterized as people of intermittently high alcohol consumption at comparatively short intervals." Perhaps the greatest light shed on the problem of driving after drinking by Jacobsen's study is his finding that one out of five of the intoxicated drivers had a previous record of conviction for violation of some other portion of the criminal code. If this figure were to stand up under careful scrutiny for bias in the probability of arrest, it would indicate that a significant portion of the driving after drinking is done by persons in whom antisocial tendencies are at least suspected.

Obviously intensive study of the demographic, social, and psychological characteristics of the intoxicated driver is vital for an understanding of the problem. The lack of such information seriously cripples the kind of explanatory effort that is being undertaken here. Perhaps even more important, these kinds of information must be available for the definition of "target populations" in any education and propaganda control program. Even if circumstances are such that we cannot obtain this information in a sampling survey of drivers, it would be useful as a first step to analyze police arrest records for the characteristics of interest.

Why Does Driving After Drinking Occur?

Perhaps some inferences can be made about the characteristics of intoxicated drivers from the available information about drinking. With the aid of recent studies, we can now put at least some numbers on American drinking behavior. For example, the drinking of alcoholic beverages is not limited to a small group of persons. Estimates of the drinking public range from about two-thirds to three-fourths who at least sometimes drink alcoholic beverages. And, of those who drink, quite a few drink frequently. About 4 Americans in 10 drink beer at least once a week; about 1 in 4 drinks whisky at least once a week. Also, men drink more frequently than women and consume larger quantities; and it is known that drinking varies according to age, reaching its peak in the age group between 35 and 40.

The social circumstances surrounding drinking indicate that it does not occur randomly across the hours of the day and the days of the week. There are certain peak periods for drinking, centering around evening hours before and after dinner. And weekend drinking far outweighs the drinking done during the working week; in a recent Berkeley survey more than 80 percent reported that they do most of their drinking on weekends.

It is a safe guess that about half of all the drinking occurs in situations where the probability of driving afterward is very low. In a nationwide study about half the people reported that their last drink occurred in their own homes. The other half, however, required some form of transportation from the place where the drinking occurred; the majority of these were drinking at the homes of friends rather than at taverns or bars. Drinking is, for most people, a social event which occurs in the presence of friends and family members.

Why do people drink? Motivation for drinking can be discussed either in terms of the fulfillment of individual needs or as the result of social influences, depending on the philosophic and disciplinary position of the person leading the discussion. Drinking is complex learned individual behavior, which almost always occurs in a social setting; an individual's drinking behavior at any one time seems to reflect his early training, his momentary needs, his long-term psychological needs, and the social context in which he finds himself or into which he has thrust himself.

Driving is also individual learned behavior which appears at first glance to be somewhat less complicated than drinking behavior. Since driving requires learned motor skills, the effect of early training on a person's characteristic driving behavior is likely to be very great. Motivationally, driving fulfills a limited range of needs. Except for the occasional joyride or the Sunday afternoon excursion into the country, driving provides the means for getting from one place to another. Much driving serves only the goal of changing location. We do not know this as a certainty because we have no systematic data on where drivers come from, where they are going, and what they expect to achieve by getting there. But it is probably safe to assume that driving provides some kind of service or auxiliary function; the main purpose of driving is to get it over with. Of course, we do not mean to imply that driving serves no important psychological functions in addition to its principal function of locomotion. It cannot be denied that driving provides a feeling of power, of strength, of increased status. Certain driving practices with which everyone is familiar provide the driver an opportunity to indulge his death urge or at least to demonstrate his daredevil tendencies. It is likely that drinking helps to exaggerate the already deviant behavior of the psychopathic driver—but it seems fair to point out this man's problem is not essentially one of drunken driving. Similarly, the contribution of the chronic alcoholic to the problem of drunken driving is not the problem under discussion here (*14*).

It is fair, then, to distinguish three kinds of drinking drivers:

1. *The chronic alcoholic who drives.* For this type the essential problem is not that he drives after drinking, but that he does everything after

drinking; his essential problem, and the community's problem with him, is his drinking and the problems that it causes, including bad driving. He can be prohibited from driving, of course; but such prohibition would represent only superficial solution of the problem. In short, we should be treating his alcoholism directly.

2. *The irresponsible driver who drinks.* This man is a menace on the road, drunk or sober. The fact that he drives after drinking represents only an incidental increase to the menace. His real problem is intolerably bad driving. Again, treating that aspect of his problem which involves the interaction between drinking and driving would reflect concentration on the specious rather than on the real problem; this man has to be taught to drive.

3. *The "normal drinker" who is a "normal driver" but who sometimes does both in close temporal conjunction.* While we do not know what proportion of driving after drinking is represented by each of our three groups, it is clear that only for this last class does the *interaction* between drinking and driving represent the essence of the problem. For members of this class, driving after drinking occurs when occasions arise such that the extremely complex motivational pattern which leads to drinking coincides with the relatively simple motivation to change location. In examining this conjunction of motives, let us look first at the individual needs, the social influences, and the situational contexts in which drinking occurs, with particular emphasis on those aspects of drinking motivation that are likely to lead to a change of location.

Initially, it should be noted that motivational studies on the chronic alcoholic are not relevant here. For the chronic alcoholic, drinking is an end in itself, the motivational pattern is one of compulsion, and control measures must take account of the essentially pathologic nature of the drinking. If the chronic alcoholic has access to an automobile and decides to use it to change location, he creates a problem of drunken driving, but the real problem is his compulsive alcoholism. Our discussion of motivation is therefore limited to drinking of the "normal" population, leading to driving after drinking when this normal drinking is followed by a need to change location and a willingness to drive a motor vehicle to accomplish the change.

In 1948, Riley and others (*17*) reported the results of the first nationwide sampling study on the motivational pattern of drinking in the general population. Riley summarized his results in the table on p. 13.

Riley's summary of his findings offers encouragement to those interested in the control of drinking and, indirectly, to those interested in the control of drunken driving:

> . . . the data lend powerful support to the hypothesis that drinking is as directly motivated by the influence of social pressures as it is by acquired inner drives. . . . Of all the people who state that they sometimes drink, more than two out of five assign main motivation to group pressure.
>
> . . . the relative weight of external social pressures versus inner acquired drives varies widely between different classes of drinkers. Direct social pressure is much

TABLE I. *Reported reasons for drinking*

Reasons		*Percent of drinkers*
Social reasons		43
Sociability	38	
To keep husband company	2	
On festive occasions	2	
Brought up with it	2	
As business courtesy	1	
	[1] 45	
Individual reasons		41
Makes me feel good	16	
I like it	12	
Quenches thirst	6	
Stimulates appetite	4	
Other health reasons	4	
	[1] 42	
Both social and individual reasons		6
Other reasons		2
No reasons given		8

100 percent equals 1,774.

[1] These apparent discrepancies are due to the fact that more than one answer was possible within the major categories.

more influential in motivating the drinking of women compared with men; the young compared with the old; and the occasional or infrequent compared with regular drinkers. On the other hand, seasoned and regular drinkers tend to state that their reasons for drinking lie more within themselves than in the direct pressures from the group situation.

. . . Since . . . social pressures play a large part in motivating drinking, they also by indirection indicate that social pressures can be brought to bear to limit drinking. But what type of social pressure is here involved? It is probably not custom—except in the case of those who descend from particular ethnic backgrounds. It is something too short-lived for that. It is certainly not institutional pressure, since with few exceptions the basic institutions of our times denounce drinking, however much the individual members may not practice what the mores admonish. It is rather the kind of transitory social pressure which characterizes so much of the personal behavior of people in a rapidly changing social order when the old mores are outmoded and new mores, or authoritatively sanctioned rules of behavior, have not replaced them. From this point of view the effective control of the problem aspects of drinking requires the establishment of new authoritative group sanctions, founded on science and supported by basic institutions. In the meantime anything which can be done to alter the one-way influence on drinking patterns of these temporary normative pressures will point in the same direction. (*17*)

Mulford and Miller's study of the population of Iowa sheds further light on the uses of alcohol in a general population (*12*). They sought to construct a measure of the meanings of alcohol to users as well as abstainers, ". . . a set of behavioral definitions of what he does *with* alcohol and *to* alcohol, and what alcohol does *for* him and *to* him." The resulting instrument, a cumulative scale of definitions of alcohol, is shown in table II.

TABLE II. *The Iowa Scale of definitions of alcohol*

Contrived item	Statement no.	Percent agree N=1185	Percent agree N=810*	Content of statement	Method of scoring
I	1	5	8	†Liquor helps me forget I am not the kind of person I really want to be.	Agree on any 2.
	2	9	14	Liquor helps me get along better with other people.	
	3	10	15	†Liquor helps me feel more satisfied with myself.	
II	4	13	20	Liquor gives me more confidence in myself.	Agree on any 3.
	5	14	20	Liquor helps me forget my problems.	
	6	14	21	Liquor makes me less concerned with what other people think of me.	
	7	16	24	Liquor helps me overcome shyness.	
	8	17	25	†Liquor makes me less self-conscious.	
III	9	24	36	†Liquor makes me more carefree.	Agree on any 3.
	10	30	44	Liquor peps me up.	
	11	31	46	Liquor gives me pleasure.	
	12	32	46	†Liquor helps me enjoy a party.	
	13	33	49	Liquor helps me relax.	
IV	14	34	50	Liquor improves parties and celebrations.	Agree on any 3.
	15	37	54	†Liquor makes a social gathering more enjoyable.	
	16	37	55	Liquor goes well with entertainment.	
	17	41	60	A drink sometimes helps me feel better.	
V	18	58	84	†Liquor is customary on special occasions.	Agree.
VI	Failure to respond affirmatively to the preceding items.				
	19	45	....	Liquor always causes problems for the drinker and his community.	
	20	33	....	Liquor is entirely and completely a social evil.	

*This is that portion of the total sample of 1,185 who responded positively to one or more of the first 18 statements listed here (*12*, p. 271).
†These 7 statements were used in a special test of the hypothesis of scalability (*12*, pp. 271–272).

In commenting upon their findings, the authors point out that the "personal-effects drinker" (scores I, II, or III) agrees to the items in the upper part of the scale in addition to accepting the social-effects statements lower on the scale. An association was found between the number of "reasons" for drinking and the amounts of alcohol consumed, and "to account for the heavier consumption of persons who obtain higher scores on the scale (personal-effects drinkers), it can be theorized that they are using alcohol as a means of attaining a greater number of goals than the persons who obtain a lower scale score (the social-effects drinkers)." In short, while the personal effects of alcohol are thought to be of great importance in any explanation of drinking behavior, a great deal of drinking is of a type closely associated with social functions—and the personal-effects drinking is in addition to and not instead of the social drinking. Further, it seems more than reasonable to expect that the drinking behavior which is an important part of the lives of so many people will, at least on occasion, overlap with driving behavior to create the situation with which we are here concerned.

The general tenor of the above findings tends to be confirmed in studies of more restricted populations. In 1952, Slater reported the results of a survey among high school students in Utah, emphasizing the importance of social motivation for those who drink (*18*). Although the proportion of students who drank corresponded closely to figures for parents of the same sex, 32 percent of the girls and 59 percent of the boys who used alcohol said they drank at least sometimes in circumstances not approved by their parents.

The role of the parents and the home in influencing drinking patterns and attitudes toward drinking is, of course, dramatically illustrated in studies such as that reported by Landman in 1952 (*9*).

The importance of the social occasion as a determinant of drinking is emphasized in the results of a poll conducted by Maxwell in 1952 in Washington State (*10*). Maxwell found that the majority of drinkers drank mostly on weekends and holidays. Four out of five designated the evening as the time when most drinking was done. The social pressure on drinking behavior is evident in the fact that the reasons most frequently checked as motives for drinking included: it seems to be the thing to do at some social gathering, on certain holidays; it permits one to fit better at social occasions. Individual reasons were presented by such statements as: it helps to relax after a hard day.

In 1955, Haer published a further analysis of Maxwell's data (*2*), ". . . to throw additional light on the problem of motivation and group influence on drinking by determining . . . the manner in which the drinking patterns of individuals are associated with those of certain family members and friends, and . . . the manner in which this association varies with selected personal and social characteristics . . . ." It was found that drinking patterns of the subjects in the study were most closely related to those of friends, then to those of his immediate family, and least to those of parents, indicating that the behavior of contemporaries is much more influential on drinking practices than that of the previous generation. Friendship cliques and the primary family constitute reference groups of great significance in regard to drinking norms and behavior, although these findings are not completely consistent when further analyzed for various sex, age, education, and rural-urban residence groups.

Straus and Bacon in the monumental 1953 study of the drinking of 16,300 college students concluded that college drinking reflects the drinking patterns of the population groups from which the students are drawn; that maturation and social background have more influence on the quantity and frequency of drinking than does entrance into college (*19*). Thus, there were clear correlations between the drinking patterns of the students and their ethnic and religious backgrounds, parental customs, family income, participation in religious and social activities.

The importance of religious affiliation, family influence, and group pressures is brought out in Jones' 1957 study of drinking among Utah high school students (*8*). One of the striking findings of this study is that a significant proportion of the students said they did their drinking in cars. If the practice of drinking in cars were to prove fairly prevalent in a general study, and not merely restricted to rural areas and the "dating" age group, we might be forced to reconsider the assumption that driving is primarily a means of changing location and that drinking-driving occurs largely *after* the drinking has occurred in some fixed location. We have very little information on the frequency with which cars are used as stationary locations for social activities such as drinking (*11*).

Assuming for the moment, however, that the use of the automobile as a substitute for a room is a teenage phenomenon that has little significance for most driving while intoxicated, what conclusions can be drawn about the motivations and the situations conducive to drinking-driving? We do not have the necessary information on which to base conclusions, but certain assumptions seem fair. Drinking certainly serves individual needs, but it occurs primarily in social settings and is fostered by group pressures and social influences. We really should find out where these drivers are coming from and where they are going, but it seems safe to assume that an important part of the problem occurs when people leave the social setting (the party or the bar) and head for home, or head for another social setting.

Consider the party as a phenomenon in American culture. Although party behavior has not been thoroughly studied, and although its study is likely to be discouraged by the adverse publicity surrounding Riesman's pioneering work (*16*), the role of the party guest and the party host are fairly clearly delineated. The guest who does not drink is somewhat out of place at many parties; he is just not a part of the social group. The proper guest cooperates in making it easy for the host to play his defined role: that of pressing drinks upon his guests. The party host who tries to minimize his guests' drinking is regarded as stingy and runs the risk of becoming the target of gossip. The correct host stages a kind of alcoholic potlatch, making sure that everyone has a glass and that no glass is permitted to remain empty. It is not the host's job to worry about how his guests will get home; and the guest who expresses such worry is challenged as a spoilsport. This picture may be somewhat overdrawn, but it is certainly true that the role of the host at a middle-class or upper-middle-class party is not conducive to sobriety on the part of his guests.

At least one psychiatrist (Knupfer) sees in his host role a shift in the general pattern of interpersonal relations in American culture which is perhaps best reflected in shifts in parental attitudes toward children. The old puritanical attitudes toward child care emphasized the responsibility of the parent to bring up a child to be a "good person," emphasizing moral behavior and the Protestant ethic. Current attitudes toward child rearing place far greater emphasis on the responsibility of the parent to make his child "happy," encouraging a permissive atmosphere and a minimum of restrictions. In a sense, the party host is a temporary father figure for his guests, and his role emphasizes his obligation to insure their happiness (which is perceived as temporarily attainable through drink) rather than to guarantee their safety and to encourage their good behavior.

This discussion is not intended as a plea for a return to the "good old days" or as a denunciation of modern morality. It is not suggested that hosts change their behavior since, in most circles, the stigma of stinginess is far worse than the stigma of sending people home in a condition unfit for driving. But, if we are correct in surmising that a great deal of intoxicated driving follows parties at which the host is socially obligated to maximize his guests' drinking, then these parties and the behavior required in the host role must be one of the primary targets for the control of drunken driving.

The substitute host, the bartender, is perhaps less motivated than the party host to insure the happiness of his guests, and it is not socially acceptable for him to force drinks on his patrons. The bartender is certainly less concerned than the party host about being labeled "stingy"; but the bartender has a strong economic motivation to maximize his guests' drinking and is likely to conceive this behavior as the rendering of good service. Few bartenders have the courage to refuse a drink to a customer who has had too many, although many jurisdictions outlaw the serving of drinks to the obviously inebriated. This kind of unenforceable law requiring individual judgment and definition of inebriety does not deter the bartender from serving what is demanded without regard to the possibility that the drinker will try to drive home directly from the bar.

Thus, from the parties and from the bars—if hosts and bartenders successfully play their assigned roles—pour the drinking drivers. Attempts to inject a waiting period between the final drink and the drive home are likely to fail, since no bartender wants a nondrinker occupying his limited space, and no host wants his party to "drop dead" toward its conclusion. Driving after drinking is a volitional act on the part of the guest or customer and, barring major changes in the role of host or bartender, the control of drinking-driving seems to require some modification either of the drinker's behavior or some modification of the means by which he moves from the site of his drinking to his next destination.

One very interesting question that might be answered through more intensive sociological study of party situations has to do with the possibility that some driving after drinking could be avoided by letting some other occupant of the car drive. We do not know, and we might benefit by finding out, how many cases of driving under the influence of alcohol occur when a more sober, qualified driver is riding as a passenger in the car. We have all seen cases, however, in which the husband, playing the dominant male role required by society, insists on driving home after the party, although his wife is a qualified driver and although she has drunk far less than he. How many husbands will permit their wives to drive while they [the husbands] are in the car? And to what extent is the need for display of male dominance intensified by alcohol? We do not have the answers to these questions, but they might help us in our efforts to do something about drinking-driving.

How Do People Feel About the Problem?

The public seems to disapprove of driving under the influence. Such driving is almost universally outlawed and there has never been any popular opposition to these laws. Newspaper editorials, church sermons, and other media reflecting public opinion are unanimous in denouncing the unnecessary waste and hardship attributed to driving after drinking. No one has a good word to say for the intoxicated driver; his offense is seen as weak willed, demonstrating lack of character. It is an unsympathetic offense in its general form.

But what about the specific case? How serious a crime is it, particularly when no significant property damage or loss of life is involved? How badly at fault is the intoxicated driver when you know all the circumstances surrounding his act?

All the available research information indicates that only a small proportion of persons disapprove of drinking as such; disapproval only begins when the drinking is not "in moderation." So a great deal of sympathy can be developed for the driver who has had "only a few" and who was on his way home when the accident occurred. The fact that it is easy to identify oneself with the accused in these circumstances probably accounts for the difficulty in obtaining convictions in those cases that are brought to jury trials. This difficulty has been the source of considerable discouragement to law enforcement agencies charged with responsibility for curbing driving after drinking; it is not surprising that enforcement officers become rather cynical about the public's attitude toward this offense and that they complain about how difficult their job is made. (See ch. VI.)

Thus, the popular disapproval is, at best, ambivalent. Perhaps driving after drinking as an act in itself is not seen as an abuse of alcohol; perhaps it is conceivable to many that it can occur even after only "normal" use of alcohol. To clear up some of the questions about public attitudes toward drinking-driving, Cisin and Fink conducted an opinion survey with a random sample of the adult population of Berkeley, Calif., during August 1960. Some results of this survey are presented in the following tables.

To estimate the extent of public knowledge of the effects of drinking upon driving, respondents were first asked: "At a 2-hour party, how many drinks do you think a person can take and still drive a car as well as usual?" Results are presented in table III. About one person in five felt himself unable to answer the question. Of those who did answer, many volunteered comments emphasizing a knowledge of individual differences in alcohol tolerance and a knowledge of intraindividual differences depending on time and circumstances, including the "empty-stomach" phenomenon. Such persons were encouraged to answer the question in terms of "average" conditions; and of those who answered, about one in three expressed the belief that you can take three or more drinks at a 2-hour party and still drive as well as usual. Many of those who gave this answer were drinkers, so that at least a small target population has been defined for education on this subject.

TABLE III. *Berkeley Survey Responses*

Question: "At a 2-hour party how many drinks do you think a person can take and still drive a car as well as usual?"

	(*N=126*) *Percent*
None	18
1 drink	6
2 drinks	28
3 drinks	13
4 drinks	9
5 drinks	3
6 or more drinks	2
Don't know or no answer	21

A second question dealt directly with the public's perception of the prevalence of the problem of drinking-driving. Each person was asked to estimate how many people often drive after drinking more than is safe. In answer to this question, more than half of the respondents said "almost everyone" or "more than half the people" often do so. Results are presented in table IV.

Table IV. *Berkeley Survey Responses*

Question: "How many people do you think often drink more than that and drive anyhow—almost everyone, more than half of the people, less than half, or only a few?"

	(*N*=*126*) *Percent*
Almost everyone	18
More than half the people	36
Less than half the people	18
Only a few	11
Don't know or no answer	17

How do people account for the prevalence of drinking-driving? It was hoped that a question asking the respondents to describe the motivation of the intoxicated driver might indicate the level of tolerance or condemnation for driving after drinking. As table V indicates, responses to an open-ended question indicated that the behavior was certainly not approved; yet there was very little severe condemnation. About 4 people in 10 told us that those who drive after drinking probably don't realize the effects of alcohol or, at least, don't realize that they have drunk too much. About one person in four said that people who drive after drinking do so because they have no other way of getting home. Now, of particular interest both to law enforcement people and to those concerned with social control, only 1 in 10 felt that there was something bad or inherently stupid about the drinking driver. By far the predominant attitude was that driving after drinking should be regarded as an error in judgment or as a result of situational factors.

Table V. *Berkeley Survey Responses*

Question: "Why do you think these people drive after drinking too much?"

	(*N*=*126*) *Percent*
"They do not realize that alcohol has affected them"	36
"They need to get home or somewhere else"	22
"People become irresponsible when drinking"	20
"People are just stupid or perverse"	3
Vague answers	5
Don't know or no answer	14

What Can Be Done About the Problem?

Our purpose in reviewing the social psychological factors in driving after drinking and in examining public attitudes on this subject is to lay the groundwork for thinking about means for social control of the problem. What are some of the boundary conditions under which a control program must operate? First, our appeals and our educational messages must be aimed at a major segment of the public, not just at a small number of alcoholics or heavy drinkers. And what is the message we want to get across? Is it an educational message to convince people that drinking will impair their driving? Certainly some people still have to learn this, but the great majority already know it. Perhaps the message that is most important is one that would tell how to get home safely after they have been drinking.

The more pressing need of those interested in understanding and controlling the problem is for more information. As promised in the introduction, this chapter has raised more questions than it has answered. In each section, it has been necessary to stretch available findings to demonstrate their applicability to the problem of drinking-driving. Questions of identifying the intoxicated driver and of accounting for his motivation have had to be answered by surmise rather than by facts. Since we know so little about the problem, are we now in position to suggest any solutions for this problem?

The prohibitionist, of course, has the quick-and-easy solution for the problem and for all other problems associated with drinking. Reasoning that man is essentially a weak-willed creature unable to resist temptation and unable to avoid abuse of a good thing, the prohibitionist reasons that man must be protected against himself. This kind of reasoning ranks with the suggestion that a great many childhood accidents could be prevented if we were to chop down all the trees so that children could not fall out of them. Of course, since driving after drinking requires both alcohol and an automobile, one might just as well suggest a prohibition on automobiles as a prohibition on drinking. Both proposals equally offend the essential value system of our culture, which does not see the abuse in the thing used, but rather sees abuse in volitional human activity and attempts to control abuse through persuasion and legislation against acts rather than against things.

In thinking about control, we might do well to remember that there are three different opposites to the target that we wish to demolish. To the prohibitionist the opposite of driving after drinking is driving after not-drinking; or, trivially, not-driving after not-drinking. Realistically, we shall probably have to set our goal in terms of the third opposite: not-driving after drinking. Let us examine some of the control possibilities, taking as given that people will drink. Some of the possibilities are, like prohibition, in conflict with our current value system. For example, there are those who suggest that if automobile designs were radically changed so as to require greater skill from the operator (in opposition to the trend toward making driving easier and easier), there would be less opportunity for the incompetent driver, drunk or sober, to do much damage. It might also be suggested that automobile traffic be so controlled as to give the driver less freedom. Devices are (or soon will be) available through which, to a significant extent, the motion of an automobile can be controlled from the road rather than from the driver's seat. Thus it would be possible, through automatic devices on the road, to stop a car if it swerved too much from a prescribed path, or if its speed exceeded some fixed limit, or if it approached too close to another car or to some stationary object. All sorts of mechanical devices can be dreamed up if we are willing to give up some of our freedom of locomotion.

How practical would it be to try to modify party behavior? As has been suggested in an earlier section, it is certainly possible that a more complete understanding of the operation of the party phenomenon and of the roles of host and guest might provide clues to the possible changes that might be effected. Advertisements sponsored by distillers on New Year's Eve have admonished us to have coffee as our "one for the road." The coffee itself is apparently of little significance; but any attempt to encourage hosts to maximize the time between the serving of the last drink and the breakup of the party is to be applauded.

In this age of advertising and of marketing research, one is tempted to assume that if enough is known about behavior and its motivation, control can be exercised through manipulation of the motivation. Throughout this chapter stress has been placed on the need for more information as though the delivery of the data would equip us automatically to find solutions. It should be clear, however, that no such guarantee is offered. All that can really be promised is that if we know what kinds of people are most likely to drive after drinking, we can define target populations. But we still face the problem of devising effective propaganda techniques to influence them. Even if we increase our understanding of the motivations involved, we cannot be sure that we know how these motives can be changed. Certainly, bringing the facts before the public can be counted on to have little effect. Similarly, we ought to know by now that a campaign built around "don't" slogans is doomed to failure. Anyone who has ever tried to modify the behavior of a child knows that the "don't" technique is ineffective. In child rearing, we speak of diversion, of substitution, of satisfying the child's motives through approved behavior, thus directing it away from the disapproved behavior. But what diversion is available for the intoxicated driver? He has to get home after the party; he is tired and wants to take his shoes off. Is he to sit in his host's living room waiting to sober up so that he can drive? It is possible that diversions may be found, but none suggests itself immediately.

Are there, then, no practical solutions. One solution, whose only impracticality lies in its expense, would call for rigid enforcement of speed and other traffic laws either through greater vigilance on the part of patrolmen or through increased use of radar devices on all highways. The technique provides a possible solution to the specific problem as well as to the more general problem of automobile accidents. The only question is: Do we care enough about this problem to pay the price of the solution?

Another area of enforcement that deserves further exploration is selective licensing. We know that it is extremely difficult to build a good enough case against the intoxicated driver to convince a judge or jury that his license to drive should be taken away. After all, how will he make a living and support his children if we do not permit him to drive in connection with his work; it is the offender we want to punish and not his children. The threat of loss of license is apparently not a sufficient deterrent. But several suggestions have been made along the lines of selective licensing or differential licensing. Dr. Raymond Fink, for example, has suggested that the licenses of convicted drinking drivers be restricted in such a way that they are not permitted to drive after dark or not permitted to drive except during their working hours. This suggestion deserves very serious consideration. Certainly it creates problems for the law enforcement people, but the problems it creates may be very minor compared to the problems it solves.

Fink has also detected a social trend that might well be encouraged. In certain communities "party pools" have developed, similar to the carpools with which we are all familiar. The party pool operates so that one member of a neighborhood group going to a party by car is designated as the driver for the whole group, and it is incumbent on the designated person not to drink at all. There are even those who keep a roster, so that this burden is shared. In even some primitive societies, it is regarded as the duty of the sober members to get the drinkers home. It is not inconceivable that Americans can be convinced that they are their brother's keeper.

In our search for solutions to complex problems, it is always possible that we assume the solutions must be as complex as the problems themselves, and therefore overlook quick-and-easy "gimmick" solutions. In London prior to 1900, it was possible for a person who was too drunk to find his own way to mail himself home: Without loss of face or dignity, he could request the postal authorities to deliver him. Today, in one of the Scandinavian countries, it is possible to avoid drunken driving by requesting the police to deliver oneself and one's car to one's home. Presumably this is done without any social stigma and at a reasonable fee. Such a device might be worth trying.

The psychopharmacological magic of recent years offers yet another possibility for the solution of the problem. It would seem relatively easy to equip people with miniature self-evaluation devices, and it might become quite a game at parties to test oneself with a little puffmeter. For those who fail the test, it is not inconceivable that a sobering pill could be developed—a pill designed to counteract the effects of alcohol. As early as 1937, Haggard and Greenberg reported animal experiments, concluding that the concentration of blood sugar influences the pharmacological effects of alcohol (*3*). In 1940, Jellinek and Jolliffe (*6*) reviewed the literature on treatment for the manifestations of alcoholism:

> The reduction of alcohol in the body has been regarded as the aim of the treatment of acute alcoholic intoxication ever since people have become intoxicated. In ancient times this was envisaged as driving the alcohol out, and later as washing it out. Now it has become a question of accelerating the oxidation of alcohol. The therapeutic trials of the near past are searches for the best means of increasing the oxidation process, although other aspects of acute intoxication have also received due consideration.

Jellinek and Jolliffe go on to discuss several studies which, although they included various other procedures, included chemical measures to increase the rate of oxidation and to overcome the effects of ingested alcohol. But it is not necessary to think only in terms of pharmacological effects. We have become quite accustomed to mood-manipulating pills, to pep pills, and to other pills which seem to operate on strictly psychological and psychomotor variables. Some combination could conceivably be devised to restore the impairment in driving skill attributable to the effects of alcohol.

Of course, any solution to the problem of the intoxicated driver is dependent upon willingness on his part to avoid driving after drinking. The achievement of this willingness in itself offers a challenge to our skill in mass motivation and the engineering of attitude change. This challenge must be met, lest we be driven in our approach to the problem to the kind of futile fatalism expressed recently by a Cambridge University professor: "Criminologists cannot solve the problem of crime; they should accept that crime is, to a large extent, inevitable, that it is an integral part of our society" (*15*).

References

1. Berry, D. S. Alcohol as a factor in traffic accidents. *Quart. J. Stud. Alc.,* 1940, **1**, 413–431.
2. Haer, J. L. Drinking patterns and the influence of friends and family. *Quart. J. Stud. Alc.,* 1955, **16**, 178–185.
3. Haggard, H. W., and Greenberg, L. A. The effects of alcohol as influenced by blood sugar. *Science,* 1937, **85**, 608–609.
4. Haggard, H. W., and Jellinek, E. M. *Alcohol explored.* Garden City, N.Y.: Doubleday, Doran, 1942.
5. Jacobsen, E. Drinking habits and motor driving: an analysis of 207 offenders. *Acta Med. leg. soc., Liège,* 1956, **9**, 105–116.
6. Jellinek, E. M., and Jolliffe, N. Effects of alcohol on the individual: review of the literature of 1939. *Quart. J. Stud. Alc.,* 1940, **1**, 110–181.
7. Jellinek, E. M., and McFarland, R. A. Analysis of psychological experiments on the effects of alcohol. *Quart. J. Stud. Alc.,* 1940, **1**, 272–371.
8. Jones, E. Student drinking in the high-schools of Utah. Unpublished thesis, University of Utah, 1957.
9. Landman, Ruth H. Studies of drinking in Jewish culture. III. Drinking patterns of children and adolescents attending religious schools. *Quart. J. Stud. Alc.,* 1952, **13**, 87–94.
10. Maxwell, M. A. Drinking behavior in the State of Washington. *Quart. J. Stud. Alc.,* 1952, **13**, 219–239.
11. McCarthy, R. G. (Ed.) *Drinking and intoxication: selected readings in social attitudes and controls.* Glencoe, Ill.: Free Press, 1959.
12. Mulford, H. A., and Miller, D. E. Drinking in Iowa. III. A scale of definitions of alcohol related to drinking behavior. *Quart. J. Stud. Alc.,* 1960, **21**, 267–291.
13. Police Department, Berkeley, Calif. Unpublished data, 1960.
14. Popham, R. E. Alcoholism and traffic accidents. A preliminary study. *Quart. J. Stud. Alc.,* 1956, **17**, 225–232.
15. Radzinowicz, L. (Cambridge University). Quoted in Ideas and men, *New York Times,* Aug. 14, 1960. Sec. E, p. 11.

16. Riesman, D., Potter, R. J., and Watson, Jeanne. The vanishing host. *Hum. Organiz.*, 1960, **19**, 17–27.
17. Riley, J. W., Jr., Marden, C. F., and Lifshitz, Marcia. The motivational pattern of drinking. *Quart. J. Stud. Alc.*, 1948, **9**, 353–362.
18. Slater, A. D. A study of the use of alcoholic beverages among high-school students in Utah. *Quart. J. Stud. Alc.*, 1952, **13**, 78–86.
19. Straus, R., and Bacon, S. D. *Drinking in college.* New Haven: Yale University Press, 1953.
20. Washburne, C. Alcohol, self and the group. *Quart J. Stud. Alc.*, 1956, **17**, 108–123.

CHAPTER II

Drinking-Driving Mortality and Morbidity Statistics

WOLFGANG SCHMIDT and REGINALD G. SMART [1]

Introduction

One question which recurs with great frequency whenever the role of alcohol as an agent in traffic accidents is discussed is, "How important is this problem?" This question typically refers to the percentage of motor vehicle accidents in which drinking drivers have been involved and by implication to the possible role of alcohol as a cause of traffic accidents. Although much has been written on this topic, there is still but little precise information available. Indeed, the most striking feature is the lack of agreement in the findings of various studies and in the official statistics reported by governments. The object of this paper is to summarize drinking-driving mortality and morbidity statistics; to review critically research findings bearing upon the issue; to consider the problems most commonly encountered in this field of research, particularly those of method and control; and to present conclusions that can be safely drawn from such investigations and statistical data.[2]

The scope of this paper can be conveniently described in terms of the categories into which research dealing with this problem has largely fallen.

[1] While the authors have had the full responsibility for the preparation of this paper, the contributions of the following participants in a preliminary U.S. Public Health Service conference held May 16–17, 1960, are gratefully acknowledged: Seymour Geisser, National Institute of Arthritis and Metabolic Diseases, NIH, PHS; William Haddon, Jr., New York State Department of Health; and Herbert H. Jacobs, Hallmark Cards, Inc.

[2] Some studies have been omitted from consideration because of poor documentation, lack of scientific accuracy and dependability, and similar limitations. Some were included for the same reasons as illustrative material.

These are:

1. The extent to which drinking drivers and drinking pedestrians are involved in motor vehicle accidents.
2. The extent to which accident liabilities increase in association with blood alcohol levels.
3. The extent to which individuals with such elevated levels are responsible for accidents.
4. The extent of the accident involvement of alcoholics, or, to put this question in statistical terms: Are persons who drive after drinking and become involved in accidents a random sample of the general population with respect to the prevalence of alcoholism among them?

Since most studies are concerned with more than one of these categories, the material has been organized mainly with reference to sources of data and the methods of analysis employed.

Official Statistics

Statistical information on alcohol as a factor in motor vehicle accidents comes from two general sources: (*a*) routine monthly and annual reports of State, provincial, and municipal governments; and (*b*) special studies revealing some of the circumstances of accidents involving alcohol.

Estimates derived from official records have been frequently criticized (*4, 15, 18*). Differences in methods used in reporting drinking accidents, differences in the completeness of the reported information, and differences in definition and law enforcement are usually singled out as the factors chiefly responsible for the enormous variation found in figures reported by State governments. To illustrate this point, data were tabulated for the years 1939 and 1955 (*4*). These 2 years were chosen for the following reasons. In 1939 reporting methods among the States differed greatly. However, during the period up to 1955 many committees had been working to standardize and improve methods of reporting and summarizing traffic accident information. By 1955 standard forms had been developed and were in use in most States. Because of this it was to be expected that the information given in the 1955 reports would show less variation among the States than that reported in 1939. However, this expectation was not confirmed by the data.

The frequency of drinking violations on the part of drivers involved in fatal accidents in the 1939 State reports varied from zero to as high as 25 percent. For pedestrians, the range was from zero to 30 percent. The range in the 1955 data for drivers involved in fatal accidents was even wider: from as low as 1 percent to as high as 50 percent. Comparative data for pedestrian fatalities were not available for 1955, but the frequency of drinking drivers in all reported accidents is given and ranges from 1 to 25 percent. The variation in these series was so large that the value of the figures as estimates of the magnitude of the problem seems questionable.

Moreover, it would seem probable that this large interstate variation is due in part to factors other than differences in reporting. We know, for example, that the per capita consumption rates of alcoholic beverages vary greatly from State to State. We also know that liver cirrhosis death rates, which can be considered rough indicators of alcohol abuse, differ greatly from one State to another. It is thus possible that some part of the variation in drinking accident frequencies may be a reflection of variation in these two measures; or, to put it differently, States ranking high in these two measures would also rank high in their reported proportions of drinking drivers in accidents, and States ranking low in these proportions would also rank low in their alcohol consumption and liver cirrhosis death rates.

This possibility was tested statistically, but neither of the coefficients of correlation was statistically significant.[3] In other words, neither per capita consumption nor rate of liver cirrhosis mortality "accounted for" the variation in reported drinking accident frequencies.

Attention thus far has been centered on official statistics, since they are frequently used to emphasize or deemphasize (as the occasion requires) the magnitude of this problem. A number of organizations concerned with the problems of traffic safety rely on such statistics to obtain estimates of alcohol involvement in traffic accidents. Regardless of the manner in which these estimates are derived, the wisdom of the choice of data on which they are based would seem open to question.

Governments as a rule are eager to amass statistics, but we should not forget that the collection of data on drinking-driving accidents is primarily oriented toward their use in criminal court cases and civil matters, and not toward their use for research purposes. A further standardization and perfection of data collection methods may produce meaningful and reliable statistics. But these can, at best, answer questions of an ecological nature such as the distribution of the phenomena—in our case driving-drinking mortality and morbidity—over space and over time, or a possible relationship in the data so distributed to the distribution of something else. In essence this approach would generate questions. It would never enable us, however, to draw causal inferences or to isolate factors contributing to drinking-driving accidents. To provide the type of information needed to answer these latter questions requires a totally different approach than has customarily been employed by official agencies. Such an approach would have to begin from a position of speculation with respect to causal factors, then development of investigative procedures and, most importantly, exposure sampling procedures which would enable these speculations to be tested. This might mean that, instead of having a single standardized reporting system across the country, a number of systems would be designed—

[3] The two coefficients of correlation were -0.28 and $+0.01$, respectively.

each for a specific investigation—and possibly be changed when information on a large enough group had been obtained. Examples of this approach will be given later. It will be seen that from these investigations, in which samples of a few hundred accident cases were used, more important information was derived than is available from the millions of accident cases in official records.

Special Studies

Further sources of information on alcohol as a factor in traffic accidents are special studies which are generally of two types: "uncontrolled" and "controlled" studies. Uncontrolled studies in this area, with the exception of two recent investigations (*11, 14*), are concerned only with accidents and accident drivers, and depend for data on official records. On the other hand, the data in what for convenience have been termed "controlled studies" are entirely or in part original with the study, and a degree of control is obtained by matching some of the attributes of accident drivers with those of a group of nonaccident drivers.

Such matching is usually accomplished by obtaining the same information from drivers or pedestrians involved in accidents and from nonaccident drivers or pedestrians passing the scene of the accident. A second distinction relates to the type of accident studied rather than to the type of investigation. All uncontrolled explorations known to the authors deal with fatal accidents only, whereas the controlled studies have frequently included other personal injury accidents as well and, in one instance (*13*), all accidents occurring within a given period. Parenthetically, Coldwell (*6*) recently reported that estimates of the frequency of markedly elevated blood alcohol levels among those involved in motor vehicle accidents, derived from sources other than official reports, have ranged from 10 to 80 percent. As a result, their usefulness is difficult to assess. For more dependable information it is necessary to turn to better documented and better designed investigations.

The group to be considered first is the uncontrolled investigation. Here the limitations are inherent in the restricted nature of the sources of the data available. Thus, one is limited in the choice of causal factors and in the selection of control factors to the information that happens to exist in accessible records of the past behavior of the subject studied. This apparently accounts for the exclusive choice of fatal accidents in such studies, since there is generally more information recorded for this accident group than for any other, and also for the frequent failure to use comparable control groups from the general population, since relevant information on nonaccident drivers is not obtainable from records. Thus the information derived from this type of investigation has validity only with reference to fatal accidents.

Haddon and Bradess (*10*) listed as the foremost shortcomings of such uncontrolled investigations:

> . . . the frequent study of only relatively small fractions of the groups of fatalities whose characteristics these fractions were assumed to represent. Furthermore, it has been a not uncommon practice to group the persons killed without reference to their individual responsibilities for the collisions in which they were involved. In addition, some investigators have studied subjects who have died as long as 24 hours after the time of the accident, a procedure which has undoubtedly resulted in the inclusion of some whose original blood alcohol levels had undergone substantial metabolic lowering in the relatively long interval prior to death. Finally, information has often been omitted both as to the biological materials on which the determinations were based and as to the circumstances of their collection.

A further deficiency present in many instances is the failure to separate accidents into discrete categories; e.g., collision versus noncollision accidents and the frequent practice of extrapolating findings applicable to one category of accidents to another without proper discrimination.

Haddon and Bradess successfully avoided the deficiencies they mentioned in their study (*10*). Accordingly, this paper deserves further attention. The authors stated as their primary objective: ". . . to determine the levels of alcohol present in the blood of a carefully studied group of drivers, those whose fatal accidents had involved neither pedestrians nor vehicles other than their own and who had survived for not more than a given short period after the event." The investigation was based on the records of fatal motor vehicle accidents occurring over an 8-year period in Westchester County, located immediately north of New York City. This area includes urban, suburban, and semirural areas. These difficulties were avoided by stringent sampling procedures and cautious interpretation of the data. This is implied by their limitation of the study to a discrete category—"single-vehicle fatal nonpedestrian accidents." As would be expected, such an approach usually results in a considerable decline in the size of the sample from a more broadly defined group of accidents. Thus, their original group of 589 fatalities was reduced to a final sample of 87, a decline of 85 percent, in order to establish a homogeneous sample.

From the literature it would appear that most investigators ordinarily are not prepared to apply such rigorous methods, since it is generally held that so small a sample is not representative of conditions in the large original group. However, in this area, sample homogeneity with respect to the elimination of contaminating conditions is essential to the discovery of a relationship between alcohol in the system of the particular driver and accident liability. Some recent findings illustrate this point. Weyrich's (*22*) report on traffic accidents in Südbaden-Germany states that accidents caused by inebriated drivers involved missing curves and running off the road relatively more often than they did collisions with other motor vehicles or pedestrians—the "collision" type being more common among sober drivers. Schmidt and Smart (*17*) in a study of the accident histories of alcoholics found that "the accidents occurring to intoxicated alcoholics are almost exclusively of the noncollision type, such as rolling the car, hitting fixed objects, ditches and bridge culverts, in contrast to accidents occurring in the general population." [4] Barmack and Payne (*1*) concluded from a study of motor vehicle accidents of military personnel that ". . . single-vehicle accident drivers exhibit the highest incidence of preaccident drinking." Thus the study of a less homogeneous sample than that of Haddon and Bradess (e.g., fatalities in collision *and* noncollision accidents) would be expected to obscure the real relationship between the factors under study.

The difficulty of determining responsibility for the accident was again at least partly eliminated by the choice of the sample. The selection of drivers involved in single-vehicle nonpedestrian fatal accidents for study is one possible way to circumvent the complexities of multiple causation. Haddon and Bradess (*10*) comment on this as follows:

> Fatally injured persons of this type constitute the only group of persons on whom autopsy is performed who may be regarded without additional evidence as having been responsible in most cases for the accidents which cause their deaths. This group offers, as a result, opportunities for study which are not present when pedestrian and multivehicle accidents are considered, since information concerning the principals (i.e., all involved drivers and pedestrians) in, and circumstances of, such events is seldom complete.

The difficulties due to the metabolic lowering of blood alcohol levels prior to death were overcome in this study by including only drivers who died within 4 hours after their accidents.

Further refinements of the analysis included: (*a*) a check of the fatalities against vital statistics records to assure completeness; and (*b*) the determination of the year-to-year variation by type of accident, class of vehicle involved, and by age and sex of the deceased. The data for the 8-year period were combined, since these variations proved to be not statistically significant.

The results were as follows: Post mortem determinations for alcohol were performed in 83 (95 percent) of the 87 cases. Of these 83, 41 (49 percent) were found to have had blood alcohol levels of 0.15 percent or more at death; an additional 17 were found to have had levels between 0.05 and 0.15 percent. It was concluded that the use of alcohol was probably a causal factor in one-half or more of the deaths which resulted from accidents of this type.

It is felt that this study provides one of the more useful models available in this field of investigation. It demonstrates that, despite the restrictions imposed by incomplete reporting and similar shortcomings commonly found in official records, they do in some instances provide useful data when suitably analyzed.

The foremost requirement in such an analysis is to refine the sample sufficiently. It may be that the lack of agreement in documentary studies

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[4] In contrast less than one-third of all accidents occurring in Ontario in the years 1955 and 1956 were of the noncollision type.

is at least partly due to the heterogeneity of the undiscriminated samples usually employed (e.g., the study of all fatalities without discriminating according to *type* of accident). Three findings were quoted which would indicate that the risk by drinking drivers of being involved in accidents varies greatly depending on the type of accident. This points to the need for studies of discrete categories in order to achieve a better understanding of the distribution of drinking drivers by type of accident. It is felt that the classification of accidents generally found in official reports is well suited to the type of problem under consideration. This classification consists of 12 types of accidents which are largely based on collision versus noncollision, and further subclassification of these according to type of obstruction (if any) encountered. The summary reporting form recently designed by Campbell and Haddon would be particularly useful for this type of investigation. It constitutes an expansion of the currently used categories with reference to time elapsed between occurrence of the accident and death. It furthermore provides for listing the alcohol concentrations of the persons involved by accident type.

Table I gives some information on the percentages of drinking-driver and drinking-pedestrian motor vehicle accidents as they were reported in a selection of studies. The studies listed under 1 to 4, inclusive, are of the uncontrolled type. Columns 1 to 5 of this table are self-explanatory. Column 6 refers to the method or biological material used to measure or estimate the blood alcohol concentrations of the accident drivers. Column 7 indicates the criterion for inclusion of accident drivers in the group of drinking drivers.

Study No. 1 by Gonzales and Gettler (*9*) represents one of the earliest attempts to obtain information of this type and demonstrates the difficulties which arise from inadequate sampling. Thus the authors reported alcohol involvement to be a factor in motor vehicle accidents based on the investigation of a group of fatalities which were described as follows: Brain alcohol determinations were made in—

> . . . 3,471 highway fatalities of all types covering a period from January 1, 1928, to December 31, 1937 . . . . During this decade 6,911 necropsies were performed in a total of 12,897 highway deaths. The patients on whom tests were not made, and hence were not included . . . were children under 15 years of age, adults who survived 24 hours or more subsequent to the accident . . . and persons on whom for various other reasons the tests were considered unnecessary.

It is clear from this description that the findings derived from this sample can only be of limited value. Seen in the light of present-day knowledge we would question whether the aggregate of 3,471 fatalities was representative of conditions in the original group which comprised 12,897 highway deaths. The selective criteria for inclusion in the study group or for exclusion from it are only partly explained. Furthermore, the 24-hour gap between accident and death allowed in this investigation would almost certainly have resulted in substantial metabolic lowering of alcohol concentrations in some cases.

TABLE I. *Percentage of Drinking-Driver and Drinking-Pedestrian Motor Vehicle Accidents in a Selection of Studies*

Study No.	Date	Author and reference No.	Type of accident	Number of cases	Test of drinking	Criterion	Percent meeting criterion
1	1941	Gonzales and Gettler (*9*)	Fatality (death within 24 hrs.)	3, 471	Brain alcohol	"Under influence"	56. 5
2	1958	Freimuth et al. (*7*)	Fatality (death within 12 hrs.)	....	Brain, spinal fluid, and blood alcohol.	0.05 percent or more	....
			(*a*) Drivers	156	....	....	58. 4
			(*b*) Passengers	137	....	....	43. 1
			(*c*) Pedestrians	207	....	....	43. 9
3	1958	Shew and Ferguson (Delaware State Police) (*19*).	Single vehicle drivers (death prior to arrival at hospital).	15	Blood alcohol	0.1 percent or more	80. 0
4	1959	Haddon and Bradess (*10*)	Single vehicle drivers (death within 4 hrs.).	83	do	0.05 percent or more	69. 9
5	1961	Haddon et al. (*11*)	Pedestrian (death within 6 hrs.)	19	do	do	47. 4
6	1938	Holcomb (*12*)	Personal injury	270	Urinalysis	Any alcohol	46. 7
7	1961	McCarroll and Haddon (*14*).	Driver-fatality (death within 6 hrs.).	34	Brain, blood	0.1 percent or more	50. 0
8	1955	Lucas et al. (*13*)	Reported evening accidents	423	Drunkometer	0.05 percent or more	22. 5
9	1959	Barmack and Payne (*3*)	Personal injury (airmen)	138	Interview	Admitted 2 or more drinks within 4 hrs. of accident.	64. 5
10	1951	Smith and Popham (*21*)	Personal injury	919	Intoximeter	0.01 percent or more	23. 0
11	1955	Bjerver et al. (*5*)	do	71	Blood alcohol	do	32. 4

It should be noted, however, that Gonzales and Gettler undertook their study in the late thirties when little dependable information in this area was available. At this time a more general exploratory approach was probably preferable, since no information was available to indicate the important variables to be controlled or the relevant questions to be asked. In other words, the approach of this early investigation, which utilized crude data and analysis, should be considered as an essential first step toward the more rigorous and limited investigations which have been proposed.

Study No. 2 (*7*) gives data on a sample of urban traffic fatalities of all types which occurred in Baltimore during a period of approximately 5 years. The contributions of this study are, first, that alcohol determinations have been performed in a large number of cases, and second, that the fatalities have been broken down into drivers ($N=156$), passengers ($N=137$), and pedestrians ($N=207$).

In this study some ambiguity arises from a lack of precision in the description of the sample. It is defined initially as "500 consecutive fatalities" and later in the study as "500 fatalities in which the victims died within 12 hours" after their accidents. The 207 pedestrian fatalities (supposedly *consecutive* cases) do not include children (according to the age distribution given). This would suggest that cases were excluded on grounds other than the 12-hour survival period. The findings of this study are of considerable value. However, some clarification of sampling procedure would be desirable.

Study No. 3 (*19*) reports on a group of 15 fatally injured drivers ". . . whose passenger automobile accidents involved neither pedestrians nor other vehicles and who were listed as having died either at the scene of the accident or prior to arrival at the hospitals to which they were taken." Haddon and Bradess (*10*) pointed out that this group is similar to the single vehicle drivers they had studied (study No. 4) and the findings suggested to these authors that ". . . the high alcohol levels observed among drivers killed in single vehicle accidents in Westchester County may exist in other sections of the United States."

Studies 5, 6, 7, and 8 represent a selection of surveys which examined a controlled group as well as a case group. We have seen that uncontrolled studies present only the accident aspect of the motorcar operation. They do not disclose, as a comparative measure, the number of drivers or pedestrians who are similarly exposed while under the influence of alcohol, but are not involved in traffic accidents. Such information has been sought through surveys conducted in Manhattan in 1959 (*11*); in Evanston, Ill., in 1935 (*12*); in four of the five boroughs of New York City in 1960 (*14*); and in Toronto in 1951 and 1952 (*13*).

The Manhattan study (*11*) is concerned with pedestrians fatally injured by motor vehicles. To indicate the size of this particular problem, some of the figures given in this report are quoted:

> . . . in 1959, of the 37,800 persons who died as the result of motor vehicle accidents in the United States, 7,750 were pedestrians. Of these, 4,850 were struck in urban

areas, and press reports and the scanty information available suggest that most, if not all, of the world's major cities are endemic foci of such deaths.

New York City is a major such focus, one in which approximately 70 percent (1955–59) of those killed in motor vehicle accidents are pedestrians. In 1959 deaths of pedestrians accounted for 515 of the 737 killed as the result of accidents in the 5 boroughs of the city, and an unknown additional number occurred in the extensive surrounding urban area. During the same period, pedestrian deaths in New York City constituted 6.6 percent of the pedestrian deaths in the nation and 62 percent of those in New York State.

Two studies, listed in table I as Nos. 1 and 2, had shown that substantial fractions of such fatally injured persons had been drinking heavily, but until the Manhattan survey it was not known to what extent pedestrians not involved in accidents, but similarly at risk, had been drinking. This survey represents the only study known to the authors which gives some of the characteristics of fatally injured pedestrians and nonaccident pedestrians who were similarly exposed. Thus the authors compared the characteristics of 50 adult pedestrians fatally injured by motor vehicles with those of a control group of 200 individuals carefully matched by sex, adulthood, accident site, time of the day, and day of the week in which the accident occurred. Blood samples were obtained from all cases in which survival had not exceeded 6 hours, and specimens for analysis with the Breathalyzer were obtained from 180 of the 200 pedestrians in the control group. The comparison between the levels of those fatally injured and those in the control group showed that persons with markedly elevated blood alcohol levels were heavily overrepresented in the fatally injured group. The difference between the fatalities and controls in regard to the proportion of cases with given blood alcohol concentrations became greater at the higher levels.

No. 6 in table I represents the well-known Evanston investigation (*12*). It constitutes the earliest attempt to disclose, as a comparative measure, the number of persons driving while under the influence of alcohol who were not involved in traffic accidents. Unfortunately, the data for the control group of nonaccident drivers were not collected until a considerable time after those for the accident drivers had been obtained. It is our impression that for this and other reasons the data did not permit a statistically valid comparison between the two groups of drivers.

Ideally, the survey to obtain comparative data should be conducted on accident and nonaccident drivers (or pedestrians) under traffic conditions as much alike as possible. This was achieved in the Manhattan pedestrian study through a careful matching of the control with the accident group, as outlined above. In study No. 7 (*14*) a similar approach was utilized. Again a carefully site-matched control group was obtained for a series of consecutive fatal motor vehicle accidents. It was found that elevated blood alcohol levels served as a major discriminant between the fatalities and the control group:

> The greatest difference between the two groups was in the prior use of alcohol. Among drivers rated as probably responsible for their accidents, 73 percent had been drinking to some extent, whereas only 26 percent of the similarly exposed, but non-

involved drivers had been drinking. Forty-six percent of the accident-responsible group had blood alcohol concentrations in the very high, 250 mg % and over, range. In contrast, not a single one of the drivers in the large control group had a concentration in this range.

In the Toronto study (*13*) a slightly different approach was used. The two New York investigations employed *consecutive* cases and the controls were obtained on a *subsequent* date. In the Toronto study only evening accidents were investigated and their selection for study was determined entirely by the availability of investigation facilities. Once an accident was included in the case group, controls were obtained *immediately* by obtaining blood alcohol levels of nonaccident drivers who were passing the scene of the accident in cars of the same vintage at approximately the same time. However, the investigators did not control for direction of traffic. That is to say, in selecting the drivers who were to represent the controls for any particular accident, no account was taken of whether or not a driver picked for the control group had been driving in the same direction as the accident driver. There is some reason to suspect that persons driving from downtown areas toward the uptown residential areas in Toronto are more likely to have been drinking than those driving in the opposite direction.

The authors reported that 22.5 percent of the accident drivers, as compared with 8.7 percent of the drivers in the control group, had blood alcohol concentrations of 0.05 percent or higher. The disproportion became greater at higher levels, and it was calculated that the risk of accident was approximately 10 times greater for drivers with levels higher than 0.15 percent than for drivers who were sober.

Earlier in this paper attention was drawn to the limitations inherent in government statistics, and it was proposed that the emphasis be placed on sampling techniques and investigative procedures tailored to specific questions rather than on standardization of reporting systems across the country. The Manhattan, Toronto, and New York studies epitomize the approach the authors have in mind.

A group of studies by Barmack and Payne (*1, 2, 3*) requires separate attention. These studies cannot be readily classified under the categories employed in this paper, since they differ greatly from the studies described so far in the method used and in the population selected for investigation. Thus, the primary data collection procedure was the "semistructured personal interview"; the subjects were airmen; and the objectives were, first, to determine the role of drinking in injury-producing private motor vehicle accidents, and second, to determine the role of drinking in the lives of the accident victims. The latter study will be described more fully later.

The accident population was defined as all airmen (located at 14 Air Force bases) who, while driving a privately owned motor vehicle, were involved in an accident which resulted in a lost-time injury to the driver or to a military subject during a 9-month period. A control sample was selected from Air Force personnel who had a valid driver's license, and who had had no traffic accidents for 1 year or longer. It was found that pre-accident drinking had occurred in 64.4 percent of the accident drivers, 60.1 percent having reported consuming amounts which resulted in blood alcohol levels of approximately 0.14 percent or higher at the time of the accident, according to the method of estimating alcohol concentrations employed by the authors. The contribution of alcohol to the accidents was also indicated by the finding that while preaccident drinking occurred among 64.4 percent of the accident drivers, it occurred among only 5.3 percent of the controls.

From the foregoing studies and other data not presented here, one may draw the following conclusions. Despite the shortcomings present in many of the investigations in this field, there appears to be convincing and consistent evidence that in a wide variety of motor vehicle accident groups, large fractions of those involved as principals have been drinking substantially. Furthermore, substantial differences between the distribution of alcohol levels among accident-involved drivers and pedestrians and that of the driving and pedestrian population from which they came have been demonstrated. These differences suggest that the existence of high blood alcohol levels is associated with a more frequent involvement in motor vehicle accidents than would otherwise be the case. This information should not be used, however, as an argument that the accidents occurring to drinking drivers are caused by the impairment resulting from elevated blood alcohol levels. To determine causality we would have to describe completely in each instance the situation immediately preceding the accident in order to differentiate it from the nonaccident situation.

For obvious reasons this is impossible. We have to entertain, therefore, the notion that drinking accidents result from a combination of causes of which drinking is one. Holcomb (*12*) dealt with this problem in an impressionistic fashion. He posed the following question: Is there any basis for advancing some other cause than drinking for the relationship between the two factors? After examining darkness, fatigue, speed, and proneness to accidents, he concluded that the four factors ". . . unquestionably exist and in themselves do cause accidents. It must be further remembered, however, that alcohol will definitely heighten the effect of any or all of these factors." He suggested that, until experimental evidence is presented to prove otherwise, it seems logical to accept the notion that alcohol is the major cause in drinking-driver accidents.

An ingenious study reported by Smith and Popham (*21*) contributed greatly to a clarification of the difficult question of causation. The authors compared the blood alcohol levels of those rated (without previous knowledge of the alcohol factor) highly responsible for the accident in which they were involved with the levels of those rated as either not responsible or only slightly so. They found an increasing excess of drivers responsible for their accidents which first became statistically significant in the 0.03- to 0.05-percent range of blood alcohol concentrations. The unique feature of this research is that it relates *driving behavior* rather than the occurrence of accidents to the blood alcohol level of the driver. Until their study this had been done only in laboratory investigations, and the findings of these cannot be directly applied to ordinary driving situations, since there is always the unknown effect of an artificial situation. On the basis of Smith and Popham's findings, we can state now that improper driving behavior resulting in an accident is more frequent among drinking drivers than among sober drivers. This information constitutes a link in the causality chain drinking-driver-accident.

Minimum Blood Alcohol Level and Accident Liability

Let us now turn briefly to a problem of a rather different type and one which perhaps lends itself better to the experimental approach.

This is the determination of the lowest point in the alcohol content of the blood at which an increased accident liability occurs or at which the performance of tasks related to driving is measurably impaired.

This topic has been given fuller attention in the chapter on effects of alcohol on psychological processes. We will, therefore, add only such information as has been derived from empirical investigations. Two surveys (*12, 13*) attempted to show at what blood alcohol levels impairment first occurs. The evidence obtained in these surveys was based on a comparison of the alcohol levels of accident and nonaccident drivers. At the point in the distribution of alcohol concentrations at which a greater proportion of drinking drivers first appeared in the accident group than in the control group of nonaccident drivers, drinking was considered responsible for the increase of accidents over the expected. This point was found to lie between 0.05 percent and 0.06 percent in the Evanston study (*12*), and between 0.05 and 0.10 percent in the Toronto study (*13*). Smith and Popham (*21*) reported that the minimum concentrations at which some motorcar operators in actual driving situations are significantly affected lies in the range 0.03–0.05 percent. These findings are in close agreement with a number of experimental studies which have reported measurable impairment in the performance of tasks related to driving at similarly low blood alcohol levels.

The Accident Involvement of Alcoholics

The final problem which we would like to discuss concerns the identification and description of persons who drive after drinking. Until relatively recently the principal focus of interest has been the role of alcohol in accidents rather than the role of the driver who uses it. This approach assumes that drinking drivers constitute a random sample of the general population with respect to their drinking habits. Seales' (*18*) statement that, "as far as safety is concerned, the real highway delinquent appears to be the so-called social drinker," illustrates this widely held view; namely, that the drinking driver is a casual drinker who has had an accident probably chiefly because of a misguided notion of his ability to function adequately under the influence of alcohol.

The first attempt to determine the drinking habits of drivers involved in traffic accidents seems to have been a study conducted in Sweden and reported by Bjerver, Goldberg, and Linda (*5*). In this research the alcohol habits of persons who had been involved in personal-injury accidents were assessed, and compared with those of the adult male population. It was found that 32.5 percent of the accident victims as opposed to 13.7 percent of the general population were alcohol "misusers" (defined as persons who were (*a*) "alcohol addicts," comprising those who had received treatment for alcoholism and (*b*) persons who had been convicted of drunkenness one or more times during the preceding 10 years).

It was furthermore shown that although "misusers" were highly overrepresented among those who had elevated blood alcohol levels, they were not overrepresented among those who had not been drinking at the time of the accident. It is clear from these findings that there is a high prevalence of problem drinking among those persons who have been drinking and are subsequently injured in traffic accidents.

The utility of these data for the North American scene is, of course, rather limited. Unfortunately, this investigation cannot be duplicated on this continent since there are no comparable data pertaining to the drinking habits of the general population available.

A different approach to this problem is found in a study conducted by Schmidt and Smart in Toronto (*17*). The authors compared the frequency of accident involvement of alcoholic drivers with that to be expected on the basis of the general Ontario experience. Information was obtained by interviewing a sample of 98 male patients of a treatment center for alcoholics, and by checking the data against official accident records. It was found that treated alcoholics, when compared to the general driving population: (*a*) were involved in a significantly larger number of accidents per year; (*b*) were involved in a significantly larger number of accidents per mile driven; (*c*) did not have a significantly greater involvement in nondrinking accidents; and (*d*) were more frequently convicted for drunk and impaired driving.

A comprehensive study of the relation between alcoholism and traffic accidents has been reported by Goldberg (*8*). Data concerning drinking habits, offenses for drunkenness, and for criminal offenses were obtained on nearly 2,000 men convicted for drunken driving during a 1-year period. It was found that 45.4 percent of the drivers, as opposed to 8.8 percent of the general population, fell into the categories "alcohol addicts or alcohol misusers" (defined as in the preceding study).

Barmack and Payne (*1*) used the same categories and criteria as reported by Goldberg (*8*) to determine the incidence of problem drinkers in their study of accident involvement of airmen. The sample and procedure of this research have been described earlier. It was found that the incidence of problem drinking habits in the accident-involved drinking drivers was greater than that of the not-drinking drivers involved in accidents or of the controls, to a statistically significant degree.

Two additional studies require mention. In the first of these (*16*), involving a comparison of alcoholism clinic records with a list of 427 accident drivers charged with impaired driving, it was tentatively concluded that the sample of 427 drivers ". . . did not represent a random sample of the drinking population with respect to prevalence of alcoholism, and that the hypothesis should be entertained, for future research, that traffic accidents involving drivers who had been drinking are to a considerable extent a problem of alcoholism rather than largely a problem of the effects of alcohol on the casual drinker." In a study (*20*) conducted 4 years later, the same list of 427 drivers was rechecked against the records of the same clinics. It was found that 8.48 percent of the 427 had been admitted to one of the clinics.

Unfortunately, it is not possible at present to make an exact statement concerning the proportion of alcoholics or problem drinkers in a population of drinking drivers. The figures reported in the last two studies are to be considered as minimal estimates. Had the list of 427 been checked against all treatment facilities available to these drivers, which would have included among others, Alcoholics Anonymous, mental hospitals, private clinics, and sanitaria, it seems likely that more alcoholics would have been identified. Moreover, it is almost certain that a considerable percentage of alcoholics never receive treatment for this condition.

The Swedish experience, together with the evidence offered in the researches conducted on this continent, establishes convincingly that the drinking driver is to a significant extent a problem of alcoholism, and may therefore represent a matter of treatment and preventive medicine as well as of legislative measures.

This has a number of implications for driver improvement programs. An underlying assumption of such programs is that most accident-precipitating factors are within control of the driver and can be mitigated by simple suggestion or legal sanctions of varying degrees of severity. It is assumed that if drivers were made to see the dangers of driving after drinking and if penalties were sufficiently severe, the problem would be removed or much reduced. In a study of the driving histories of alcoholic clinic patients (*17*), it was stated that: ". . . few groups were more aware of or concerned about legal sanctions and predicted consequences of driving when intoxicated than the alcoholic driver. Nevertheless, these persons drove more frequently after consumption of alcohol, had more convictions for drunken driving, more suspensions from driving because of impairment and, finally, were involved in more accidents per driver and per mile driven than the general population." A conclusion of the study was that highway education slogans and legal sanctions would hardly affect drivers whose very abnormality immunizes them against such appeals.

References

1. Barmack, J. E., and Payne, D. E. Injury-producing motor vehicle accidents. I. The role of drinking. In *Driver personality and behavior characteristics.* Highway Res. Bd. Bull. 285 (National Academy of Sciences-National Research Council Publication 855). Washington, D.C., 1961. Pp. 1–11.
2. Barmack, J. E., and Payne, D. E. Injury-producing motor vehicle accidents. II. Background correlates of the lost-time accident. In *Driver personality and behavior characteristics.* Highway Res. Bd. Bull. 285 (National Academy of Sciences-National Research Council Publication 855). Washington, D.C., 1961. Pp. 11–22.
3. Barmack, J. E., and Payne, D. E. Injury-producing private moto vehicle accidents among airmen: Psychological models of accident-generating processes. *J. Psychol.,* 1961, **52,** 3–24.
4. Berry, D. S. Alcohol as a factor in traffic accidents. *Quart. J. Stud. Alc.,* 1940, 1, 413–431.
5. Bjerver, K. B., Goldberg, L., and Linda, P. Blood alcohol levels in hospitalized victims of traffic accidents. In *Proceedings of the Second International Conference on Alcohol and Road Traffic.* Toronto: Brewers' Warehousing Co., Ltd., 1955. Pp. 92–102.
6. Coldwell, B. B. (Ed.) *Report on impaired driving tests.* Ottawa: Crime Detection Laboratory, Royal Canadian Mounted Police; Queen's Printer, 1957.
7. Freimuth, H. C., Watts, S. R., and Fisher, R. S. Alcohol and highway fatalities. *J. forensic Sci.,* 1958, **3,** 65–71.
8. Goldberg, L. Drunken drivers in Sweden. In *Proceedings of the Second International Conference on Alcohol and Road Traffic.* Toronto: Brewers' Warehousing Co., Ltd., 1955. Pp. 112–127.
9. Gonzales, T. A., and Gettler, A. O. Alcohol and the pedestrian in traffic accidents. *J. Amer. med. Ass.,* 1941, **117,** 1523–1525.
10. Haddon, W., Jr., and Bradess, Victoria A. Alcohol in the single vehicle fatal accident. Experience of Westchester County, New York. *J. Amer. med. Ass.,* 1959, **169,** 1587–1593.
11. Haddon, W., Jr., Valien, P., McCarroll, J. R., and Umberger, C. J. A controlled investigation of the characteristics of adult pedestrians fatally injured by motor vehicles in Manhattan. *J. chronic Dis.,* 1961, **14,** 655–678.
12. Holcomb, R. L. Alcohol in relation to traffic accidents. *J. Amer. med. Ass.,* 1938, **111,** 1076–1085.
13. Lucas, G. H. W., Kalow, W., McColl, J. D., Griffith, B. A., and Smith, H. W. Quantitative studies of the relationship between alcohol levels and motor vehicle accidents. In *Proceedings of the Second International Conference on Alcohol and Road Traffic.* Toronto: Brewers' Warehousing Co., Ltd., 1955. Pp. 139–142.
14. McCarroll, J. R., and Haddon, W., Jr. A controlled study of fatal automobile accidents in New York City. *J. chronic Dis.,* 1962, **15,** 811–826.

15. Plymat, W. N. The relation of alcohol to highway accidents. In *Proceedings of the Second International Conference on Alcohol and Road Traffic.* Toronto: Brewers' Warehousing Co., Ltd., 1955. Pp. 34–49.
16. Popham, R. E. Alcoholism and traffic accidents. A preliminary study. *Quart. J. Stud. Alc.,* 1956, **17,** 225–232.
17. Schmidt, W. S., and Smart, R. G. Alcoholics, drinking and traffic accidents. *Quart. J. Stud. Alc.,* 1959, **20,** 631–644.
18. Seales, T. A. The drinking driver. *Traffic Safety Res. Rev.,* 1957, 1(3), 80–93.
19. Shew, H. S., and Ferguson, J. P. (Delaware State Police). Personal communications, 1958. Reported by W. Haddon, Jr., and Victoria A. Bradess, Alcohol in the single vehicle fatal accident. Experience of Westchester County, New York. *J. Amer. med. Ass.,* 1959, **169,** 1592.
20. Smart, R. G., and Schmidt, W. S. Problem drinking as a factor in drinking-driving offenses. *Canad. J. Corrections,* 1961, **3,** 153–158.
21. Smith, H. W., and Popham, R. E. Blood alcohol levels in relation to driving. *Canad. med. Ass. J.,* 1951, **65,** 325–328.
22. Weyrich, G. Alkohol und Strassenverkehrsunfälle im Lande Südbaden. (Alcohol and traffic accidents in Südbaden.) *Dtsch. med. Wschr.,* 1957, **82,** 1100–1103.

CHAPTER III

Effects of Alcohol on Psychological Processes

JOHN A. CARPENTER, Ph. D.[1]

Introduction

One of the purposes of this chapter is to review studies on the psychological processes as they are related to driving and are affected by alcohol, and to come to some conclusions about what additional steps are needed to fill in our knowledge.

Certain questions come to mind immediately: What kind of behavior are we concerned with, and in what way is it affected by alcohol? Can the changes produced by alcohol be conceptualized along various behavioral dimensions?

How does alcohol affect behavior? Is the gait of an inebriated man the result of alcohol's action on the central nervous system? Where in the central nervous system? This leads to other questions: Is the change in gait caused by an imbalance in the normal relations between sensory and motor activity? Has one or the other or have both been reduced? Is it a matter of critical timing? Or could it be a simple reduction in impulses in the motor nerves resulting in a weaker response?

Another question: Does human response time increase under alcohol because the subject sees or hears less well, because his muscles cannot react as fast, because he cannot attend the stimulus, or because he cannot decide which response to make?

Still another question: Do people learn under alcohol? What do they learn? Can people reason under alcohol?

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[1] While the author has had the full responsibility for the preparation of this paper, the contributions of the following participants in a preliminary U.S. Public Health Service conference Apr. 4–5, 1960, are gratefully acknowledged: Blake B. Coldwell, Royal Canadian Mounted Police; George C. Drew, University College, London; Charles P. Larson, Tacoma General Hospital; Ted A. Loomis, University of Washington; and H. Ward Smith, The Attorney-General's Laboratory, Province of Ontario.

And finally, how should we go about trying to answer these questions? And, if we thought we had answered them, how could we be sure?

A review of the literature reveals that efforts have been made to determine some answers. For the sake of clarity and uniformity, the studies have been summarized in tabular form. (See pp. 64–85.) The material in the tables comes from two sources: original articles and the Abstract Archive of the Alcohol Literature. The use of original articles was determined by their being in English and available in the Yale Library. The Abstract Archive is very nearly complete—material from Ph. D. dissertations, difficult-to-locate journals like the *Journal of Aviation Medicine*, special projects of the Naval Medical Research Institute, etc., can be found abstracted there. The abstracts are quite faithful to the original articles.

In many cases, several kinds of experiments (different skills, sensory functions, intellectual functions, etc.) are reported in a single paper. Each type of test is treated separately in the tables. Thus, an article may appear several times. Papers that report on other drugs as well as alcohol are included if they present results on normal subjects with alcohol alone.

Column 3 gives the number of subjects, sex when the author gives it, and any other special characteristics like experienced pilots or heavy drinkers. The number of authors who are not concerned with the possibility that differences in response to alcohol are created by the sex of their subjects is surprising. Teichner (*75*) in reporting on RT (Reaction Time) points out that "the weight of the evidence indicates that sex differences favoring men does exist . . . ." One may assume that most of the subjects have been men in these experiments. The number of subjects ranges from 1 to 1,170. In most cases, a small number of subjects is probably adequate provided that a sufficient number of responses are obtained on each one. Generally, the number of responses either prior to or after drinking cannot be determined from the report. Howells presents enough data to show that as few as 7 responses went into some determinations (either prealcohol or postalcohol) and as many as 44 in others (*38*).

Column 4 gives the dose converted, when possible, into milliliters of absolute alcohol per kilogram of body weight (ml/kg), regardless of the units specified by the author. These units (ml/kg) have the convenient property of being approximately equal to ml/lb of 90 proof whisky which is easily converted to ounces of whisky when desired. Other information on alcohol administration, such as frequency of ingestion, e.g., 10.6 ml hourly, is also given. Blood alcohol levels (BAL) appear in column 5 in milligrams of alcohol per milliliters of blood (mg/ml) unless otherwise indicated. This is apparently the unit most frequently used. In general, the maximum level attained is presented, as is the range when it is available. The Forbes paper on reaction time is unique in presenting dosage without reference to body weight and in units to which only he is privy (*27*).

Column 6 is intended to convey some idea of the duration of testing in relation to the blood alcohol curve. This is not always possible since many authors report their tests as taking place so many minutes "after ingestion." Because the time required to ingest may be variable, additional information is required; i.e., time spent drinking. Since absorption starts immediately with drinking, all tests and blood analysis schedules should use this as a reference rather than the cessation of drinking.

Results are given in column 7. Most experimenters have not evaluated their results statistically, and most experiments do not seem to have been designed in the strict sense of the word. Many studies probably contain significant practice effects. However, the various experiments agree on a general conclusion: alcohol impairs psychological functions at low blood alcohol levels. Some attempt was made to present the most important results where more than one was given in the original. In some cases, additional results, calculated from the original articles, are included. Only alcohol results from experiments with other drugs, e.g., pervitin, levulose, are given. A number of experimenters report differences in the magnitude of deterioration depending on whether measures are made during the rising or falling phase of the blood alcohol curve (*34, 63*). Because practice and blood alcohol changes occur concurrently, most of these experiments cannot assess the two sources of change separately. A more convincing procedure would be to test one group of subjects on the rising curve and another on the falling curve at the same level of practice. Similar observations can be made about the effects of fatigue because order of testing is confounded with time of testing (*6*).

In concluding this section, it can be said that results of these experiments are disappointing. Because it is known a priori that psychological functions can be infinitely disrupted by anesthetic doses of alcohol, the question to be settled by experimentation concerns the degree and direction of change at low and moderate levels of blood alcohol. For instance, Jellinek and McFarland pointed out that difficulties of earlier RT (Reaction Time) experiments lay in faulty technique and data handling (*40*). This does not rule out the possibility that shortened RT's (important in understanding how alcohol functions) might not be observed with the more advanced techniques of today. Most of the psychological experiments in the alcohol literature could never hope to detect such fine changes because they show a gross disregard for the finer points of experimentation. In addition, the alcohol experiments compare unfavorably with general levels of sophistication within experimental psychology. Some evidence of this opinion can be obtained from examination of research equipment. Only a few studies have developed esoteric apparatus to investigate a single phenomenon once, a distinguishing mark of the advance of conceptualization in science. The choice of experiments with alcohol seems sometimes to depend on the existence of discarded equipment. Other evidence comes from the degree of specialization in psychology. For example, sensory psychology can be divided into senses. The senses may be further subdivided. A man may spend his life in a narrow area of color vision or the single nerve response of the limulus eye. There can thus be no specialists in alcohol; rather one must be an expert some place else first. The complexity of alcohol administration can easily be understood by experts in vision; the reverse is not true.

In the following pages, the material has been somewhat arbitrarily organized into experiments on reaction time, motor skills, nystagmus, sensory phenomena, and intellectual processes. Reaction time is treated separately because of the large amount of material on it. It is used as a critical paradigm and thus receives a more detailed discussion than it deserves. Many of the remarks true of it apply to other areas as well. Positional nystagmus appears to have a unique relation to symptoms of malaise during intoxication and hangover. Its first phase is a definite indicator of the presence of alcohol in the blood. For this reason, it is treated separately. The section on intellectual functions is a catchall for material that might be called higher processes. The behavior depends heavily on language. Other topics, such as conditioned reflexes or learning, are not included because of space limitations or quality of material dealing with alcohol.

Reaction Time Experiments

An elaborate analysis and summary of simple reaction time experiments with alcohol up to 1940 have been given by Jellinek and McFarland (*40*). Teichner's 1954 review (*75*) contains a section on drugs, etc. Both reviews criticize heavily the quality of the experiments in this area. Since 1940, more than a dozen additional reaction time experiments have been reported, and it is clear that very little has been learned from the Jellinek and McFarland critique. The general picture that emerges is that the quality and sophistication are still rather low.

Table II presents a summary of the RT experiments reviewed by this paper. Some advance over the papers reported by Jellinek and McFarland is obvious. The sample sizes are larger. An interesting variation in procedure is reported by Howells (*38*). He used subjects singly or in pairs. He also allowed subjects to bring a friend to the experiment, which lends an air of conviviality to the proceedings. Unfortunately, it is neither a group nor an individual experiment since no systematic routine was followed.

The experiments are classified into two categories when possible (table II, col. 2): simple RT, in which the same response is always made to a single stimulus, and complex or choice RT, in which different responses are required depending on which of the two or more stimuli are presented. The distinction between simple and choice is important because a considerable time difference may be expected for the same sense modality. In addition, simple RT can be thought of as a measure of the ability of the subject to respond, whereas complex RT measures this and simultaneously involves making a decision. The Grüner and Ptasnik (*35*) experiments are choice RT experiments, with the additional feature that the RT's are performed while the subjects are engaged in the Bourdon test, which requires constant attention of the subjects. In this test the subject is required to strike out every "e" in a printed sheet while responding to RT stimuli, which presumably occur without warning.

Stimulus characteristics are important determiners of reaction time. Many experimenters do not give much more than the sensory modality (col. 2). Many are satisfied to report that various colored lights were used or, simply, that a light was used as a stimulus. Such characteristics as size and location of visual field are seldom considered (Grüner and Ptasnik, visual stimulus at the periphery of the eyes), whether or not both eyes or one eye were used (Carpenter, one eye), room illumination, dark adaptation, duration of stimulus, etc. Some workers do not respect the difference between senses enough to keep observations from different modalities separate when processing and reporting results.

Response characteristics (col. 2) are not available from 6 of the 14 reports. In many cases only the barest statements about response characteristics are made, such as levers and pedals being operated. Whether the preferred or nonpreferred hand is used is not stated in most of these experiments.

In some of the experiments, the reaction time test is an element in a battery of tests (*34, 35*). Hausser and Truffert (*37*) obtained other measures of behavior of the psychomotor type in addition to reaction time as a part of their battery. Their term "temps de reprise," time of reprise, eludes translation. Results of equilibrium tests are presented in connection with RT by Laves (*43*). Mueller used the drawing test, Rauschke a ring test, and Zirkle et al. seven other tests of variable character and difficulty (*51, 63, 79*). Only one comment can be made here—reaction time, simple or choice, is sufficiently complex and difficult to carry out that additional tests may increase the experimenter's burden and reduce the quality of all tests. Carpenter, and Lambercier and Martin du Pan agree that little or no effect on simple visual RT occurred at relatively low blood alcohol levels (*11, 41*). Howells found RT increased 4 to 36 percent, no distinction being made between the visual and auditory RT's (*38*). Zirkle et al. are alone in reporting no effect on choice RT, probably because of the very small dose of alcohol used (*79*). Grüner and Ptasnik found the largest effect, 200 percent deterioration (increase in RT), as compared to about 50 percent in an almost identical experiment (Grüner (*34*)), the difference being that in the former peripheral visual stimulation was used.

The Forbes' results are interesting (*27*). Forty-five observations were clinically judged unfit to drive, while 167 were judged fit. In the unfit group, an average increase over the sober condition of 0.14 second was observed, as compared to 0.05 second for the fit group (visual stimuli). Thus, the agreement between the clinical evaluation and the laboratory test is very good. The clinical evaluation permits roughly four times the increase found by Carpenter (*11*), which he called negligible impairment (0.012 second), or 4 additional feet to stop as compared to 1 foot at 60 mph.

Grüner (*34*) obtained a composite score on RT and the Bourdon test, which he calls total attention, a mixture of tenacity (Bourdon test) and vigilance (RT). Results were poorer on the average for both tests (total attention). If individuals were able to compensate on one test, a greater decrement was observed on the other.

The question to be answered by a simple RT experiment is: Given the most favorable conditions under which to respond as rapidly as possible, to what degree will alcohol affect the response time? Choice reaction time experiments start after this point has been established. The results of the choice reaction time experiments thus bear on the problem of discrimination. A clear separation of these two questions is not obvious from the body of experimental literature, as can be seen in this section.

Effect of Alcohol on Motor Skills

Experiments in this category are summarized in table III. The papers in this table are arranged in a roughly decreasing order of complexity of skill.

In general, the experiments agree that alcohol impairs motor performance at low and moderate blood levels. In experiments where attempts are made to illustrate a relationship between impairment and drinking habits (*31, 76*), one finds that, drink for drink, the heavy drinkers first show intoxication at higher levels than do light drinkers. Prag showed that abstainers have a lower consumption tolerance than either moderate or heavy drinkers (*60*). Consumption tolerance is the theoretical amount of alcohol which produced 1.5 mg/ml BAL in 2 hours. A mean of only 88.7 g of alcohol was required to reach 1.5 mg/ml in his abstainers, as compared to 111 g for his heavy drinkers. In contrast, wide variations in performance were noted by Newman and Abramson (*53*) in subjects described as having the same drinking habits (occasional drinkers). In the following pages, a brief discussion of some experiments is given.

The Link trainer studies are in many respects like the simulated driving studies. The advantage of this instrument is the possibility of obtaining continuous recording of the result of the operator's efforts, much the same kind of measures as those obtained by Drew et al. That is, a continuous record of the subject's conformity to a test pattern is obtained. An infinite variety of test patterns is one of its most powerful advantages. Since task and location familiarity may be important conditions with which alcohol effects can interact, the Link trainer provides an almost uniquely flexible apparatus in this respect. It also provides the operator with some of the nonvisual cues that are experienced in flight. Analogous conditions have not been obtained for auto simulators.

Eyer and Ivers used a modified trainer that recorded only the time that the flight remained within tolerance for airspeed, pitch, degree of bank, and rate of turn, and a total time within which all were within tolerance together (*26*). Unfortunately, this method yields no information on the kind and degree of behavior of the trainer when it was beyond the tolerance limits, the very information the trainer is designed to give and which is of great interest in alcohol experimentation.

In the target-shooting experiment of Newman (*52*), interest was primarily in natural tolerance rather than the motor performance. He used the apparatus (not described) to obtain a frequency distribution of the number of subjects failing to meet criterion scores at intervals of 0.20 mg/ml blood alcohol levels; e.g., 0.40–0.59, 0.60–0.79 . . . 2.00–2.19 mg/ml. The modal interval is 1.00–1.19 mg/ml, a remarkably high BAL for a skill of this apparent complexity. The skew of the distribution suggests that failure is normally distributed with respect to the logarithm of blood alcohol level. The Newman and Abramson (*53*) entries are from the same experiment on two subjects (both described as occasional drinkers), one being more resistant to alcohol than the other. Both subjects regained normal performance after originally deteriorating when peak BAL was first reached. The less susceptible subject showed less deterioration (22 percent) than the susceptible one (39 percent) under the same conditions, although at a higher blood level of alcohol, which occurred earlier. The two other results (less susceptible subject) indicate that the subject's performance remained unaffected by alcohol even at very high BAL; e.g., 2.0 mg/ml (urine). Newman and Abramson say the effects of alcohol depend on concentration and how long the concentration has been in the body. Their results probably are a function of this and practice effects.

McCleary and Johnson (*49*) found an interesting result. When subjects carry out industrial assembly at very low temperatures (−40° F), less total time to perform is required when alcohol is given because subjects do not take time out to warm their hands.

Vogel's experiment, using visual-motor coordination, showed that improvement in performance is a function of BAL, depending on the personality adjustment of the subjects (*76*). The rationale here is that tension, nervousness, and self-criticism hinder performance of some tasks. If alcohol relieves tensions, performance should improve. More alcohol would be required to reduce tension in more poorly adjusted people. Results support this hypothesis.

Takala et al. (*73*) present two innovations: an experiment which attempts to measure the aftereffects of drinking, i.e., performance during hangover; and the use of tests that are designed to measure functions isolated by factor analysis (Perceptual Speed, Space, Dexterity, and Number Factors). All tests registered impairment during intoxication. Brandy hangover results were almost as good as controls. Beer hangover results showed some impairment (Space Factor) and others showed improvement (Dexterity Factor).

Rosenthal's experiment shows that performance and not learning is affected by alcohol (*67*). After alcohol tests were carried out, performance of the alcohol group was equal to that of the control group which had practiced an equal number of trials.

Goldberg's and Pihkanen's experiments on the Romberg test indicate that body sway is exceedingly sensitive to alcohol assault (*31, 59*). Both Goldberg's and Pihkanen's success with the phenomenon is due to their careful instrumentation. Goldberg measured area of sway and Pihkanen extent of sway in two dimensions. Goldberg contrived the modified Romberg (in which one foot is placed in front of the other rather than beside each other), which is what Pihkanen used. Considerable argument can be made against Goldberg's data handling (for all his tests) which results in extravagant deterioration of performance. His percentages are not conventional since he used 100 percent as his basal value. From a variety of places in Goldberg's paper, including a definite statement to the effect, it is clear that his results are log normal. Percentages calculated on the transformed data are much nearer the expected impairment level. Pihkanen's data are plotted on log paper, although his tables present raw data.

In generalizing from the results of these experiments to driving and other practical situations, some comment is necessary. In only a few instances are the tests known to relate to real-life situations either as a result of studies designed to establish a relationship as in the Link trainer (*26*), or because the test and the objective situation are identical, as in typing tests. According to Flanagan (as reported by Lanier), subjects do well on some but poorly on other training devices that are designed to exercise the same function and which are apparently similar (*42*). Correlations between similar situations tend to be low. This means that generalization from many of these experiments to driving must be done with care. The effect of alcohol on the ring test (e.g., *9, 10, 24*) may be simply that and nothing more can be made of it. Validation studies are needed.

Positional Nystagmus

Results of positional alcohol nystagmus [2] (PAN) experiments are summarized in table IV. Positional nystagmus resulting from alcohol intoxication consists of two phases. The first phase, PAN I, occurs when blood alcohol reaches a critical level (0.38 mg/ml, Aschan) on the rising leg of the blood alcohol curve and continues until a critical level (0.33 mg/ml, Aschan) is reached on the falling leg. At this time the nystagmus consists of fast movements to the right in the right lateral position, or fast movements

[2] Positional alcohol nystagmus is an alternating horizontal eye movement occurring when a person lies on his side or tilts his head to the side after having drunk a sufficient amount of alcohol.

to the left in the left lateral position. The second phase, PAN II, appears 1–2½ hours after cessation of PAN I when there is no longer any alcohol present in the blood. It is characterized by rapid movement to the left in the right lateral position and vice versa, and lasts for several hours. PAN II is more intense than PAN I, and both are related to unpleasant sensations of intoxication and hangover.

Effect of Alcohol on Sensory Phenomena

Table V summarizes a sample of experiments in which alteration in sensory phenomena occurs as a result of alcohol administration. Of the 18 experiments listed, 16 involve the eye, although only 14 can properly be included under vision. Considering the state of the art in sensory psychology, none of the experiments represents a very profound excursion into sensory phenomena. One of the reasons for this may be that sensory phenomena are the territory of the specialist who is too busy with this one interest to bother with alcohol experiments. The result is a series of relatively straightforward experiments.

Effect of Alcohol on Intellectual Functions

The results of experiments on intellectual functions are summarized in table VI. It is customary to assume that higher processes are more affected by alcohol than lower ones. Thus, it is expected that intellectual processes are impaired at lower BAL than motor and sensory processes. The results of the experiments summarized here do not confirm this point of view. Goldberg's data are most convincing (*31*). Goldberg investigated motor, sensory, and intellectual activities, and computed appearance and disappearance thresholds for each. The appearance threshold is the BAL on the rising phase at which impairment first occurs, while the disappearance threshold is the BAL at which the behavior is again normal. The average appearance thresholds were very similar for sensory, motor, and intellectual functions. The average disappearance thresholds were 0.46, 0.61, and 0.72 mg/ml for sensory, motor, and intellectual functions. This means that the intellectual functions returned to normal functioning sooner, at higher BAL. Slopes of the plots of logs of each measure against BAL shows that the motor functions have the steepest slope and the intellectual the shallowest. One sees from this that the evidence is contrary to the hypothesis; i.e., intellectual functions are more rather than less resistant to alcohol than sensory and motor processes. The results of Pihkanen on the square test (*59*) and of Hartocollis and Johnson on verbal fluency (*36*) indirectly support Goldberg; the tests of significance for differences here tend to show relatively small differences on the five occasions that they are significant. Goldberg explains his results by saying that the subjects compensate by increased motivation, etc. Why compensation should be activated for intellectual functions and not sensory and motor is not clear. One might suspect that attentiveness is more variable in the former and is also more susceptible to change through motivation. Nevertheless, in a recent experiment on problem solving (*12*), alcohol was found to facilitate problem solving at one small dose and to be damaging only at the highest one. Many of the component processes showed increases over the whole range of doses.

In the face of this evidence, perhaps it is better to entertain alternative hypotheses. Two come to mind immediately: (1) Intellectual processes, considered in the evolutionary scheme of things, are advantageous to those animals that possess them, but only if they are relatively resistant to adverse and unusual conditions. If this were true, we would expect the higher processes to continue to function as blood alcohol levels increased. (2) Intellectual functions are not more complex but simpler.[3] If they are simpler, there is less to go wrong. Hence, they are more resistant to adverse conditions such as alcohol or other forms of intoxication, high altitude, extreme temperatures, etc.

The advantage of these hypotheses is that they put into perspective the unsatisfactory nature of one for which there appears to be an unwarranted attachment.

Tests of Driving Skill

The literature in this section is almost unanimous in its conclusions that driving skills deteriorate at relatively low blood alcohol levels (less than 0.05 percent). However, precise evaluation of alcohol effects is difficult because investigators are seldom interested in exactly the same question. For example, Huber (*39*) reports blood levels at which most of his motorcycle operators showed impairment (1.0 mg/ml or greater); Gelin and Wretmark (*28*) report the value at which at least one of their subjects showed impairment (0.32 mg/ml); and Bjerver and Goldberg (*6*) emphasize the degree of impairment at very low levels (25 percent–30 percent at 0.4–0.6 mg/ml). Table I summarizes the basic findings of each report. The language of the original report is preserved as nearly as possible.

The remainder of this section is given over to a closer and more critical look at the reports. The first topic compares driving course studies with simulated driving tests. The question of validity of the tests as expressions of actual road driving is thus raised. The third topic explores some subject characteristics that may be important in determining the response to alcohol. It is also concerned with driving test subjects and their representativeness as drivers in general. The last topic examines a few obvious methodological problems in driving and alcohol experimentation.

It has been pointed out that there are two kinds of driving studies: the driving course and the driving simulator experiments. Both techniques

[3] The use of "complex" for "higher" is also an assumption which may only indicate confusion. There is no necessary reason for "higher" (however it is defined) processes to be more "complex" (however that is defined) than "lower" ones.

have advantages and disadvantages. The major disadvantage that they share is that neither of them permits operation of a car under actual road conditions. Absence of traffic reduces considerably the hazard of actual driving and presumably the motivation that goes with it. It is not known to what extent either type of study duplicates real driving.

The advantage of the driving course study is that real cars are used. It provides many of the cues of the normal situation. The disadvantages fall into two groups: what the subject is required to do, and what measures are provided. Subjects are required to perform a number of discrete tests, each of which is scored. The tests stress close-quarter maneuvers at low speed (*6, 15, 16*). For example, in one study (*16*) subjects were required to back the car into a space only 7 inches wider than the car. The assumption is that delicate behavior is more apt to be impaired at low blood alcohol levels than cruder operations. The assumption presents the safest position with respect to dangerous results of drinking alcohol. However, it should be pointed out that this assumption, that alcohol affects delicate behavior more strongly than cruder behavior, has not been thoroughly explored. The test of this assumption would constitute an ambitious experiment in itself.

The limitations of the driving course studies are known to the people who use them. Coldwell, for example, points out the difference between conditions of his experiment and those of actual driving: slow speed (15 mph), absence of distracting passengers, absence of emergencies, knowledge of what to expect, etc. Nevertheless, there is still a difference: ordinary driving has a different goal (to get from starting point to destination) from that of the driving course (to drive as well as possible).

Because of the technical problems involved in instrumenting full-size cars, the alcohol driving course experiments have typically made measures such as time around the course, number of stanchions hit, turning in a limited space, number of bricks contacted with front wheel, etc.[4] These studies have not provided continuous records of the position of the car with respect to the road, continuous records of speed, steering wheel movement, or other measures which relate to driving conceived as a continuous process rather than a series of discrete events. Such measures are, at least in concept, easier to obtain from the driving simulators.

The driving simulators offer the opportunity for a variety of these process measures; e.g., accuracy of tracking in the Drew experiment, accuracy of holding the car in the center of the road, accumulated time off the road, percentage of time car is correctly aligned with the road (*45, 47, 54*). In both the Newman and Fletcher (*54*) and Loomis and West studies (*45*),

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[4] Coldwell et al.: garage test, alley test, parking test, and roadway test (turning around in limited space). Bjerver and Goldberg: garage test, steering forward test (object to knock down 3 blocks with front wheel, steering side), starting test (object to drive into sandbox and stop at proper location and drive out at signal), steering backwards test (object to back the wheels of the car onto a plank, steering side), turning test (turning around in limited space).

a signal light indicated to the subject when he was not properly positioned within well-defined limits; i.e., off the road—a somewhat unreal event in actual driving. Other process measures available from the Drew study were speed over the course and operation of controls; e.g., amount of steering wheel movement.

The simulators have serious disadvantages in terms of the degree to which they duplicate the stimulus situation provided by real cars. So far the automobile simulators used in alcohol experiments have reproduced certain characteristics of driving and ignored others. The greatest amount of development has been in presenting the subject with a realistic visual situation. Cues having to do with orientation in space and acceleration, etc., have been left out (although such simulators are under development). Mechanical features of the automobile itself have been only crudely reproduced, sometimes not at all. There is, of course, the problem of knowing what to duplicate, because the difference between various cars is so great. For example, one car has a steering ratio twice that of another; some cars have automatic transmissions and are customarily stopped by braking with the left foot, etc. Any of a long list of differences may affect the transfer to a simulator or a vehicle used in a test course.

There is as much room for conceptual development of driving simulation as there is for technical development of simulation of the task. Drew et al., for example, appear to be the first among recent experimenters to give consideration to duration and monotony of driving which they consider an important feature of driving under the influence of alcohol (*21*). In their study, four 20-minute periods, separated by 10-minute rest periods, were spread out over 2 hours of each of five experimental sessions, whereas Loomis and West spread four tests of about 5 minutes each over approximately 6 hours (*45*). In contrast, the Marquis group took one 15–30-minute measure, 30 minutes after drinking (*47*). Although findings are shown in table I, it is pertinent to cite a few results. For example, Drew et al. found that both tracking error and steering wheel movement were linearly related to blood alcohol, while speed was not. Loomis and West found that time off the road followed the blood alcohol curve closely. Newman and Fletcher found a correlation of 0.485 between a combination of tracking and braking, and alcohol. Loomis and West reported a relation between alcohol and time to brake at a red light and release of pressure on the accelerator for an amber light.

Other measures obtained in the course of driving tests were braking to a red light, release of pressure on the accelerator at an amber light (*45*), simple braking (*54*), braking at three different speeds (*47*), and braking with judgment; i.e., red but not to green light (*79*). Huber measured braking to signals during actual driving (*39*). Loomis and West found the responses to both lights related to alcohol, the larger influence being on the red light. Newman and Fletcher found significant relations between vigilance steering and braking (combination of simple steering and simple braking) and blood alcohol level. Marquis et al. found no relation between alcohol dose and braking, nor did Zirkle et al. Huber reported that RT's were prolonged. In these studies the responses made to lights, etc., are usually referred to as reaction time. Actually, the driving situation probably involves much more than comparable RT experiments as they are carried out in the laboratory. The term "reaction time" should be reserved for the laboratory. Braking response more accurately describes the behavior in the driving situation.

The Cohen et al. study requires special attention (*14*). The study is not so much one of actual driving skill as it is a study of judgment. It represents one of the few experiments which attempt to measure confidence in ability to perform a given operation that may be important to safety. For instance, the size of gaps through which a busdriver would attempt to drive was determined. Drivers, both with and without alcohol, were willing to drive through a space narrower than the bus, and the proportion increased with dose. The fact that sober drivers were willing to drive through a space narrower than the bus speaks against the validity of the experiment rather than the judgment of the drivers. Some factor in the experiment obviously did not duplicate actual road conditions. This experiment has been criticized on other grounds (*5, 57*). However, the basic idea remains good regardless of how the experiment was carried out.

Huber's experiments on actual driving differ from others in this group in that subjects performed on the road, sometimes in heavy traffic as well as on a test course (*39*). The vehicles used were motorcycles. Blood alcohol levels as high as 1.52 mg/ml (1.11–1.52 mg/ml) were obtained in some tests. Each subject of the 17 showed impairment on at least one of these series. In general, impairment was observed on the tests when it was not clinically discernible.

Validity

The simulated driving studies, e.g., Loomis and West, pose the question of validity much more clearly than do the studies of driving on a test course, since the differences between simulated and actual driving conditions are so obvious.[5] The problem of validity in both kinds of driving tests is the

[5] A few details from these experiments demonstrate obvious differences between actual driving and the simulators, and suggest the need for validity determinations. The Marquis et al. experiment made use of the AAA auto trainer, an apparatus which is criticized by Loomis and West as being unduly repetitive and therefore subject to easy learning and relatively insensitive to the measurement of tracking. The Loomis and West as well as Marquis' study can be criticized as lacking face validity because the subjects operated standard-size driving controls which regulated the movements of a miniature car on a miniature moving road surface. This is somewhat like being able to control the car in front by moving the steering wheel of one's own car. Newman and Fletcher's simulated driving situation seems more realistic from the subject's point of view. The subject saw a radiator cap and a hood through a windshield. Beyond this was a "photographic scene depicting a three-

same as it is in any testing operation, whether the object is to predict scholastic aptitude or neurotic tendency: To what extent does the test predict the behavior involved in the real thing? This turns the question toward the nature of actual driving, about which there is no clear knowledge at this time.

Although a driving course experiment very closely resembles actual driving, even to the extent of using real cars, it cannot be taken for granted that it is the same thing. This is emphasized by the kind of behavior required in these experiments; e.g., backing the car into a narrow space. It may be that the behavior in response to this requirement is an excellent diagnostic element for the true driving situation, but this is not known. In both the driving course and driving simulator, the measurements show very clear changes, most often deterioration, with alcohol, but these measures may be completely beside the point in actual driving as it normally occurs.

The same problem arises in the laboratory studies. It is tempting to generalize to driving after it has been shown that some behavior observed in the laboratory has been affected by alcohol. Conclusions drawn from laboratory experiments about driving are valid only if it has been shown that a relationship exists between them and driving. This is independent of the quality of an experiment or its theoretical importance. For example, many of the large numbers of reaction time experiments have concluded that deterioration due to alcohol has obvious significance for driving. This is based on an assumption that driving calls for split-second timing.[6] However, this cannot be settled either by discussion or meditation; validation procedures must be conducted.

The problem of validation raises another much-discussed problem. As already mentioned, in order to validate the behavior observed in driving studies, it is necessary to show a relation between it and actual driving. To do this, one must have descriptions of driving. Although everyone can identify driving when he sees it, no one knows what it consists of or what its significant features are. Without a proper description, it is not possible to determine the relations between driving and any other piece of behavior. The alternative to doing validation studies is to carry out alcohol experiments under live road conditions, an impossible proposal.

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lane highway, in the right-hand lane of which the rear elevation of a truck was apparent." The scene was made to move in an irregular and unpredictable manner. Drew et al. used the "Miles motor driving trainer" which comes closer to the ideal. The subject sits in a dummy car facing a screen on which a changing road scene can be seen. One assumes that the subject has the illusion of driving along a road. These experimenters point out that nondrivers require more practice than experienced drivers, who require little learning to operate the trainer. The driving circuit, about 1 mile in length, is also repetitive and is subject to practice effects.

[6] This assumption was questioned by members of the First Working Conference of the National Conference on Alcohol and Traffic Safety, May 1961, who feel that small changes in reaction time are of little significance for driving.

The determination of the relation between simulator and driving course experiments seems to be an obvious step toward validation. Since it is assumed that both kinds of studies relate to actual driving, it has been assumed that they relate to each other. A test of this assumption could lead to interesting conclusions. If there were no correlation, we would know that one or both kinds of studies was not a measure of actual driving. If the correlations were significant, we would only know that the two techniques measure the same thing, whatever that may be.

Subject Variability

In experiments on behavior, there is one remarkable characteristic: the degree to which subjects differ from each other. These differences are sometimes forgotten because the experiment was directed toward a different goal; i.e., alcohol effects. In addition, many experimental designs are satisfactory for isolating subjects as a source of variation, but far from ideal for examining the reasons for the variability within individual subjects. Nevertheless, some experimenters (e.g., Drew et al.) have been successful in using subject measures as an adjunct to the main purpose of an experiment. The experiment in which a subject variable represents the primary consideration is quite rare. The Vogel study is an example: personality adjustment of the subjects is the independent variable (*76*).

Drinking patterns seem to be important. Goldberg found differences on his sensory, motor, and intellectual tasks for abstainers, moderate, and heavy drinkers (*31*). On the problem-solving task mentioned earlier, there was a suggestion of a relationship between quantity-frequency drinking score and ability to solve problems (*12*). Provided that subjects did not have blackouts, those with a higher quantity-frequency score solved more problems. The relation is left in doubt because of a statistical and methodological disadvantage.[7]

Level of skill is a ubiquitous problem in any behavior experiment. Rosenthal's experiment using a sensory-motor test illustrates its effectiveness (*67*). With increasing experience, both groups (control and alcohol) continued to improve until a point was reached at which the alcohol group was performing better under alcohol than either group at some earlier stage of skill. This suggests that some accidents occurring at very low blood alcohol levels could have been prevented had the drivers had higher levels of basic skill.

Ethnic and religious factors are sometimes mentioned as important determiners of the response to alcohol (*72*). Attitudes may be important; alcohol may change a defensive driver to a nondefensive driver without altering his skill. He would then constitute a hazard because some accidents which he normally could have prevented are no longer avoidable.

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[7] Snyder, C. R., University of Southern Illinois, personal comment.

Along with Conger's and Masserman's animal studies (*18, 48*), skin conductance studies on human subjects (*33*) suggest that alcohol has a tension-reducing effect. But McDonnell and Carpenter cast doubt on any simple interpretation of skin conductance as a measure of tension (*50*). These authors found that a decrease in skin conductance can be interpreted as an increase as well as a decrease in tension, depending on the reported tension level of each subject. Such a result suggests that some levels of alcohol may have an energizing effect for some people.

Some of these problems can be more concretely illustrated in the driving studies where experimenters have frequently described their subjects in greater detail. The question to be answered here is one of sampling. To what extent, in terms of skill, personality, drinking patterns, etc., do the drivers in these experiments represent drivers in general?

Bjerver and Goldberg's subjects were driving school instructors, and three of Coldwell's subjects were eliminated for failure to master the course in preliminary testing. Cohen et al. used busdrivers with an average of 12 years' experience and awards for safe driving. One is forced to assume that these subjects were very good drivers. It might be inferred that the skill displayed even when impaired under alcohol was better than the average skill of the average driver under ordinary driving conditions without alcohol.

Drew et al. used what appears to be a homogenous group of subjects (staff members of the Road Research Laboratory) who may have had special skills, opinions, or attitudes related to a group or professional affiliation which may in some way affect driving skill or habits. The same comment can be made for the Newman and Fletcher study ("mainly physicians and medical students and a few skilled workers").

Drew's group does not look so homogeneous after closer examination. Drew et al. found that behavior in the driving simulator was related to an introversion-extroversion dimension of personality. Subjects classified as extroverts made more tracking errors under the influence of alcohol, while those classified as introverts made more changes in speed of driving. The introverts divided about equally into those who slowed down below their customary driving speeds when sober and those who speeded up. It seems likely that no single set of attributes can typify subjects as far as alcohol is concerned. Both Drew et al. and Vogel are examples. Gelin and Wretmark suggest that "constitutional psychic factors" may influence the reaction of alcohol. Bjerver and Goldberg found poorer drivers improved more under nonalcohol conditions and less under alcohol conditions than did the better drivers. Coldwell et al. found heavy drinkers less affected by alcohol than light drinkers.

On the other hand, Drew et al. found that "age, sex, previous driving experience, and previous drinking habits, within the limits available, showed no relation to individual differences in response to alcohol." Newman and Fletcher reported very similar results, thus contradicting to some extent (sex was not a factor in Bjerver and Goldberg, or Coldwell et al.) the findings of Bjerver and Goldberg, and Coldwell et al. These studies are not adequate tests of sex as a differential factor. Marquis et al. used the highest proportion of women (14 out of 50), but it is not clear whether sex differences for alcohol were determined. Five of the 40 subjects used by Drew et al. were women. Newman and Fletcher used only 8 women in a group of 65 subjects. Loomis and West report 10 subjects, Bjerver and Goldberg used 37, and Gelin and Wretmark used 12, probably male; Coldwell et al. and Cohen et al. used only men. In the studies where women are used, the proportion is too small to constitute a reasonable test of sex as a factor in differential driving ability or response to alcohol.

In view of Lisansky's finding, that women experience a different and more rapid course in alcoholism, it is possible that an interaction between sex or other subject characteristics and task would be found (*44*). For example, one would expect that had Bjerver and Goldberg and the Coldwell group used both men and women in their experiments, in which a premium is placed on close-quarter, precision maneuvers, a significant sex difference would have been found. But the Drew and the Newman and Fletcher experiments might not have found differences between the sexes because the subjects were asked to engage in what appeared to be routine driving.

In summary, the following factors have not received enough attention: sex, driving experience, age, and circumstances immediately prior to driving. More attention could be given to initial driving skill, personality adjustment, and drinking experience. Future studies should be conducted so as to gauge the relative magnitude of the effect of these factors as compared to that of alcohol rather than simply eliminating them as contaminating features or showing that they operate. Safe driving may depend first on the basic skill of the driver and similar factors and, secondly, on low or moderate blood alcohol levels.

Methodological Question

It seems appropriate to raise some questions about the administration of alcohol. In order to have an experiment using alcohol, it is necessary to be certain that the alcohol has reached the blood of the subjects and that variation in blood alcohol levels for any one dose is as small as possible. Where blood alcohol level cannot be measured, alcohol should be administered in a manner that would give confidence that it is the agent causing behavioral change. For example, in one study, 2 ounces of 86-proof whisky were given to subjects whose body weights were distributed over a range of 41 kg to greater than 85 kg, or 0.30 ml of absolute alcohol per kg of body weight to 0.63 ml per kg (0.14 ml/lb to 0.29 ml/lb), one dose being double the other. The interval between the administration of the drug and the last meal is not mentioned. It is, therefore, impossible even to guess what percent of alcohol was in the subjects' blood, and it is not surprising that little or no effect of the alcohol was observed (*47*).

The effect of repeated measurements (practice, fatigue, warmup, etc.) on the behavior being observed continues to be a source of difficulty. Although actual driving may be a relatively stable situation, experiments usually involve practice effects. For example, in the simulated driving studies, there is probably enough difference between the controls operated by the subjects and those of an actual car to result in considerable change in performance with additional experience. Bjerver and Goldberg, and Drew et al. found ways to estimate their alcohol effects with the practice effects removed (*6, 21*). Other experimenters preferred to give subjects what they considered to be sufficient practice to reach a stable condition in advance of actual testing. But passing from a practice to an experimental session can alter a plateau and it is impossible to know if the level reached during practice is maintained. When steps are taken to keep practice separated from drug effects, the presence or absence of practice effects is beside the point. When pure practice effects are available, they can be used as a reference against which the changes produced by the drug may be compared.

A somewhat related problem is concerned with the control dose (zero alcohol), when the subjects are used as their own controls. Designs of this kind are more efficient in that they eliminate differences due to characteristics of individual subjects. If such a design is used, the question is: Should the control dose come before or after alcohol? Because of the practice effect, overestimation of the alcohol effect will occur if the control dose follows the drug, and underestimation if it precedes the drug (assuming that alcohol produces deterioration). One solution is to use a nontreated control group, as Bjerver and Goldberg did, or one of the more sophisticated experimental designs which is specifically designed to answer this problem (latin squares, etc.). Where more than two doses of alcohol are used, efficiency and ease of analysis are gained by using a series of equally spaced doses, including the zero dose, in which case each dose must appear in each experimental session if subjects are to serve as their own control (Drew et al., Carpenter, Carpenter et al.).

A doubtful procedure is one which estimates the drug effect from the predrinking level of behavior. For example, in some experiments the subjects perform on tests spread over several hours after the alcohol administration and the effect of the drug is estimated from the predrinking level obtained from a relatively short period. Thus, motivational changes and fatigue may affect the postdrinking behavior, to say nothing of practice effects. The point here is that measuring predrinking behavior is not the same as administering a zero dose. A zero dose must be administered under exactly the same conditions as the nonzero doses. The proper comparison is between two postdrinking periods, one of which contains the zero dose. Failure to use the zero dose properly militates against otherwise carefully and thoughtfully planned experiments.

One additional point: There is no substitute for common sense in experimentation. This is illustrated by Zirkle et al., who administered a tranquilizer (chlorpromazine) at therapeutic doses for a week (in the manner it is ordinarily used) in advance of testing with alcohol (*79*). A mild dose of alcohol (BAL of 0.50 mg/ml) produced unexpectedly severe effects. This is in contrast to the results of others who administered the tranquilizers only a short time prior to testing (*47*).

Summary

1. At the present time, we lack a definition of driving. That is, we have no precise description of driving. We cannot say which behaviors are absolutely necessary, which are nice to have, and which are superfluous.

2. We lack validation studies which depend, to a certain degree, on our definition of driving. In other words, we do not know to what extent, if any, our experiments reflect, reproduce, or correlate with actual driving or parts of driving. For all we know, our work may be irrelevant to driving or possibly not as relevant as we have hoped.

3. We need intensive attempts to distinguish among subject variables and to determine the direction and extent to which they operate. One may anticipate that alcohol will produce entirely opposite effects for groups of subjects who have been segregated by homogeneous personality and social characteristics. Some of our present concepts may be modified by showing that alcohol operates more or less powerfully once we confine ourselves to more homogeneous subject groupings.

4. No matter how humble an experiment, if it is methodologically sound, it will be more useful than a complex one which leads to uncertain conclusions. Similarly, we need the same degree of expertise, ingenuity, and creativity that is required for successful experimentation when alcohol is not a feature of the research.

5. Hypotheses become explanations without ever being tested. We need a critical look at our most revered assumptions about how alcohol works, and a set of alternative hypotheses would be useful. Is it true that alcohol is a universal and continuous depressant? Are complex functions more susceptible to alcohol than simple ones? Is recent learning more apt to be affected by alcohol than older learning?

TABLE I. *Driving*

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Huber (*39*)	Road tests: motorcycle.	6 5 and 7	Not stated	1.11–1.52 0.34–0.97	Not stated	Mistakes in handling motorcycle seen at BAL over 1.0 mg/ml; ability to judge speed and prolonged reaction times observed below 0.5 mg/ml.
Gelin and Wretmark (*28*).	Driving tests	12 drivers, all moderate drinkers.	40–106 ml	.....	do	Clinical tests showed drivers "under the influence" at 0.7 mg/ml; driving impaired in some as low as 0.32 mg/ml.
Bjerver and Goldberg (*6*)	Driving tests: garage, steering forward, parking, turning, starting, steering backward.	37 male driving school instructors.	0.69 ml/kg (brandy). 0.80 ml/kg (beer).	0.49 0.46	BAL 74 minutes after beginning to drink and immediately after driving test.	3.3 to 71.8 percent impairment on separate tests: average of 27.9 percent at 0.4–0.5 mg/ml.
Coldwell et al. (*16*).	Driving tests: garage, alley, parking, roadway.	50 male, divided into light, moderate, and heavy drinkers.	Approximately 1.1 ml/kg in 3 doses.	.....	1 hour for drinking, 20 minutes per dose; BAL 45′–50′ after end of drinking and every 30′ of test to 2.5 hours.	Impairment in 5 of 7 subjects at BAL not greater than 0.5 mg/ml; in heavy drinkers, 8 of 10 showed impairment at BAL 0.51–1.2 mg/ml; 50 percent exhibited significant impairment at BAL 0.78 mg/ml.

Cohen et al. (*14*)	Estimation of success and performance of driving bus through gaps of varying widths.	3 groups of bus drivers with about 20 years' experience and awards for safe driving.	23 ml. 68 ml. zero	0.04 0.58	BAL approximately 1.74 hours after drinking.	Drivers were willing to drive through gaps narrower than the bus, the proportion increasing with the amount of alcohol; wider gap was required for success at higher doses.
Loomis and West (*45*).	Simulated driving	10 male	Not stated	0.3–1.8	6 hours of hourly doses; tests run before and at 90′, 180′, and and 300′ from beginning to drink.	BAL well below 1.5 mg/ml induced measurable impairment; all subjects showed some impairment at 0.5 mg/ml.
Marquis et al. (*47*).	Modified AAA auto trainer.	36 male; 14 female.	60 ml. with or without meprobamate.	Not stated	Test 30′ after administration.	Of 21 variables (8 on driving test), 15 unfavorably affected by alcohol as compared with placebo.
Newman and Fletcher (*54*).	Simulated driving: simple steering, simple braking, vigilance steering and braking.	57 male; 8 female (98 trials); no heavy drinkers.	1.0 ml/kg (in a few subjects 0.5, 1.5, and 2.0 ml/kg).	Peak 0.90–0.99.	15 minutes for drinking; tests before and 1 hour after end of drinking.	BAL and percentage loss in vigilance steering and braking correlation: 0.485 ± 0.077; loss of vigilance steering, and braking and crude steering correlation: 0.576 ± 0.068.

TABLE I. *Driving*—Continued

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Drew et al. (*21*)	Miles motor driving trainer. Steering accuracy. Speed. Steering wheel movement. Individual differences in personality characteristics.	35 male; 5 female.	0.0 ml/kg 0.25 ml/kg 0.44 ml/kg 0.69 ml/kg 0.82 ml/kg	.... 0.20 0.40 0.60 0.80	10 minutes for drinking. 10 minutes after drinking testing began.	Increase in error of steering with increased blood alcohol. Amount of steering wheel movement increased with blood alcohol. Extroverts made more errors, less consistent in positioning car, larger increase in error. Introverts greater variability in response. Some introverts increased, some decreased speed.

Table II. *Reaction Time*

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Carpenter (*11*)	Simple RT Stimulus: visual. Response: thumb flexion.	9 male	0.00 ml/kg 0.40 ml/kg 0.80 ml/kg Caffeine also given.	 0.40–0.50 0.70–0.80	Tests made between 30′ and 90′ after beginning of drinking.	Increase 12 msec., 6 percent over zero dose.
Dettling (*20*)	Stimulus: visual, auditory. Response: not stated.	20 male; 2 female.		0.70–2.10		Prolonged 30 percent for visual stimulus; prolonged 38 percent for auditory stimulus.
Forbes (*27*)	Stimulus: visual, auditory. Response: not stated.	61	"100 cc. whisky at 30 under proof"; "100 cc. whisky +40–75 cc. absolute alcohol."		Tests made 30′ to 60′ "after ingestion"; 215 observations of RT.	45 clinically unfit to drive: 0.1428 second increase visual RT; 0.1197 second increase auditory RT. 167 clinically fit to drive: 0. 0453 second increase visual RT; 0.0320 second increase auditory RT.
Grüner (*34*)	Choice (RT part of battery of tests carried on simultaneously). Stimulus: 3 visual, 1 auditory. Response: levers, pedal.	10	1.53 ml/kg		Test included absorption and elimination phases of blood alcohol curve; 90′ or longer from beginning to drink.	50 percent deterioration at 1.1 mg/ml; lower performance on both tests during ascending phase of BAC; composite results: "total attention," 80 percent lower in absorption phase; 57 percent lower in elimination phase.

TABLE II. *Reaction Time*—Continued

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Grüner and Ptasnik (*35*).	Choice (RT part of battery of tests carried on simultaneously). Stimulus: 3 visual (periph.), 1 auditory. Response: levers, pedal.	10	1.53 ml/kg	......	4 hours "after ingestion."	200 percent increase in RT (peripheral stimulation).
Hausser and Truffert (*37*).	Not stated	Not stated	0.64 ml/kg 1.27 ml/kg	0.65 "by weight."	4 hours after ingestion; 2 hours.	RT and other measures unfavorably influenced by alcohol.
Howells (*38*)	Simple RT Stimulus: visual, auditory. Response: Morse key, extension of left index finger.	11 male; 1 female.	0.70–1.40 ml/kg	......	15′ to 60′; 10′ allowed for drinking.	RT increased 4.3–35.9 percent at appearance of nystagmus; further increases with time.
Lambercier and Martin du Pan (*41*).	Simple RT, choice RT. Stimulus: visual. Response: simulated auto, turn wheel, press accelerator, brakes, etc.	10	1.27 ml/kg	0.80–1.00	75′	No effect on simple RT; choice RT lengthened by 10 percent.

Do	Simple RT, choice RT.	25		0.80–1.00		Psychic capacity definitely diminished, especially functions involved in driving.
Laves (*43*)	Stimulus: visual. Response: not stated.	100				RT generally longer; large amount of scatter.
Mueller (*51*)	Not stated	10		1.0, 1.5, 2.0		RT prolonged in 8 subjects; improved in 2 subjects at 1.0 mg/ml; RT prolonged in all subjects at 1.5 and 2.0 mg/ml.
Patay et al. (*56*)	Choice RT. Stimulus: visual, auditory.	10	100 ml	0.80–1.40	1–4 hours after ingestion.	Increased RT (all subjects); 10-percent increase in error at 0.80 mg/ml; 26-percent increase in error at 1.4 mg/ml.
Rauschke (*63*)	Choice RT. Stimulus: 1 visual, 1 auditory. Response: key (hand).	19, of which 8 used again after sleep.	1.27 ml/kg; additional dose after sleep.	0.8–1.0	Tests included absorption and elimination phases of BAC.	RT longer during elimination than absorption phase; additional alcohol after sleep resulted in improvement in 3 of 8 subjects.
Zirkle et al. (*79*).	Choice RT. Stimulus: visual. Response: levers.	24	0.59 ml/kg with chlorpromazine.	0.35–0.48	60′ from beginning of drinking.	No effect on choice RT.

TABLE III. *Motor Skills*

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Aksnes (*7*)	Link trainer	14 experienced pilots.	0.27 ml/kg 0.66 ml/kg	0.20 0.77	Test run 90′ after drinking; BAL taken at end of test.	Ability lowered at BAL 0.5 mg/ml; may be lowered at 0.2 mg/ml.
Eyer and Ivers (*26*.)	do	6; trained about 30 hours each.	60 ml 120 ml	0.5 0.8	BAL before test, after 30′, and at end; total 2½ to 3 hours.	Group I (60 ml dose) mean showed no significant changes; Group II (120 ml dose) most pronounced decrement on bank scores; Link trainer can be used to show effects of drugs but is impractical.
Newman (*52*)	Target shooting	39 male	0.22 ml/kg every 20 minutes.	Peak depression at 1.00–1.19, range 0.40–2.19.	Dose given every 20′ until drop of 100 points from average score of 600 was attained.	Failure in coordination showed at much lower levels than clinical signs of intoxication; large individual variations.
Newman and Abramson (*53*).	do	1; "susceptible to alcohol."	1.06 ml/kg, plus additional doses, amount not specified.	0.56 (0.7 in urine).	Maximum concentration at 1 hour maintained with additional doses for 2.5 hours.	Performance dropped at maximum concentration; rose to normal at 2.5 hours (39 percent deterioration).

Do	do	1; "less susceptible to alcohol".	(*a*) 1.32 ml/kg +10.6 ml hourly.	(*a*) 1.6 (2.0 in urine).	(*a*) Maximum at 30′–45′; 6 hours total.	(*a*) Performance dropped at maximum, returned at 4 hours (22 percent deterioration).
			(*b*) 21.2 ml hourly in milk.	(*b*) 0–1.2 (0–1.5 in urine).	(*b*) 6 hours	(*b*) Performance remained normal.
			(*c*) 0.66 ml/kg hourly.	(*c*) 0.8–1.6 (1.0–2.0 in urine).	(*c*) 4 hours	(*c*) Performance remained normal and constant throughout.
Eggleton (*23*)	Typing	1	Not stated; additional dose.	0.8–1.25 (peak); 1.25–1.16 (descent); then return to 0.5.	15 minutes later	Errors, 35 percent. Recovery complete. Errors reappeared on additional dose.
Prag (*61*)	do	5 female professional typists.	0.66 ml/kg	Maximum 0.55–0.70.	5 minutes to drink; time counted from end of drinking; maximum BAL at 120′ for 0.66 ml/kg dose, at 60′ or 90′ for 1.32 ml/kg.	Errors increased from 0–4 percent (normal) to 17–35 percent with smaller dose and to 35–61 percent with larger dose; errors increased markedly even when no clinical signs of intoxication were present.
			1.32 ml/kg	Maximum 1.4–1.7.		
Rabin and Blair (*62*).	Handwriting	40 male	135–225 ml over 4.5-hour period.	0.54–1.75	4.5 hours	Significant differences in writing done before and after drinking.

Table III. *Motor skills*—Continued

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Schweitzer (*69*)	do	80	Not stated	1.3 1.5 2.0		Most changes at 1.3 and 2.0 mg/ml; most errors at 1.5 and 2.0 mg/ml.
McCleary and Johnson (*49*).	Brush-assembly breakdown in cold room.	64 male	60 ml; zero		Alcohol 10 minutes before beginning test; test takes about 20 minutes at room temperature.	Working time with and without alcohol showed no difference, total time significantly less, no time taken to warm hands with alcohol.
Vogel (*76*)	Toronto complex coordination.	40 male 20 high adj. on medical questionnaire; 20 low adj. on same questionnaire.	Not stated	0.10–0.40 0.50–0.80		Accuracy on complex task increased in better adjusted subjects at BAL of 0.10–0.80 mg/ml, but in poorer adjusted subjects not until 0.50–0.80 mg/ml; heavy drinkers slowed performance at BAL 0.10–0.40, no correlation at higher BAL.
Enzer et al. (*25*)	Tapping	3 male	13.5–54 ml at 4 or 5 levels per man.	0.52 mg/ml maximum concentration at 120 ml dose.		2 subjects increased rate 25 percent at 30–60 ml doses; decreased at 120 ml dose. Third subject results not consistent.

Takala et al. (*73*).	"Dexterity"	38 male; 45 controls.	1.9 ml/kg as beer or brandy Hangover: beer brandy	 1.24 1.52 0.06 0.17		Significant impairment in all tests for both beverages; brandy hangover tests almost as good as controls; beer hangover dexterity improved.
Rosenthal (*67*)	Visual-motor skill "sleeve test."	11	45 ml			Alcohol affected performance but not learning. Extensor movements more affected than flexor movements.
Bschor (*9*)	Ring test	6 male; 5 habituated to alcohol; 1 not habituated was dropped from the experiment.	2.0 ml/kg	1.2–1.4	BAL at 15′–20′ intervals during first 90′, then at half hour and hour intervals.	Impairment at equal BAL differs on ascent and descent of alcohol curve.
Elbel (*24*)	Ring test	2 males	78 ml. as beer +37 ml as schnapps +9 mg pervitin before drinking or at maximum concentration.		Drinking period 1 hour; maximum 1 hour later; total 5 hours.	Pervitin brought performance curve within sober limits or kept it there depending on when taken; use of pervitin may give a man too much confidence in his ability to perform normally; simulated sobriety dangerous.

TABLE III. *Motor skills*—Continued

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Berg (*4*)	do	7	Not stated + "Benadon" (B_6).	1.3–1.9	B_6 given 1 hour after maximum concentration.	60–70 percent deterioration under alcohol, no sudden sobering or improvement with B_6.
Berg (*3*)	do	6 male; 2 female.	Not stated + levulose.	1.5	5 hours	Levulose causes psychological sobering but performance worsens; given during absorption causes lower alcohol curve, during declining part of curve it hastens elimination.
Pihkanen (*59*)	Finger-finger	10	1.3 ml/kg in 6 equal parts drunk 10 minutes apart, as brandy or beer	Mean at 60′ and 90′; 1.24 for brandy; 0.87 and 1.04 for beer; brandy dropped to 0.80 at 240′.	BAL at 30-minute intervals for 3 hours.	Maximum impairment for brandy at 60′ and for beer at 90′.
Goldberg (*37*)	do	17 moderate drinkers.	0.84–1.9 ml/kg	1.20 peak		174 percent increase in area at 1.0 mg/ml; threshold at 0.39 mg/ml (reference=100 percent).

Pihkanen (*59*)	Swaying (modified Romberg).	12	1.3 ml/kg in 6 equal parts drunk 10 minutes apart; as brandy or beer.	Mean at 60′ and 90′; 1.24 mg/ml for brandy; 0.87 and 1.04 mg/ml for beer; brandy dropped to 0.80 mg/ml at 240′.	BAL at 60′, 90′, 120′, 150′, 180′, and 240′ after start.	Swaying maximum in first hour after brandy; at 120′ after beer; 140.0 percent raw data; 30.6 percent based on logs.
Goldberg (*31*)	Romberg: ordinary, modified.	17 moderate drinkers.	0.84–1.9 ml/kg	1.20 peak		Threshold appeared at 0.65 mg/ml for ordinary Romberg and at 0.41 mg/ml for modified Romberg; 490 percent at 1 mg/ml; 1,622 percent at 1 mg/ml, respectively (reference=100 percent).
Small et al. (*71*).	Romberg	6 alcoholics	2.0–2.65 ml/kg in 2–3 doses + 0.5–2.0 pyridoxine hydrochloride (B_6).		Test before and after B_6.	Performance improved after B_6, but no change in BAL.
Do	do	5 normal males	0.66–2.32 ml/kg in 1–2 doses + 0.5–2.0 pyridoxine hydrochloride.	Not measured		Effect of B_6 not sufficient to indicate its use in alcoholic intoxication.

TABLE IV. *Positional Nystagmus*

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Aschan et al. (*2*).	Positional alcohol nystagmus (PAN).	9 male; 8 female; no heavy drinkers.	0.82 ml/kg (average).	0.24–1.18 (average 0.61).	BAL every 15–30′, then 30–45′ for 4–5 hours for PAN I or 13–14 hours for PAN II.	PAN I appeared at average of 31′ after alcohol (BAL 0.38 mg/ml) and lasted about 3 hours (BAL 0.33 mg/ml), is independent of amount, correlates positively with BAL; PAN II appeared at average of 4.75 hours after alcohol and lasted average of 6 hours; relationship between amount and duration of PAN II.
Howells (*38*)...	PAN..............	11 male; 1 female.	0.7–1.0 ml/kg (to produce PAN); some up to 1.4 ml/kg.	Not stated....	....	PAN accompanied by increase in reaction time of 4.3–35.9 percent at onset of nystagmus (some as early as 15 minutes after alcohol).
Seedorff (*70*)...	PAN..............	7 (in a party setting).	Not stated......	1.0–2.0.......	....	Observed at an early stage in all subjects; still present the next morning.

Taschen (*74*)	PAN	570 (600 controls).	do	Not stated		Nystagmus lasting over 10 seconds always corresponds to BAL of at least 0.8 mg/ml.
Walter (77)	PAN	43	40–60 ml	do		PAN I appears 79±43 minutes after beginning of drinking, lasts 216±50 minutes; period of 55±19 then PAN II at 4–5 hours after end of drinking and lasts 6–10 hours.

TABLE V. *Sensory Processes*

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Enzer et al. (*25*)	CFF (critical flicker frequency).	3 male	13.5–54 ml at 4 or 5 levels per man.	0.52 maximum concentration at 120 ml dose.	...	In all but 1 of 14 tests, flicker fusion frequency diminished with rising alcohol concentration.
Goldberg (*31*)	CFF	17 moderate drinkers.	0.84–1.9 ml/kg	...	9 tests over 7–9 hour period; 2 before alcohol; BAL every 20′–30′ during absorption, every 40′–60′ during elimination.	Threshold at 0.54 mg/ml for CFF; 151 percent increase in light intensity to reach fusion at 1.0 mg/ml (reference 100 percent).
Goldberg (*32*)	CFF	10 (9 controls)	0.49–0.92 ml/kg (average 0.69 ml/kg).	0.67 average maximum.	BAL at 30′, 60′, and 90′.	32.4 percent lowered efficiency on CFF; 48 percent increase in light intensity over predrinking levels.
Rizzo (*65*)	CFF	20	0.64 ml/kg	...	Tested every 5 minutes for 1 hour.	Significant decrease only for first 15 minutes; variability continued only through first 25 minutes; explained by adaptation to rising alcohol levels.

Rokseth and Lorentzen (*66*).	CFF	25 male	0.66–0.93 ml/kg + hypoxia effects.	Average 0.34	Alcohol effect greatest at 60′ to 90′ after ingestion.	At sea level many persons remained unaffected by BAL of 0.3 to 0.4 mg/ml; performance decreased during hypoxia at levels above 0.3 mg/ml.
Charnwood (*13*).	Fusion	4	9 ml at 15-minute intervals for 5 doses.	....	Tested before every dose and after the last dose.	Reduction in power to overcome prisms (Risley rotating) is proportional to amount of alcohol drunk.
Peters (*58*)	Color fields	1 male	21.6 ml every 30 minutes to total of 151.2 ml in 3 hours (as beer).	Not stated	10 minutes for drinking; 10 minutes for examination of each eye; repeat for each of 7 doses.	After 64.8 ml depression stage of exogenous toxemia; after 151.2 ml first 2 stages of a degenerative toxic condition with collapse of color fields.
Newman and Fletcher (*55*).	Visual acuity, depth perception. Distance judgment Lateral fields Eye coordination Glare resistance Glare recovery	35 male; 15 female.	1.0 ml/kg minimum; more on request.	0.58–2.18	15–30 minutes for drinking; tests before and 45 minutes after drinking.	Changes in various components not always correlated with alcohol level; at 1.15 mg/ml at least 1 component impaired significantly; wide individual variations; demonstrates limitations of BAL as sole criterion of intoxication.

TABLE V. *Sensory Processes*—Continued

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Schmidt and Bingel (*68*).	Color saturation thresholds (red, green, blue).	3 10 5 13	28.5 ml 45 ml 60 ml 60 ml	Not stated	Tests at 0, 30′, 60′, and 90′.	No effect with 28.5 and 45 ml doses; results of 13 subjects with 60 ml dose showed lowest mean of correct response at 30′ after alcohol; all 3 colors affected; "alcohol effect in general produces lowering of recognition by deterioration of cerebral function."
Brecher, Hartman, and Leonard (*8*).	Binocular vision	14	17.4 ml every 30 min.	...	Tests before alcohol and every hour as long as subject was able to cooperate.	Binocular fusion retained at 82 cm when lost at 600 and 33 cm; voluntary convergence not impaired at levels up to 0.3 mg/ml; impairment in fusion power and convergence marked between 0.5 and 1.5 mg/ml.
Goldberg (*32*)	Corneal sensitivity	10 (9 controls)	0.49–0.92 ml/kg (average 0.69 ml/kg).	Average maximum 0.67.	BAL at 30′, 60′, and 90′.	35 percent lowered efficiency.

Goldberg (*31*)	Corneal sensitivity threshold.	14 moderate drinkers.	0.84–1.9 ml/kg	....	9 tests over 7–9 hour period; 2 before alcohol; BAL every 20′–30′ during absorption, every 40′–60′ during elimination.	Threshold at 0.31 mg/ml; 178 percent increase in air pressure at 1.0 mg/ml to produce blink reflex (reference=100 percent).
Wolff, Hardy, and Goodell (*78*).	Pain threshold raising.	3 (authors): 2 male, 1 female.	14.2–94.2 ml given at various intervals.	Not stated	Tests made every 10′ until threshold returned to control level.	Maximal threshold raising effect (45 percent) achieved by 28.4 ml dose, usually 30′ after ingestion and lasting 2.5 hours; larger amounts did not change maximum; effect prolonged by spacing doses of 28.4 ml 1 to 1.5 hours apart.
Margulies, Irvin, and Goetzl (*46*).	Olfactory acuity	3 female; 2 male.	9.0 ml with or instead of lunch.	do	28 days; 15 control, 5 alcohol instead of lunch, 3 alcohol with lunch, 5 neither alcohol nor lunch.	Alcohol produced increase in threshold (decrease in acuity) frequently greater than food; alcohol with food did not differ from food alone.
Giardini (*29*)	Dark adaptation	6 abstainers 6 occasional 4 excessive	0.67 ml/kg or 1.32 ml/kg + anoxia effects.	do	Observation 1.5–2.0 hours.	Alcohol had no effect on dark adaptation; some transitory increases in threshold in abstainers and occasional drinkers.

TABLE V. *Sensory Processes*—Continued

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Rizzo (*64*)	Nagel's anomaloscope, the red and green mixture necessary to produce yellow.	20 (normal color vision).	1.32 ml/kg	Not stated	Tested at 5–10 minute intervals for 1 hour.	After alcohol 16 subjects required more red to make it match; 3 more green, 1 no change.
Giardini (*30*)	Fusion of retinal images, Maddox cross.	12	1.32 ml/kg while fasting.	Not determined; assume maximum BAL at 20–40 minutes after ingestion.		All subjects showed diminution of fusion ability.
Colson (*17*)	Visual acuity Visual field. Dark adaptations. Color vision.	21	60 ml whisky every ½ hour until incapacitated; 240–300 ml.			No effect on acuity, field, color vision; major effect on muscular balance.

Table VI. *Intellectual Functions*

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Bohné et al. (*7*)	Bourdon, modified Bourdon, "psychotechnic" device (synchronization of hand, eye, attention, and judgment).	15	1.72 ml/kg	0.98–1.38	....	Average 48 percent impairment of attention.
Goldberg (*31*)	Bourdon, subtraction	17 moderate drinkers.	0.84–1.9 ml/kg	....	9 tests over a 7–9 hour period; 2 before alcohol; BAL every 20′–30′ during absorption, every 40′–60′ during elimination.	Threshold at 0.49 mg/ml for subtraction; at 0.48 mg/ml for Bourdon, number correct, and 0.40 mg/ml for Bourdon time.
Pihkanen (*59*)	"Square test" (similar to Form 1, Block Design Test of Wechsler-Bellevue).	12; 18 controls	1.3 ml/kg in 6 equal parts drunk 10 minutes apart as beer or brandy.	Mean at 60′ and 90′: 1.24 for brandy; 0.87 and 1.04 for beer, respectively.	Tests at 0, 60′, 120′, and 180′.	Performance more strongly disturbed by brandy during first hour (0.02 mg/ml); maximum disturbance for both brandy and beer at 120′; "no remarkable change after this time."

TABLE VI. *Intellectual Functions*—Continued

Author and reference No.	Type of test	Subjects	Dose	BAL (mg/ml)	Timing	Results
Takala et al. (*73*).	Space factor; number factor.	38 male; 45 controls.	1.9 ml/kg as beer or brandy; hangover considered for each beverage.	1.24 for beer; 1.52 for brandy. 0.06 and 0.17 for hangovers, respectively.	BAL after ingestion & 12 hours later, evening session 2½ hours, 1–1½ hours spent on tests; hangover session 12½ hours after cessation of drinking.	Impairment most readily seen in space factor; space and number more readily disturbed than dexterity and perceptual speed; some impairment found during hangover for space and number while not for dexterity.
Schweitzer (*69*).	Drawing (perception).	80	Not stated	1.3, 1.5, 2.0	....	40 percent of subjects could not accomplish task (recognition of figure outlined by dots) under alcohol; at 1.7 mg/ml, figure could not be seen but in 1 case as low as 0.8 mg/ml; at same time arithmetic problems solved easily.

Hartocollis and Johnson (*36*).	Verbal fluency: 4 tests with various degrees of restriction on words produced.	30 male; 30 controls; groups matched for age and intellectual background.	0.83 ml/kg	Amount of alcohol given to produce 1.0.		On 3 tests alcohol reduced fluency; on 1 test (naming common classes of objects; e.g., birds, trees, etc.) alcohol increased fluency (not significant) by lowering standards of performance; thus "family tree" was included with "trees."
Davis et al. (*79*)	Memory span for digits and sentences, consecutive addition, reverse clock problems, strength of grip.	6 male	2.0 ml/kg	1.25–1.40	BAL at 60′, 90′, 120′, 240′, and 300′; tested every hour for 5 hours.	Performance impaired, particularly in addition, clock problem, and strength of grip while BAL at peak; poor performance "associated with slurring of speech, ataxia, emotional changes, and failure of cooperation."
Düker (*22*)	Arithmetical calculation.	Both sexes; number not stated (9 series of experiments).	4 ml; 8 ml		Alcohol taken 20 minutes before testing; task required 1 hour.	Performance lowered by 5.6 percent (4 ml dose); errors increased by 266 percent (4 ml dose). In 2 of 9 cases there was a further lowering of performance; in 7, a slight improvement (8 percent).

References

1. Aksnes, E. G. Effect of small dosages of alcohol upon performance in a Link trainer. *J. Aviat. Med.,* 1954, **25,** 680–688, 693.
2. Aschan, G., Bergstedt, M., Goldberg, L., and Laurell, L. Positional nystagmus in man during and after alcohol intoxication. *Quart. J. Stud. Alc.,* 1956, **17,** 381–405.
3. Berg, S. P. Zur Frage einer Beeinflussung des Alkoholrausches durch Laevulose. (On the question of influencing alcohol intoxication through levulose.) *Med. Klinik,* 1953, **48,** 626–628.
4. Berg, S. P. Vitamin B_6 und Alkohol. (Vitamin B_6 and alcohol). *Med. Klinik,* 1954, **49,** 1037–1038.
5. Bignold, B. C. Driving under the influence. (Correspondence.) *Brit. med. J.,* 1958, **ii,** 449–450.
6. Bjerver, K., and Goldberg, L. Effect of alcohol ingestion on driving ability. Results of practical road tests and laboratory experiments. *Quart. J. Stud. Alc.,* 1950, **11,** 1–30.
7. Bohné, G., Luff, K., and Trautmann, H. Experimentelle Untersuchungen über die Kompensationsmöglichkeit alkoholbedingter Störungen der Aufmerksamkeit und Motorik. (Experimental studies on the possibility of compensating for disturbances of attention and motor functions caused by alcohol.) *Dtsch. Z. ges. gerichtl. Med.,* 1957, **46,** 226–234.
8. Brecher, G. A., Hartman, A. P., and Leonard, D. D. Effect of alcohol on binocular vision. *Amer. J. Ophthal.,* 1955, **39,** No. 2, Part II, 44–52.
9. Bschor, F. Studien über den Ablauf der Alkoholintoxikation unter besonderer Berücksichtigung der pharmakopsychologischen Beziehungen in der Resorptionsphase bei Alkoholgewöhnten. (Studies on the course of alcohol intoxication, with special consideration of the pharmacopsychological relationships during the absorption phase in habituated subjects.) *Dtsch. Z. ges. gerichtl. Med.,* 1951, **40,** 399–420.
10. Bschor, F. Beobachtungen über ein funktionales Prinzip bei der psychomotorischen Leistungsminderung in den verschiedenen Phasen der akuten Alkoholintoxikation. (Observations concerning a functional principle in the decrease of psychomotor performance during various phases of acute alcohol intoxication.) *Dtsch. Z. ges. gerichtl. Med.,* 1952, **41,** 273–276.
11. Carpenter, J. A. The effect of caffeine and alcohol on simple visual reaction time. *J. comp. physiol. Psychol.,* 1959, **52,** 491–496.
12. Carpenter, J. A., Moore, O. K., Snyder, C. R., and Lisansky, Edith S. Alcohol and higher-order problem solving. *Quart. J. Stud. Alc.,* 1961, **22,** 183–222.
13. Charnwood. Influence of alcohol on fusion. *Brit. J. Ophthal.,* 1950, **34,** 733–736.
14. Cohen, J., Dearnaley, E. J., and Hansel, C. E. M. The risk taken in driving under the influence of alcohol. *Brit. med. J.,* 1958, **i,** 1438–1442.
15. Coldwell, B. B. (Ed.) *Report on impaired driving tests.* Ottawa: Crime Detection Laboratory, Royal Canadian Mounted Police; Queen's Printer, 1957.
16. Coldwell, B. B., Penner, D. W., Smith, H. W., Lucas, G. H. W., Rodgers, R. F., and Darroch, F. Effect of ingestion of distilled spirits on automobile driving skill. *Quart. J. Stud. Alc.,* 1958, **19,** 590–616.
17. Colson, Z. W. The effect of alcohol on vision. An experimental investigation. *J. Amer. med. Ass.,* 1940, **115,** 1525–1527.
18. Conger, J. J. The effects of alcohol on conflict behavior in the albino rat. *Quart. J. Stud. Alc.,* 1951, **12,** 1–29.

19. Davis, Pauline A., Gibbs, F. A., Davis, H., Jetter, W. W., and Trowbridge, L. S. The effects of alcohol upon the electroencephalogram (brain waves). *Quart. J. Stud. Alc.,* 1941, **1**, 626–637.
20. Dettling. L'influence de l'alcool sur le temps de réaction d'un automobiliste. (Influence of alcohol on the reaction time of a driver.) *Rev. Alcool.,* 1956, **4**, 40–45.
21. Drew, G. C., Colquhoun, W. P., and Long, Hazel A. Effect of small doses of alcohol on a skill resembling driving. *Brit. med. J.,* 1958, **ii**, 993–999.
22. Düker, H. Über die Wirkung sehr geringer Alkoholmengen auf die geistige Leistungsfähigkeit. (On the effect of very small amounts of alcohol on mental activity.) *Arch. exp. Path. Pharmak.,* 1956, **228**, 175–176.
23. Eggleton, M. Grace. The effect of alcohol on the central nervous system. *Brit. J. Psychol.,* 1941, **32**, 52–61.
24. Elbel, H. Pervitin und Alkohol. (Pervitin and alcohol.) *Dtsch. Z. ges. gerichtl. Med.,* 1942, **36**, 90–100.
25. Enzer, N., Simonson, E., and Ballard, Grace. The effect of small doses of alcohol on the central nervous system. *Amer. J. clin. Path.,* 1944, **14**, 333–341.
26. Eyer, S. W., and Ivers, J. B. The effect of alcohol upon Link trainer performance. National Naval Medical Center, Bethesda, Md., June 9, 1950. (Project NM 001 056.06.01, Naval Medical Research Institute.)
27. Forbes, G. The effect of alcohol on the psycho-motor reactions as a possible index of the degree of alcoholic intoxication. *Med.-leg. J., Lond.,* 1947, **15**, 23–38.
28. Gelin, L. E., and Wretmark, G. Alkohol och körskicklighet; resultat av praktiska körprov. (Alcohol and responsible driving; results of practical driving tests.) *Svenska Läkartidn.,* 1951, **48**, 3041–3050.
29. Giardini, A. Ricerche suglì effetti della associazione alcool-anossia sul senso luminoso. (Study of the associated effects of alcohol and anoxia on vision.) *Riv. Med. aero.,* 1948, **11**, 531–543.
30. Giardini, A. Azione dell'alcool sul potere di fusione delle immagini retiniche. (The action of alcohol on the ability to fuse retinal images.) *G. ital. oftal.,* 1949, **2**, 446–451.
31. Goldberg, L. Quantitative studies on alcohol tolerance in man. The influence of ethyl alcohol on sensory, motor, and psychological functions referred to blood alcohol in normal and habituated individuals. *Acta physiol. scand.,* 1943, **5**, Suppl. 16.
32. Goldberg, L. Laboratorieförsök med bilförare. (Laboratory experiment with automobile drivers.) *Tirfing,* 1949, **43**, 54–65.
33. Greenberg, L. A., and Carpenter, J. A. The effect of alcoholic beverages on skin conductance and emotional tension. I. Wine, whiskey and alcohol. *Quart. J. Stud. Alc.,* 1957, **18**, 190–204.
34. Grüner, O. Alkohol und Aufmerksamkeit. Ihre Bedeutung im motorisierten Verkehr. (Alcohol and attention. Its significance in motorized traffic.) *Dtsch. Z. ges. gerichtl. Med.,* 1955, **44**, 187–195.
35. Grüner, O., and Ptasnik, H. Zur Frage der Beeinflussung alkoholbedingten Leistungsabfalles durch Laevulosegaben. (On the question of influencing alcohol-caused decrease in efficiency by administration of levulose.) *Münch. med. Wschr.,* 1953, **95**, 931–933.
36. Hartocollis, P., and Johnson, D. M. Differential effects of alcohol of verbal fluency. *Quart. J. Stud. Alc.,* 1956, **17**, 183–189.
37. Hausser, G., and Truffert, L. Influence de l'alcool éthylique ingéré (doses de 0,5 à 1,5 pour 1.000 en poids). Résultats des examens psychotechniques. (Influence of ingested ethyl alcohol [dosages from 0.5 to 1.5 per 1000 by weight]. Results of psychotechnical tests.) *Pr. méd.,* 1940, **48**, 1067–1069.

38. Howells, D. E. Nystagmus as a physical sign in alcoholic intoxication. *Brit. med. J.*, 1956, **i**, 1405–1406.
39. Huber, O. Untersuchungen über die Veränderung der Fahrtüchtigkeit von Kraftradfahrern nach mässigem Alkoholgenuss. (Studies on alteration of driving ability of motorcyclists after moderate intake of alcohol.) *Dtsch. Z. ges. gerichtl. Med.*, 1955, **44**, 559-577.
40. Jellinek, E. M., and McFarland, R. A. Analysis of psychological experiments on the effects of alcohol. *Quart. J. Stud. Alc.*, 1940, **1**, 272–371.
41. Lambercier, M. R., and Martin du Pan, R. L'intoxication alcoolique aiguë et les accidents d'automobile. II. Les effets psychiques de l'intoxication alcoolique aiguë. (Acute alcoholic intoxication and automobile accidents. II. Psychological effects of acute alcohol intoxication.) *Schweiz. med. Wschr.*, 1946, **76**, 395–398, 421–426.
42. Lanier, L. H. Review of Flanagan, J. C., *The aviation psychology research program in the Army Air Forces.* AAF Aviation Psychology Program Research Reports, Report No. 1. Washington, D.C.: U.S. Government Printing Office, 1948. In *Psychol. Bull.*, 1949, **46**, 499–501.
43. Laves, W. Mass und Zahl in der medizinischen Begutachtung der Fahrtüchtigkeit. (Measure and number in medical expert testimony on ability to drive.) *Med. Klinik*, 1955, **50**, 9–12.
44. Lisansky, Edith S. Alcoholism in women: Social and psychological concomitants. I. Social history data. *Quart. J. Stud. Alc.*, 1957, **18**, 588–623.
45. Loomis, T. A., and West, T. C. The influence of alcohol on automobile driving ability. An experimental study for the evaluation of certain medicological aspects. *Quart. J. Stud. Alc.*, 1958, **19**, 30–46.
46. Margulies, Norma R., Irvin, Dona L., and Goetzl, F. R. The effect of alcohol upon olfactory acuity and the sensation complex of appetite and satiety. *Permanente Fdn med. Bull.*, 1950, 8, 1–8.
47. Marquis, D. G., Kelly, E. L., Miller, J. G., Gerard, R. W., and Rapoport, A. Experimental studies of behavioral effects of meprobamate on normal subjects. *Ann. N.Y. Acad. Sci.*, 1957, **67**, Art. 10, 701–711.
48. Masserman, J. H., Yum, K. S., Nicholson, Mary R., and Lee, S. Neurosis and alcohol. An experimental study. *Amer. J. Psychiat.*, 1944, **101**, 389–395.
49. McCleary, R. A., and Johnson, R. H. Psychophysiological effects of cold. 2. The role of alcohol ingestion and complexion in manual performance decrement. U.S. Air Force School of Aviation Medicine, Project No. 21–1202–0004, Report No. 2, 1954. Pp. 1–9.
50. McDonnell, G. J., and Carpenter, J. A. Manifest anxiety and prestimulus conductance levels. *J. abnorm. soc. Psychol.*, 1960, **60**, 437–438.
51. Mueller, B. Alkoholgenuss und Fahrfähigkeit. Bericht über Modellversuche. (Ingestion of alcohol and ability to drive. Report on model experiments.) *Hefte z. Unfallheilk.*, 1954, Heft 47, 188–193.
52. Newman, H. Variability in tolerance to depressant drugs. *Stanf. med. Bull.*, 1947, **5**, 12–14.
53. Newman, H., and Abramson, M. Relation of alcohol concentration to intoxication. *Proc. Soc. exp. Biol., N.Y.*, 1941, **48**, 509–513.
54. Newman, H., and Fletcher, E. The effect of alcohol on driving skill. *J. Amer. med. Ass.*, 1940, **115**, 1600–1602.
55. Newman, H., and Fletcher, E. The effect of alcohol on vision. *Amer. J. med. Sci.*, 1941, **202**, 723–731.
56. Patay, R., Van den Driessche, J., and Cormier, M. A propos de l'action de l'alcohol éthylique sur la phase discriminative du temps de réaction. (Effect of ethyl alcohol on the discriminative phase of reaction time.) *Bull. Acad. nat. Méd.*, 1956, **140**, 325–329.

57. Patrick, J. F. Alcohol and driving. (Correspondence). *Brit. med.* J. 1958, **ii**, 46.
58. Peters, H. B. Changes in color fields occasioned by experimentally induced intoxication. *J. appl. Psychol.*, 1942, **26**, 692–701.
59. Pihkanen, T. A. *Neurological and physiological studies on distilled and brewed beverages.* Helsinki: Maalaiskuntien Liiton Kirjapaino, 1957.
60. Prag, J. J. The chemical and the clinical diagnosis of "driving under the influence of alcohol" and the use of the chemical tests in traffic law enforcement. *S. Afr. J. clin. Sci.*, 1953, **4**, 289–325.
61. Prag, J. J. The chemical diagnosis of alcoholic intoxication. *S. Afr. J. med. Sci.*, 1953, **18**, 141–154.
62. Rabin, A., and Blair, H. The effects of alcohol on handwriting. *J. clin. Psychol.*, 1953, **9**, 284–287.
63. Rauschke, J. Leistungsprüfung bei an- und abfallendem Blutalkoholgehalt unter besonderen Bedingungen. (Tests of performance during rising and falling blood alcohol levels under special conditions.) *Dtsch. Z. ges. gerichtl. Med.*, 1954, **43**, 27–37.
64. Rizzo, P. Effetto dell'alcool sull'equazione di Rayleigh all'anomaloscopio di Nagel. (The effect of alcohol on Rayleigh's equation in Nagel's anomaloscope.) *Riv. Med. aero.*, 1955, **18**, 338–357.
65. Rizzo, P. Ricerche sulle modificazioni della frequenza critica degli stimoli luminosi indotte dall'ingestioni di alcool etilico. (Study of the modifications induced by the ingestion of ethyl alcohol in the critical frequency of light stimuli.) *Riv. Med. aero.*, 1957, **20**, 249–261.
66. Rokseth, R., and Lorentzen, F. V. Combined effect of alcohol and hypoxia on flicker fusion frequency. *J. appl. Physiol.*, 1954, **6**, 559–565.
67. Rosenthal, V. The influence of alcohol practice on learning a visual-motor skill. Unpublished doctoral dissertation, Illinois Institute of Technology, Chicago, 1955. Abstracted in *Quart. J. Stud. Alc.*, 1959, **20**, 369.
68. Schmidt, I., and Bingel, A. G. A. Effect of oxygen deficiency and various other factors on color saturation thresholds. U.S. Air Force School of Aviation Medicine Project No. 21–31–002, April 1953.
69. Schweitzer, H. Graphologische, klinische und psychologische Untersuchungen unter Alkoholwirkung (Graphological, clinical and psychological investigations on the influence of alcohol.) *Öff. GesundhDienst*, 1955, **16**, 361–372.
70. Seedorff, H. H. Effect of alcohol on the motor fusion reserves and stereopsis as well as on the tendency to nystagmus. *Acta ophthal., Kbh.*, 1956, **34**, 273–280.
71. Small, M. D., Zamcheck, N., Vitale, J. J., Longarini, A., and Fisher, B. The effect of pyridoxine hydrochloride in acute alcoholic intoxication. *J. Lab. clin. Med.*, 1955, **46**, 12–20.
72. Snyder, C. R. *Alcohol and the Jews. A cultural study of drinking and sobriety.* Glencoe, Ill.: Free Press, 1958.
73. Takala, M., Siro, E., and Toivainen, Y. Intellectual functions and dexterity during hangover. Experiments after intoxication with brandy and with beer. *Quart. J. Stud. Alc.*, 1958, **19**, 1–29.
74. Taschen, B. Eine einfache Nystagmusprobe zur Feststellung der Alkoholbeeinflussung. (A simple nystagmus test for the determination of the influence of alcohol.) *Med. Mschr., Stuttgart*, 1955, **9**, 25–27.
75. Teichner, W. H. Recent studies of simple reaction time. *Psychol. Bull.*, 1954, **51**, 128–149.
76. Vogel, Muriel. Low blood alcohol concentrations and psychological adjustment as factors in psychomotor performance. An exploratory study. *Quart. J. Stud. Alc.*, 1958, **19**, 573–589.

77. Walter, H. W. Alkoholmissbrauch und Alkohollagenystagmus. (Abuse of alcohol and positional alcohol nystagmus.) *Dtsch. Z. ges. gerichtl. Med.,* 1954, **43,** 232–241.
78. Wolff, H. G., Hardy, J. D., and Goodell, H. Studies on pain: measurement of the effect of ethyl alcohol on the pain threshold and on the "alarm" reaction. *J. Pharmacol.,* 1942, **75,** 38–49.
79. Zirkle, G. A., King, P. D., McAtee, O., and Van Dyke, R. Effects of chlorpromazine and alcohol on coordination and judgment. *J. Amer. med. Ass.,* 1959, **171,** 1496–1499.

CHAPTER IV

Alcohol Determination—Some Physiological and Metabolic Considerations[1]

KURT M. DUBOWSKI, Ph. D.

Introduction

Chemical tests for ethyl alcohol are essentially toxicological studies for the detection and quantitation of this substance in biological materials, and as such form a special category of clinical chemistry methodology. In common with many other procedures in this field, alcohol determinations are subject not only to the usual reliability and practicability considerations applying to all bioanalytical techniques but are also particularly susceptible to physiological and metabolic considerations affecting their applicability and effectiveness for the purposes intended. Alcohol determination, in traffic law enforcement and investigative situations, is commonly performed to determine whether at a given material time any ethyl alcohol was present in the body of a subject under investigation and, if so, in what concentration, most commonly referred to blood. The blood alcohol concentration found or calculated is then usually evaluated with regard to either of two questions:

1. Was the presence of ethyl alcohol in the body of the subject responsible for his death or some other specified condition at the material time, either wholly or in part?
2. What was the condition of the subject at the material time, with reference to the known effects of ethyl alcohol on the human body, its functions, and its behavior?

In traffic law enforcement and traffic investigations, the first question is of frequent interest in connection with (*a*) deaths in which the effects of

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ethyl alcohol are an accessory cause in the presence of trauma, synergistic or potentiating pharmacological actions, etc.; (*b*) acute alcoholic influence complicated by violence or acute illness; (*c*) resolution of questions of contributory negligence in civil proceedings (insurance or industrial compensation claims, etc.) or criminal proceedings arising from death or injury by motor vehicle operation; (*d*) differential diagnosis of coma, unconsciousness, or insensibility states in individuals under arrest or in confinement or custody. The second problem arises most frequently in such situations as (*a*) determination of culpability or nonculpability under statutes prohibiting motor vehicle operation or other acts while under the influence of intoxicants, drugs, or combinations thereof; (*b*) determination of the degree of responsibility at a specified time, as in connection with claimed inability to recall events, contributory negligence problems, etc.

In all of the former instances, a common element is the recognized presence of some unknown degree of alcoholic influence, the extent and consequences of which are in issue and may have been masked or obscured under the circumstances. In the latter situations, the possible presence of alcoholic influence is usually not independently known or recognized, but it may be suspected or one may desire to eliminate alcoholic influence as an element in the case.

Susceptibility of Alcohol Determination to Physiological and Metabolic Factors

The nature of chemical alcohol tests and the somewhat unique situations under which they are commonly employed render them especially susceptible to the effects of physiological and metabolic factors, some of which markedly affect both selection and performance of the analyses and interpretation of the results. Depending upon the legal, administrative, and technical demands in a particular jurisdiction, the characteristics required of suitable methods will differ. For modern traffic law enforcement purposes it is now generally accepted that directly obtained information regarding the blood alcohol concentration is the most meaningful because of the large number of studies correlating degrees of alcoholic influence and driving impairment directly with observed blood alcohol levels. Direct blood analysis, however, often is not the method of choice because of practical problems in obtaining and analyzing blood samples. Although it is obviously highly desirable, if not indeed requisite, to retain blood alcohol as the universally accepted index of impairment by alcohol in order to make use of the vast backlog of past studies and the opportunity for international comparison of findings and interpretations, it has become necessary to devise systems and methods for obtaining blood alcohol level results by calculation or otherwise from analysis of other body materials simpler to obtain and analyze. Thus interrelation of body fluid and tissue alcohol levels is an important (and complex) consideration in alcohol determination.

Each body material presents a variety of problems as a medium for blood alcohol estimation in such respects as true instantaneous alcohol levels, prevention of contamination from other body alcohol sources, and isolation of a single identifiable body fluid component in those instances where multiple types exist, as with breath and blood, each with a significantly different alcohol concentration. In breath alcohol determination methods, physiological variables such as body and breath temperature, the blood/breath alcohol partition ratio, and for some methods alveolar carbon dioxide level affect the test results. In practical situations, a sufficient interval often elapses between the time of a significant event and the sampling time to produce an often significant and sometimes very marked difference in the respective alcohol levels in blood and other materials. Time relationships involving ingestion, distribution, storage, and elimination of alcohol thus become important, sometimes overwhelmingly so. If estimates of a preexisting blood alcohol level are to be made on the basis of alcohol analyses, then body alcohol elimination rates and blood alcohol clearance rates, in particular, become important.

A clear distinction should probably be made between those physiological and metabolic factors directly affecting the validity of alcohol determinations as analyses in such respects as choice and collection of sample material, and those factors affecting the applicability and interpretation of the analysis results with respect to their extrapolation to other times, total estimated alcohol consumption, etc. Adequate safeguarding of analytical systems and results from consequential physiological deviations is a much simpler problem than meaningful integration of the host of physiological and metabolic variables, many of unknown applicability to the individual and the specific situation, into the complex pattern of retroactive extrapolation, extension, and interpretation of the factual findings.

Issues Commonly Raised Regarding Reliability of Alcohol Determination

Consideration of allegedly controversial issues will here be limited to those dealing with the analyses for alcohol in biological materials. The history of these allegations roughly parallels the development of various alcohol determination principles and methods over the past 100 years and tends to reflect the increasing confidence in the purely chemical aspects of the analyses, such as specificity, and the consequently greater emphasis in recent years upon physiological factors such as sample choice and suitability. Major developments in chemical tests for alcohol have been summarized (*21, 29*) and do not require repetition here. In living subjects many of the cogent and valid cautions and criticisms pertaining to choice of post mortem sample materials and possible errors (*9, 14, 20, 59, 83*) introduced thereby are inapplicable. Questions regarding correlation of various body alcohol concentrations, especially blood/breath alcohol ratios, have secondarily led to a reexamination of differences in arterial-venous-capillary blood alcohol concentration at various times after ingestion of alcohol (*45, 46, 71*), which can explain some earlier discrepancies in studies by different investigators of impairment levels and of breath/blood alcohol correlations. Most purely methodological considerations regarding analytical methods for other than breath alcohol determinations have been extensively studied and largely resolved (*18, 19, 24, 79*).

Breath testing issues. Breath alcohol determination has been subject to much skeptical scrutiny and many attacks principally directed against three separate phases of breath alcohol testing: (*a*) reliability of the breath analysis methods and procedures with respect to both chemical and physiological considerations; (*b*) applicability of these methods to an actual or hypothetical subject under varying conditions of subject state abnormality; and (*c*) adequacy of operator competency, skill, and performance (*6, 22, 25, 30, 43, 71, 78, 81*). Some of the more frequent questions raised in these three areas concern the following points:

A. Reliability of Breath Analysis Methods

1. *Chemical and technical considerations*
   - *a.* Specificity of the alcohol reagents; interference phenomena, contamination.
   - *b.* Quantitation problems, endpoint recognition.
   - *c.* Keeping qualities of reagents, deterioration.
   - *d.* Qualitative and quantitative identity of reagents; reagent and disposable component integrity; posttest preservation.
   - *e.* Sampling techniques and materials, sample losses and gains.
   - *f.* Recording and reporting of raw test data.
   - *g.* Effects of ambient conditions (temperature, etc.); apparatus state.
   - *h.* Computation of final results.
   - *i.* Reliability and integrity of ancillary apparatus (balance, etc.).
   - *j.* Accuracy and precision of total method.
2. *Physiological considerations*
   - *a.* Actual blood/alveolar breath alcohol ratio; constancy of this ratio.
   - *b.* Time relationships; subject state steadiness.
   - c. Methods and techniques for quantitation of alveolar breath sample proportion in sample.
   - *d.* Suitability of alveolar, rebreathed, mixed expired or other breath sample for analysis.
   - *e.* Effects of body and mouth temperature, pulmonary diffusion processes, etc.
   - *f.* Breath sampling technique.

B. Individual Subject Applicability

1. Mouth alcohol; pretest preparation and waiting period.
2. Breath sample contamination, eructation, regurgitation, vomiting, volatile interference.
3. Hyperventilation and hypoventilation states; indirect quantitation of alveolar breath; pretest activities.
4. Effects of food, digestive processes, and activity on acid-base balance.
5. Alleged metabolic and other illnesses; abnormal subject state with respect to temperature, hydration, etc.

C. Operator Performance

The other considerations affecting breath alcohol determinations, such as operator competency and performance, are outside the scope of this discussion.

Physiological Factors Affecting Alcohol Determination

Absorption and Distribution of Alcohol

The unique nature and pattern of ethyl alcohol absorption markedly influences both proper performance and adequate interpretation of alcohol analysis; e.g., in the choice of venous or capillary blood for analysis. Alcohol is rapidly absorbed by diffusion from the oral mucosa, stomach, small intestine, and colon (*32, 49, 67, 76, 82*), since it is a small molecule, is highly soluble in water, and requires no digestion or formation of intermediate compounds for absorption. The speed and relative degree of alcohol absorption from the stomach and the intestine are modified by many factors such as quantity and nature of food present; volume, character, and dilution of the alcoholic beverage; presence or absence of pylorospasm; and individual personal peculiarities such as permeability of gastric and intestinal tissues. Depending on these factors, complete absorption of alcohol from the gastrointestinal tract may require 45 minutes to 3 hours, with the prolonged absorption leading to lower peak blood alcohol levels; however, maximal blood alcohol levels are commonly reached 45 to 90 minutes after ingestion of alcohol (*45, 49, 67, 76*).

The greater part of the absorbed alcohol is conveyed from the small intestine directly to the liver by the portal circulation, so that during active absorption the portal vein blood alcohol concentration exceeds that of the other blood. Through loss to the liver, liver metabolism of alcohol, and admixture of blood from the systemic circulation, the portal vein blood alcohol concentration is progressively reduced before the right atrium is reached. During circulation through the lungs, some alcohol is lost from the arterial blood by diffusion into the lung tissue and into the alveolar air. Finally, the alcohol concentration of the arterial blood is considerably reduced as it passes through the capillary network, so that during the period of active absorption peripheral venous blood may contain significantly less alcohol than arterial or capillary blood. This concentration difference is greatest during rapid absorption and disappears only when alcohol level equilibrium is reached between the blood and tissues. For divided doses of alcohol, especially if accompanied by food, absorption proceeds somewhat slower and equilibration occurs more rapidly under these circumstances. These considerations significantly affect such practical matters as choice of venous vs. capillary blood as a sample material adequately reflecting the brain alcohol level and properly correlative with the breath alcohol level at any given time during or after the absorptive phase. A schematic blood alcohol curve following the drinking of 8 ounces of whisky is shown in figure 1, as represented by Muehlberger (*65*). This illustrates the usual initially rapid and then slower rise in blood alcohol during active absorption, the peak blood level about 2 hours after initial ingestion, and the normally linear blood alcohol decline during the postabsorptive elimination phase.

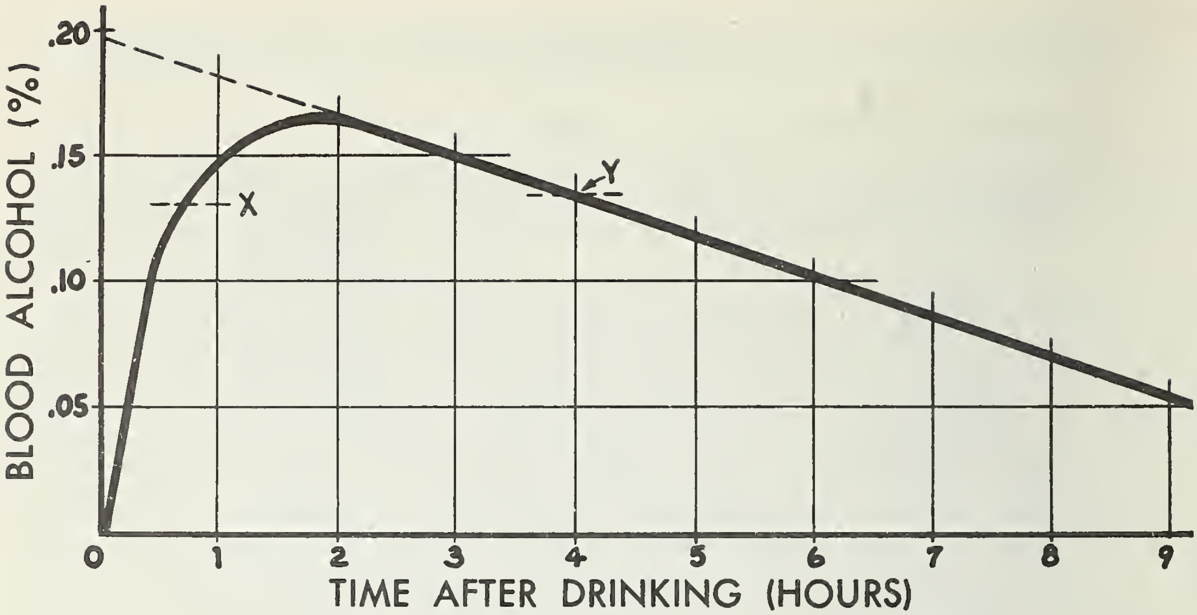

Figure 1. Schematic blood alcohol curve after ingestion of 8 ounces of whisky (65).

Ingestion of alcohol in divided doses as it commonly occurs in social drinking situations can alter this sequence of events so that total absorption may continue during several hours and for 45 to 90 minutes after the last dose. However, even in the simplest case of single dose consumption, it is often impossible to establish the actual blood alcohol concentration at a prior material time from the results of a single blood alcohol determination on a subsequently obtained specimen, as illustrated in figure 2, based upon a suggestion of Bayly and McCallum (*3*). If t_1 represents the material time of an incident and t_2 the time at which a blood sample is subsequently obtained, it is apparent that the alcohol concentration in the sample (at t_2) can be related to that at time t_1 in at least the four ways shown: (*a*) Curve A represents a continuous blood alcohol concentration decrease resulting in a lower level at time t_2 than existed at t_1, the peak blood alcohol level having been passed at some time prior to t_1; (*b*) curve B represents another condition for reaching a lower alcohol level at t_2 than existed at t_1, the blood alcohol concentration having risen for a short time to the peak level and having then declined; (*c*) curve C demonstrates fortuitous identity of blood alcohol levels at times t_1 and t_2, the alcohol concentration fall being equal in magnitude to the rise during the interval; (*d*) curve D illustrates an increase in concentration during the interval, rapid and probably recent absorption having been in progress at time t_1 and having achieved a peak level exceeding the initial level at t_1 by more than the quantity eliminated during the interval. Many other combinations of events are obviously possible, but these stylized examples suffice to demonstrate one of the difficulties inherent in retrograde extrapolation of alcohol analysis results. These difficulties generally increase greatly with the magnitude of the time interval between sampling and material time, which can legally extend 2 hours in some of our jurisdictions (*16*).

Following its absorption into the blood, alcohol is carried to all cellular and extracellular parts of the body and distributed, by diffusion, in a manner related to the water content of the organs, to the volume and the alcohol

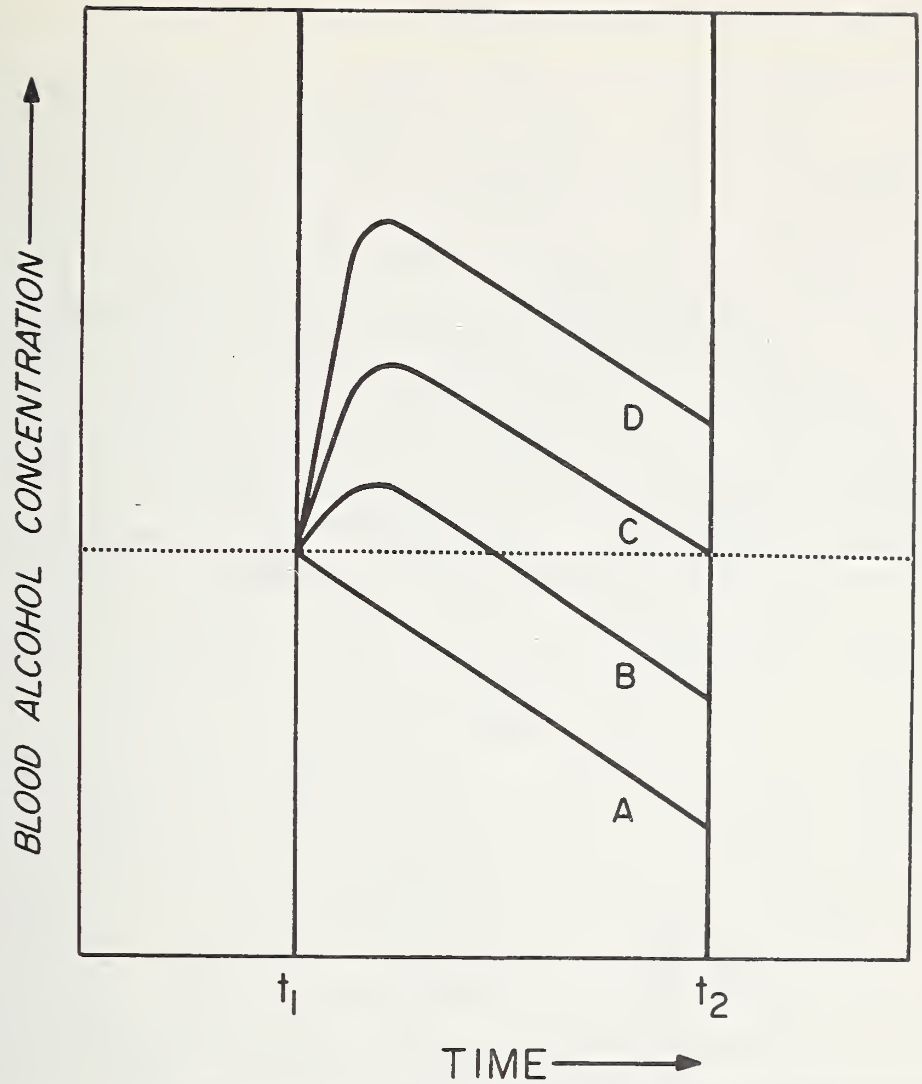

Figure 2. Schematic blood alcohol curves in four hypothetical situations.

concentration of the blood reaching them, and to the characteristics of the local blood circulation. At alcohol distribution equilibrium, the alcohol concentration in each body tissue or liquid is proportional to its water content (*49, 67*). Consequently the alcohol concentration of the blood or other body material after equilibrium has been established can be calculated with reasonable accuracy from the known concentration in another body fluid or tissue. Table I is a compilation of the average alcohol concentration of several body materials at equilibrium, compiled from the literature (*10, 11, 12, 13, 20, 24, 29, 32, 45, 46, 49, 59, 65, 67, 76, 82, 84*) and from our own experimental data.

TABLE I. *Relative Distribution of Ethyl Alcohol at Equilibrium*

Body material:	*Mean relative concentration*
Whole blood	1.00
Alveolar breath	0.00048
Blood plasma	1.15
Brain	0.85
Cerebrospinal fluid	1.10–1.27
Saliva	1.12
Skeletal muscle	0.85
Urine	1.25

Choice of Sample Materials for Analysis

The relationships shown in table I hold only after alcohol absorption is essentially complete and distribution equilibrium established, or during such slow and continuous absorption as to allow simultaneous distribution equilibrium. Harger et al. (*46*) have shown that the alcohol level tends to be definitely higher in the capillary blood than in the venous blood of human subjects less than 70 minutes after the last drinking, averaging 7.5 percent above the venous level. Since the alcohol level of cutaneous capillary blood closely approximates that of arterial blood (*39*) and since venous blood from an extremity does not correctly reflect, during equilibration, the alcohol content of the vascular organs, including the brain (*39, 45, 49, 68*), analysis of capillary blood, saliva, and breath is more valid and preferable during this interval or when the state of absorption is unknown (*68*). Problems pertaining to alcohol concentration differences in whole blood, plasma, and serum (*38*) are readily avoided by analyzing whole blood, reconstituted from a clotted blood sample if necessary (*20*).

Urine alcohol determination requires certain rigorous precautions to safeguard its validity. The urine/blood alcohol ratio of about 1.25 holds strictly only for ureteral urine at the time of its excretion (*20, 24, 45*), or for short-term collection with an initially empty bladder. It is apparent that presence of an initial alcohol-free bladder urine pool will decrease the bladder urine/blood alcohol ratio during active alcohol excretion and that presence of an alcohol-containing bladder urine pool can significantly change the alcohol concentration of urine excreted during and after the elimination phase. Bladder urine alcohol levels consequently change more slowly than blood levels, since absorption through the bladder is also slow (*39, 45, 49, 67*). A simple technique to circumvent these problems first suggested by Haggard et al. (*40*) is to collect one or two urine specimens at precisely known intervals of from 30 to 45 minutes after initial complete emptying of the bladder. The alcohol levels in the first or second specimens after the initial emptying of the bladder represent an average of an infinite number of instantaneous ureteral urine alcohol levels during the entire secretion period of that specimen. Consequently, the blood alcohol level calculated by use of the distribution ratio of 1.25:1 closely approximates that at a time midway between the beginning and the end of that urine collection period, though not necessarily the blood level at the time of voiding. When two specimens are thus obtained and analyzed, it is usually possible to establish whether the subject's blood alcohol level was increasing or decreasing during the collection period. These procedures assume that the bladder is completely emptied each time and that no residual urine is retained. This is ordinarily a reasonably valid assumption but Mulrow and associates (*66*) have demonstrated that subjects with lower urinary tract disease, renal impairment, or degenerative changes such as benign prostatic hypertrophy occasionally retain substantial volumes of the bladder urine, compared to the 0–20 ml residual volume considered normal, and further confirmed that either absence of an urge to void or a markedly distended bladder, at the time of a voiding, can give rise to increased residual urine volumes in otherwise normal subjects (*57*).

One application of combined blood and urine alcohol analyses is the estimation of a preexisting peak blood alcohol level. If a pooled urine alcohol concentration (e.g., in a post mortem specimen) exceeds that of the blood obtained simultaneously by more than 25 percent, it is apparent that a higher blood alcohol concentration than that found by direct analysis existed at some prior time. Conversely, if the blood alcohol level equals or exceeds that of a simultaneously collected urine specimen, the subject is probably in the absorptive phase and therefore probably within 0 to 3 hours of last consumption time, which can frequently be fixed with some accuracy.

A final factor in urine alcohol analysis may be briefly mentioned. Alcohol passes from the blood to the urine by diffusion and is distributed according to the relative water content of the two liquids. While the water content of blood, reflected in its specific gravity, is fairly constant, that of urine is known to vary considerably. It is to be expected, therefore, that the urine/blood alcohol ratio would decrease with increasing specific gravity of urine; and this has been experimentally observed by Moritz and Jetter (*63*), who reported that the ratio decreases by approximately 0.07 for each specific gravity increment of 0.010 between 1.010 and 1.040; and by Haggard et al. (*40*), who reported a somewhat smaller rate of ratio decrease. In most drinking-driver situations, these differences can be neglected because of the diuretic effects of alcohol in living subjects combined with other factors.

Analysis of saliva for alcohol has found only limited practical application, partly because of the need for considerable cooperation from the subject to obtain an adequate specimen, and the possibility of contamination by mouth alcohol remaining from recent drinking or eructation (*67*). Recent work by Coldwell, Smith, and associates (*12, 13*) has demonstrated the practicability of saliva analysis and that venous blood alcohol concentrations can be estimated with reasonable accuracy ($\pm$0.0075 percent W/V) from the saliva alcohol level by use of the saliva/blood ratio of 1.12:1 between 0.5 and 2.5 hours after drinking.

Breath alcohol analysis possesses many practical advantages and a few limitations (*29*), including the following physiological considerations:

1. Breath as the analyzed material accurately reflects the actual arterial blood alcohol level at the time of the test, without lag or overrun, and is usually obtainable nearer the time in issue than other sample materials.
2. Generally less cooperation and considerably less time are required than for collection of adequate saliva or urine specimens.
3. Multiple, replicate, and serial analyses at frequent brief intervals are practical because of the rapidity of analysis and rapid nontraumatic sampling of breath specimens, allowing accurate determina-

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tion of the directional trend of the blood alcohol curve and many experimental analyses on a given subject.

4. Some cooperation is required from the subject for collection of an adequate breath specimen, the extent varying with the nature of the required breath sample (alveolar air, mixed expired air, or rebreathed air) and the collection apparatus.
5. Most breath alcohol methods except, under some conditions, those employing the alcohol-carbon dioxide ratio are inapplicable to unconscious or totally uncooperative subjects.
6. A period of approximately 10–15 minutes after the last ingestion of alcohol (or regurgitation) must elapse before breath alcohol analysis, to insure elimination of the possible effects of any residual mouth alcohol.

Special Problems of Breath Alcohol Analysis

All breath alcohol analyses depend on the fundamental principle that the distribution of alcohol betwen circulating pulmonary blood and alveolar air occurs instantaneously by simple diffusion and, like that of other volatile substances, obeys Henry's law, which defines for a given set of conditions the concentration of a volatile substance present as a vapor in equilibrium with the liquid phase of the substance in solution (*15, 33, 39, 45, 49, 51, 53, 58, 67, 84*). Therefore distribution equilibrium obtains, and for a given temperature a constant ratio exists between the concentration of alcohol in the pulmonary circulation blood and that in alveolar air. The mean value of this Ostwald partition ratio of blood alcohol to alveolar air alcohol concentration at the average temperature of exhaled air, 34° C (*41, 46, 47, 51, 58*), is now accepted as approximately 2100:1; i.e., 2100 ml of alveolar air contain the same quantity of alcohol as 1 ml of blood (*12, 13, 24, 35, 36, 45, 46, 47, 84*). Although there are many chemical and physiological factors affecting every breath alcohol determination method, the significant question is whether the methods reliably predict the blood alcohol level. Under properly controlled conditions (which include proper training and continuing expert supervision of competent operators and adequate expert control of equipment, reagents, and procedures (22)), breath alcohol analysis is indeed capable of serving as an index of blood alcohol concentration of adequate reliability for clinical and legal purposes (*11, 12, 28, 35, 65, 84*).

Several recent studies require mention in this connection. In 1953, the National Safety Council's Committee on Tests for Intoxication (now Committee on Alcohol and Drugs) reported the results of a study at Michigan State University which included 1,700 analyses of blood and breath specimens from 127 human subjects (*84*). Differences between direct blood alcohol analysis results obtained by the method of Muehlberger (*64*) and blood alcohol levels calculated from breath analyses were as follows:

Alcometer (*34*) (38 tests):
Mean absolute difference = 0.010 percent.
Difference range ------- = +0.021 to −0.020 percent.
Drunkometer (*50*) (48 tests):
Mean absolute difference = 0.010 percent.
Difference range ------- = +0.028 to −0.020 percent.
Intoximeter (*53*) (44 tests):
Mean absolute difference = 0.008 percent.
Difference range ------- = +0.020 to −0.016 percent.

In 130 simultaneous analyses of blood and breath by these 3 instruments, an overall mean difference of 0.009 percent was obtained, with 3 instances of analyses differing by more than 0.02 percent. It was concluded that breath alcohol analysis may be expected to yield blood alcohol concentration within +0.015 percent of the actual value. (One assumes from the data that these limits would apply in more than 80 percent of the cases.)

In 1957, Chastain (*11*) reported the results of breath alcohol determinations on 36 subjects arrested for drunkenness or driving while intoxicated, performed essentially simultaneously with withdrawal of blood specimens which were analyzed by the Dubowski and Withrow method (*23, 29*). Differences found between these results were as follows:

Alcometer (36 tests):
Mean absolute difference = 0.016 percent W/W.
Difference range ------- = +0.034 to −0.068 percent W/W.
Breathalyzer (*7*) (34 tests):
Mean absolute difference = 0.013 percent W/W.
Difference range ------- = +0.031 to −0.034 percent W/W.

Also in 1957, a report of a detailed and extensive practical experimental study of alcoholic impairment of driving performance was issued from the Royal Canadian Mounted Police Crime Detection Laboratories (*12*). Included therein were the results of 247 venous blood alcohol analyses from 66 subjects, performed by the Smith desiccation method (*79*), compared with the same number of breath alcohol analyses. Findings were as follows:

Breathalyzer (253 tests):
Mean absolute difference = 0.012 percent W/V.
Difference range ------- = +0.025 to −0.043 percent W/V.

The study was further described by Coldwell and Smith (*13*), who concluded that from 0.5 to 2.5 hours after consumption of alcohol and over a venous blood alcohol concentration range from 0.04 to 0.17 percent W/V, the magnitude of the difference between Breathalyzer-derived and directly determined blood alcohol concentrations was independent of the alcohol concentration, and that the Breathalyzer estimated the venous blood alcohold concentration within ±0.012 percent W/V of the existing level. (One assumes from the data that these limits would apply in more than 95 percent of the cases.)

In 1959, Drew, Colquhoun, and Long reported a study on the effects of small amounts of alcohol (*17*) during which they had occasion to evaluate breath alcohol analyses. They reported the following results in comparison with direct capillary blood analysis by a modified Cavett method (*56*):

Alcometer (82 tests):
- Standard deviation of the differences = 0.020 percent W/V.
- 95 percent confidence limits________ = ±0.040 percent W/V.

Breathalyzer (Production Model) (103 tests):
- Standard deviation of the differences = 0.012 percent W/V.
- 95 percent confidence limits________ = ±0.024 percent W/V.

Drunkometer, Weight Method, Series I (67 tests):
- Standard deviation of the differences = 0.023 percent W/V.
- 95 percent confidence limits________ = ±0.047 percent W/V.

Drunkometer, Weight Method, Series II (58 tests):
- Standard deviation of the differences = 0.012 percent W/V.
- 95 percent confidence limits________ = ±0.023 percent W/V.

The authors concluded that blood alcohol levels obtained by Drunkometer and Breathalyzer analysis were in close agreement with those obtained by direct blood analysis, and that differences between the alcohol levels so obtained will be less than 0.025 percent W/V 95 times in 100.

A key physiological element in each breath alcohol method is the procedure employed for determination of the quantity of alveolar air actually analyzed for its alcohol content, since the accepted partition ratio of 2100:1 holds only for the blood/alveolar air relation at a fixed temperature. The following methods have been employed:

1. Alveolar air is collected directly, as by mechanically trapping the final portion of a prolonged expiration, and is analyzed directly.
2. Rebreathed ("venous") air, which is identical in alcohol concentration to alveolar air (*41, 45, 46, 47*) is obtained by having the subject rebreathe ordinary expired air four of five times from a flexible bag, with the nose closed, and is analyzed directly.
3. Mixed expired air is collected and analyzed for alcohol and carbon dioxide content. The proportion of alveolar air in the sample is estimated from its CO_2 concentration on the basis of observations that the alveolar air of normal male persons contains about 5.5 percent of carbon dioxide by volume (*4, 27, 28, 36, 42, 52, 53, 54, 69, 75, 85*), while atmospheric air contains only approximately 0.03 volume percent CO_2 (*59, 69*).
4. Mixed expired air is collected and analyzed for alcohol only. As a screening method for the estimation of the approximate blood alcohol level, some "volumetric" tests assume that ordinary expired breath normally contains about 58 to 63 percent alveolar air, and hence employ an equivalence factor of approximately 3,200 ml of ordinary mixed expired breath measured at 25° C after removal of CO_2 as containing the same quantity of alcohol as 1 ml of blood (*37, 44, 46, 47, 50, 77*).

Recent discussions reflect the satisfactory experimental findings for breath alcohol systems employing alveolar air as detailed above, and in general concur with Greenberg's opinion that ". . . the existing breath testing techniques which employ alveolar or rebreathed air possess this advantageous quality [opportunity for accuracy and reliability] and when used under the proper circumstances are entirely accurate enough for medicolegal purposes" (*33*). Harger, Forney, and Baker (*46*) have reported their experiences with blood alcohol estimation by use of rebreathed air analysis. In 93 tests on 31 human subjects, they compared rebreathed air analysis by Drunkometer with direct analysis of capillary blood and venous blood for respective intervals of less than 70 minutes and greater than 70 minutes after drinking. Ninety-eight percent of the blood-breath results yielded differences within ±15 percent, 87 percent of the results within ±10 percent, and 54 percent of the results within ±5 percent.

The blood/alveolar air alcohol ratio is temperature dependent, and the 2100 : 1 ratio accepted for breath at 34° C would be expected to vary with different body temperatures. That such body temperature effects are not a consequential source of error is demonstrated by the correlations cited above, all of which depend upon the standard 2100 : 1 ratio at 34° C exit temperature. On the basis of the partition ratio data for air and blood given by Harger and associates (*51*), theoretically a 1° C increase in alveolar breath temperature between 34° C and 37° C would tend to increase the calculated blood alcohol concentration by about 6.5 percent over the actual level (*47, 51*).

Use of mixed expired air for breath alcohol analysis by means of the alcohol-carbon dioxide ratio assumes uniformity of four biologic relationships, as pointed out by Harger (*47*), by Smith (*81*), and by Greenberg (*33*), among others: (*a*) that the carbon dioxide concentration in alveolar air is uniformly 5.5 percent by volume; (*b*) that the ratio of alcohol to carbon dioxide is identical for alveolar air and air from other parts of the respiratory tract; (*c*) that the ratio of alcohol to carbon dioxide is therefore identical in alveolar air and in mixed expired air; (*d*) that the ratio of alcohol between alveolar air and pulmonary blood is a constant 1 : 2100. The last of these assumptions has already been discussed above; the ratio is admittedly an average value subject to temperature and other factors, but varies within sufficiently narrow limits to achieve adequate reliability for clinical and legal purposes. The alveolar carbon dioxide content does vary somewhat in normal individuals and averages about 8 percent less for women than for men (*44*). Using an assumed constant alveolar air CO_2 content, Jetter and Forrester (*53*) compared Intoximeter results with direct venous blood alcohol analysis, finding an average deviation of ±10 percent, with a maximum deviation of ±16 percent. Similarly, Harger and associates (*47*) compared venous blood alcohol levels obtained by direct analysis with Drunkometer results based on the assumed 5.5 percent alveolar CO_2 content and found an average difference of ±9.7 percent, with maximum difference of −28 percent and +32 percent. These findings include differences resulting from the alveolar carbon dioxide content variation as well as any discrepancies resulting from lack of a single uniform alcohol-carbon dioxide ratio for the entire respiratory tract.

Certain markedly abnormal subject states can affect the reliability of breath alcohol analyses, particularly those relying upon the alcohol-carbon dioxide ratio. The breath alcohol methods, however, are designed for employment under specified conditions, eliminating the usually readily detected gross abnormalities which can lead to major discrepancies. It has been claimed (*53, 71, 79*) that strenuous hyperventilation can cause temporary reduction in alveolar carbon dioxide content to 60 percent or even 40 percent of its prior normal value, and thus lead to falsely elevated calculated blood alcohol levels. Jetter and Forrester (*53*), however, also demonstrated that a 2.5-minute period following strenuous hyperventilation to the point of imminent syncope usually sufficed to restore normal breathing and restored computed blood alcohol levels to those of the prehyperventilation controls. They concluded that in all cases normal equilibrium was restored within 5 minutes after cessation of hyperventilation. These investigators (*53*) also found that light exercise, such as moderate walking for periods of up to 1 hour, had no effect upon the accuracy of breath alcohol analysis by use of the alcohol-carbon dioxide ratio; and that the effects of violent physical exercise to the point of acute fatigue produced a transitory 20 percent decrease in the calculated blood alcohol levels, compared with control values of some subjects, while in other subjects the calculated alcohol level lowering from this increased alveolar carbon dioxide tension mechanism was negligible. They concluded that the effect of violent exercise upon breath alcohol analysis is dissipated with the return of normal breathing. Finally, these investigators (*53*) found that a transitory alkalosis resulting from emesis and consequent elevation of the alveolar carbon dioxide tension in drinking subjects depressed calculated blood alcohol levels up to 35 percent, compared with control determinations, within 10 minutes after emesis. This effect had passed 15 to 25 minutes after the end of emesis.

Emesis and regurgitation of stomach content can also cause spuriously high blood alcohol results from breath analysis if it occurs when the stomach content is high in alcohol and a breath sample obtained immediately thereafter is analyzed. In practice, of course, such an event is precluded by proper instructions for performing breath analysis (*22*). Further, the alcohol level of the stomach contents falls rapidly as a result of the combined effects of active alcohol absorption through the gastric mucosa and dilution with gastric secretions. The same rule holds as for preventing contamination of breath samples by mouth alcohol from recent ingestion; i.e., a waiting period of 10–15 minutes after last oral alcohol contact will prevent interference from this source (*22, 33, 74*). Rinsing the mouth with water after emesis, followed by a few minutes' wait prior to analysis, is an additional precaution which reduces the necessary waiting interval according to the experiments of Seifert (*74*). Eructation has also been mentioned as an occurrence which can jeopardize the validity of breath alcohol analysis

(*33, 72*). Smith and Lucas (*80*) were unable to alter the agreement between breath and blood alcohol concentrations by taking breath samples within 5 minutes after subjects had consumed 6 to 10 ounces of whisky during 10 minutes. Some of the subjects were given sodium bicarbonate, and pressure increased during collection of the samples to ascertain whether alcohol reached the expired air directly from the stomach under these extreme conditions as claimed by Rabinowitch (*72*); no such effect was found. Sillery and associates (*78*) reported experience with breath alcohol analysis by the Drunkometer in one subject, whose calculated blood alcohol levels on two occasions were respectively 18 and 11 percent lower than those obtained by direct analysis, attributing this deviation to the subject's ingestion of a quantity of water immediately before the breath alcohol test. This phenomenon has been noted by others (*8*), and its explanation may be in the absorption of alcohol by the greater-than-normal moisture film in the oral cavity and the breath-collecting apparatus components.

Metabolism and Fate of Alcohol in Relation to Alcohol Determination

Elimination of Ethyl Alcohol

The disappearance of alcohol from the body occurs by a combination of metabolism and excretion. Metabolism accounts for about 90 percent of a given dose while the remainder is eliminated unchanged in the breath, urine, sweat, and feces (*2, 86*). The major significance of alcohol elimination for this discussion, aside from the fact that it provides the mechanism for supplying the alcohol content of the breath and urine, lies in the disappearance of alcohol from the blood accompanying this elimination. From the absorption and distribution dynamics of alcohol it is clear that during initial rapid absorption of alcohol from the gastrointestinal tract, the entry of alcohol into the bloodstream exceeds the rate at which it can be distributed to the tissues and removed by simultaneous elimination, and that consequently the blood alcohol level rises to reach a maximum value when most of the alcohol has been absorbed (fig. 1). This maximal value may appear only transiently if removal of alcohol from the blood at that point becomes more rapid than its entry into the blood; or a plateau may appear at the maximal blood alcohol level if absorption into the blood equals the removal rate for a period. If no additional alcohol is consumed, the concentration of alcohol in the blood gradually falls to zero as the result of its removal by oxidation and excretion.

It is now well established, as first shown by Mellanby (*62*) and by Widmark (*87*), that in the postabsorptive phase the blood alcohol level initially declines approximately rectilinearly with time (*2, 12, 13, 17, 24, 49, 60, 61, 67, 76, 86, 87*), meaning that the rate of disappearance from the blood is constant and is independent of the amount of alcohol present in the body. In this regard, alcohol is an unusual metabolite, since most substances have an exponential disappearance curve. However, below a blood alcohol level of 0.005 to 0.010 percent W/V, an exponential rate of decline appears established (*61, 86*). The simplest explanation of this difference between alcohol and other drugs is that the usual doses of alcohol present in the body are greater than necessary to saturate the clearance mechanism, which consists predominantly of the alcohol dehydrogenase enzyme system responsible for oxidation of alcohol. The greater-than-saturation substrate concentration cannot increase the reaction rate; the disappearance of alcohol from blood at low concentrations becomes exponential because the enzyme system is then no longer saturated with substrate. Since only small amounts of alcohol (1–5 percent) are excreted in the urine depending upon the volume of urine produced and the blood alcohol level during the period of urine production, and equally small quantities (5 percent maximally) are lost through the breath (*67, 86*), the major mechanism for alcohol elimination must be its metabolism. Alcohol is oxidized stepwise to acetaldehyde, then to acetic acid and to carbon dioxide and water (*49*), and the rate of alcohol clearance from the blood is primarily dependent upon the rate of this oxidative metabolism.

Blood Alcohol Clearance

Since the disappearance of alcohol from the blood at levels of forensic and clinical interest proceeds at an essentially constant rate during the postabsorptive phase, blood alcohol levels at any time of interest during this phase could be computed from a known blood alcohol concentration at any other time during this phase, if the blood alcohol clearance rate were known. The blood alcohol clearance rate has consequently been the subject of many studies, and is now generally considered to lie between 0.010 and 0.025 percent per hour, usually being between 0.015 and 0.020 percent per hour for most persons (*86*). An average alcohol clearance rate of 0.015 percent per hour is most frequently mentioned (*17, 49*) for a normal man weighing 70 kilograms, but this rate is subject to considerable variation among individuals.

Abele (*1*) studied the alcohol clearance rate, Widmark's factor $\beta 60$ (*87*), in 922 men involved in traffic offenses. He found the rate to vary from 0.006 to 0.040 percent per hour, with a mean of 0.0184 percent and a mode of 0.018 percent (fig. 3). The RCMP study reported by Coldwell (*12*) included figures on the alcohol clearance rate of 110 subjects, with a mean of 0.013 ± 0.005 percent per hour. Goldberg (*31*) reported experiments with 62 subjects yielding an average blood alcohol clearance of 0.014 percent per hour. Ponsold and Heite (*70*) studied the blood alcohol clearance in 1,655 subjects arrested for intoxication and reported a mean value of 0.0172 ± 0.0046 percent per hour. It is apparent from these studies that for very accurate blood alcohol level extrapolations, the blood alcohol clearance rate for the individual concerned should be determined. All retrograde extrapolations of blood alcohol concentrations, of course, presuppose existence of the postabsorptive state during the entire interval subjected to computation; and it is establishment of the existence of the postabsorptive state which offers the greatest difficulties in practice. A simple practical application of blood alcohol clearance rate data is the estimation of how soon after a given dose or blood alcohol level the body will be alcohol free.

Occasionally, an unusual subject state, such as metabolic disease, is cited in support of an alleged deviation from normal average alcohol metabolism. Blotner (*5*) recently reported that he had found blood and urine alcohol concentrations to rise appreciably higher in diabetic subjects who had been given 0.6 ml of absolute alcohol per kilogram body weight than in normal persons. He postulated that diabetic subjects possibly could not metabolize alcohol as rapidly as normal persons, leading to a greater accumulation in the blood and greater concentration in the urine. A figure included in Blotner's paper, however, shows a blood alcohol clearance rate of approximately 0.015 percent per hour in his diabetic subjects, compared to a blood alcohol clearance of approximately 0.008 percent per hour for his "normal" subjects, the blood analysis method not being given. These data would appear inconsistent with slower metabolism of alcohol by diabetic subjects under otherwise identical conditions.

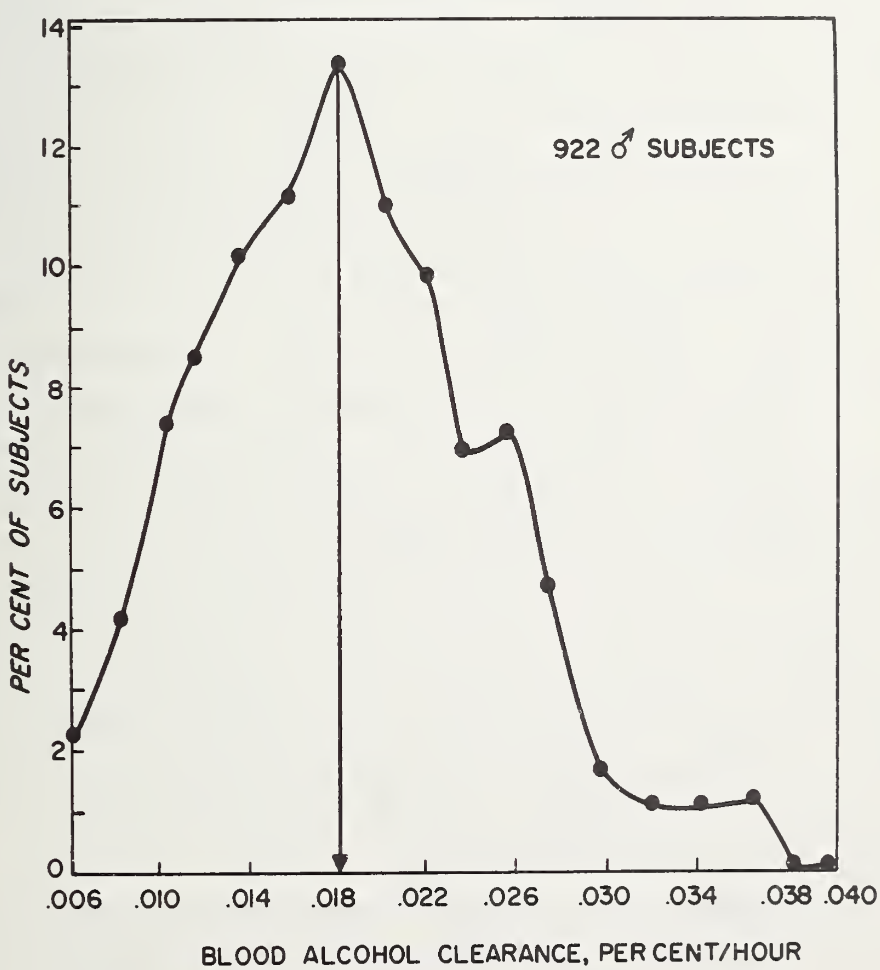

Figure 3. Blood alcohol clearance in men (*1*).

"Normal" Blood Alcohol Levels

Consideration of the blood alcohol clearance rate in drinking subjects leads to the question of what actual blood alcohol concentration represents the zero or "normal" fasting value. A voluminous literature has accumulated regarding this matter, with many older divergent findings probably resulting from less refined analysis methods. Without reviewing the extensive literature (*18, 19*), it can now be considered settled that the normal fasting blood alcohol concentration in abstaining subjects, or drinking subjects after total ingested alcohol metabolism, is 0.001 percent or less (*18, 19, 24, 48, 60*), evidently representing endogenous alcohol.

Time Relationships and Sample Validity

In traffic investigations and other occasions for use of alcohol determinations, it is highly desirable to reduce to a minimum the interval between the material time for which blood alcohol level information is required and the time of sample collection. Reduction of this interval curtails the opportunity for misleading physiological and metabolic events, such as rapid blood alcohol concentration increase during absorption, to occur and reduces the magnitude of unavoidable changes, such as a decrease in blood alcohol level, through the normal elimination process. Under some circumstances in law enforcement and in experimental situations, breath alcohol determination or procurement of other sample materials is possible near the time in issue; and such procedures are generally acceptable if performed within 30 minutes of the material time in issue, provided the subject is at or past the maximal blood alcohol level at the material time. Alveolar breath is a particularly convenient sample to collect for subsequent direct analysis and lends itself well to simple field collection near the material time, provided suitable containers are available which adequately preserve the entire breath sample including its alcohol content. Such breath alcohol containers were first reported by Kalow, Lucas, and McColl (*55*), who employed polyethylene bags and found that approximately one-half of the original alcohol quantity remained in the samples at the end of 4 hours. Harger, Forney, and Baker (*46*) reported their investigations of four different types of flexible breath bags, of which flexible aluminum bags showed the least alcohol loss, 15 percent at the end of 20 hours, while polyvinyl bags showed an average alcohol loss of 16 percent after 4 hours. Salem, Lucas, and Lucas (*73*) reported experience with an improved breath alcohol container, consisting of a formed Saran bag, which showed alcohol losses of less than seven percent after 62 hours. Combined plastic and aluminum breath sample bags developed by Etzlinger (*26*) are now available (fig. 4) and presently undergoing evaluation in the author's laboratory.

Such breath collection bags should make possible collection for subsequent analysis of breath specimens, preferably alveolar, near enough to the material time to avoid the pitfalls mentioned. If specimens of other body

Figure 4. Breath collection bags.

materials, e.g., blood, are collected near enough to the material time, the analyses should be similarly valid. In the absence of opportunity for specimen collection near the material time, several alternate and more complicated sampling schemes are available to permit meaningful interpretation of the results of analysis. Collection of two or more serial specimens of the same body material, e.g., blood or breath, at precisely known intervals of approximately 15 minutes will permit estimation of the stage(s) of alcohol absorption-distribution-elimination which obtains at the time of sample collection, and will thus sometimes permit considerably more reliable estimates of the probable situation at a prior material time than any single specimen analysis. The rationale is as follows. Three different major situations can be encountered at the time of sampling: (*a*) alcohol absorption with rapidly increasing blood alcohol levels; (*b*) the alcohol elimination phase with slowly decreasing blood alcohol levels; (*c*) an absorption-elimination plateau with a constant blood alcohol level indicative of temporary balance between the two phases. The first situation would be readily revealed by two or more analyses at 15-minute intervals because of the comparatively steep blood alcohol rise during absorption. The second situation in most persons will yield identical blood alcohol levels for two specimens taken at 15-minute intervals, because the usual blood alcohol decrease in 15 minutes due to elimination is substantially smaller than the analytical precision of practical alcohol analysis methods. The third situation will be encountered less commonly and will also lead to absence of any consequential blood alcohol level difference in the two analyses. Absence of a substantial positive differential between the second and first specimen analyses will, therefore, effectively rule out active alcohol absorption at the time the first sample was obtained, but will not per se permit estimation of the length of time elimination has been occurring. Analysis of two or more properly chosen different body materials will also often greatly increase the interpretation potential. As an example, a substantial positive difference in alcohol levels of a blood specimen and a simultaneously collected pooled bladder urine specimen indicates that the subject is in the absorptive phase.

Analysis of two specimens of the same body material separately collected also in effect eliminates the possibility of unrecognized fortuitous physiological contamination of a sample by such events as regurgitation or eructation in breath analysis, and is consequently good practice.

Some Chemical Test Safeguard Practices

Recommended Practices

The above physiological and metabolic considerations lead to certain obvious recommendations to safeguard the validity and reliability of alcohol determinations and to increase their potential for correct and adequate interpretation. Extensive prior discussions and summaries are available (*12, 20, 22, 24, 29, 33, 80*) and do not require repetition. Elimination of spurious effects in breath alcohol analysis is simple and requires so little effort that the following precautions, among others, should be routinely observed:

1. At least two separate breath specimens should be collected at intervals of from 5 to 15 minutes, and analyzed.
2. Prior to analysis, the following subject conditions should exist: (*a*) subject rested for at least 5 minutes following recent strenuous exercise; (*b*) subject not obviously hyperventilating; (*c*) no mouth alcohol exposure within past 15 minutes from alcohol consumption, emesis, or regurgitation; (*d*) no ingestion of water immediately before collection of the breath sample.

Single alcohol determination results, regardless of the body material analyzed, should not be employed for estimation of the blood alcohol concentration at a time other than the sampling time. Single pooled bladder urine specimens cannot normally provide an adequate basis for blood alcohol estimation even at the time of collection, and where this latter information is desired from urine alcohol analysis, the timed multiple urine sample collection scheme mentioned above should be employed. Extrapolation of the blood alcohol concentration to other than the sampling time is only applicable to intervals wholly in the postabsorptive elimination phase, and should be carried out with caution to employ the correct individually determined blood alcohol clearance rate or an adequately low estimated rate (i.e., 0.010 percent W/V per hour for retroactive calculations) to avoid prejudice to the subject.

Finally, care must be taken in reporting body material alcohol levels both in the scientific literature and in practice to cite the correct units of alcohol concentration applicable to the actual analytical and specimen measurement techniques employed; to avoid confusion between such commonly used concentration terms as "percent by weight," "percent by volume," "percent W/V," "pro mille," "$^0/_{00}$," etc.; and to prevent discrepancies resulting from misunderstanding or disregard of the units of measurement stated (*29*).

References

1. Abele, G. Die Abhängigkeit des Factors β von der Konzentrationshöhe. (The dependence of the β factor on concentration level.) *Dtsch. Z. ges. gerichtl. Med.,* 1955, **44,** 374–382.
2. Bartlett, G. R., and Barnet, H. N. Some observations on alcohol metabolism with radioactive ethyl alcohol. *Quart. J. Stud. Alc.,* 1949, **10,** 381–397.
3. Bayly, R. C., and McCallum, N. E. W. Some aspects of alcohol in body fluids. Part II. The change in blood alcohol concentration following alcohol consumption. *Med. J. Aust.,* 1959, **2,** 173–176.
4. Best, C. H., and Taylor, N. B. *The physiological basis of medical practice.* (7th ed.) Baltimore: Williams & Wilkins, 1961.
5. Blotner, H. Blood alcohol in a diabetic. (Questions and Answers) *J. Amer. med. Ass.,* 1961, **175,** 542.
6. Booth, C. E. *Drinking driver defendant.* Daytona Beach: Charles E. Booth, 1951.
7. Borkenstein, R. F. *Breath tests to determine alcoholic influence.* (3d ed.) Bloomington: Indiana University, 1959.
8. Borkenstein, R. F., Smith, H. W., Dubowski, K. M., and Shupe, L. M. Unpublished observations, January 1961.
9. Bowden, K. M., and McCallum, N. E. W. Blood alcohol content: some aspects of its post-mortem uses. *Med. J. Aust.,* 1949, **2,** 76–81.
10. Casier, H., and Delaunois, A. L. L'intoxication par l'alcool éthylique. Pharmacologie, toxicologie et médecine légale. (Intoxication by ethyl alcohol. Pharmacology, toxicology, and legal medicine.) Paris: Masson & C[ie], 1947.
11. Chastain, J. D., Strauss, H. J., and Maupin, C. W. *A correlation study of blood alcohol levels as determined by Alcometer, Breathalyzer and direct blood analysis including blood-urine alcohol ratio.* Austin: Texas Department of Public Safety, 1957.
12. Coldwell, B. B. (Ed.) *Report on impaired driving tests.* Ottawa: Crime Detection Laboratories, Royal Canadian Mounted Police; Queen's Printer, 1957.
13. Coldwell, B. B., and Smith, H. W. Alcohol levels in body fluids after ingestion of distilled spirits. *Canad. J. Biochem.,* 1959, **37,** 43–52.
14. Cornish, R. E., Draper, H. D., and Finn, J., Jr. Validity of post-mortem tests for alcoholism. *Amer. J. med. Jurispr.,* 1938, **1,** 86–88.
15. Cushny, A. R. On the exhalation of drugs by the lungs. *J. Physiol.,* 1910, **40,** 17–27.
16. Donigan, R. L. *Chemical tests and the law* (edited by E. C. Fisher). Evanston, Ill.: The Traffic Institute, Northwestern University, 1957.
17. Drew, G. C., Colquhoun, W. P., and Long, Hazel A. *Effect of small doses of alcohol on a skill resembling driving.* Med. Res. Council Memorandum 38. London: Her Majesty's Stationery Office, 1959.

18. Dubowski, K. M. An evaluation of methods for the determination of ethyl alcohol in biological materials. Doctoral dissertation, The Ohio State University, 1949.
19. Dubowski, K. M. A comparative experimental study of current methods for the forensic determination of ethyl alcohol. Paper read at the Organizational Meeting, American Academy of Forensic Sciences, Chicago, Jan. 26–28, 1950.
20. Dubowski, K. M. Some practical laboratory aspects of forensic alcohol determinations. *Proc. Iowa Acad. Sci.,* 1956, **63,** 364–390.
21. Dubowski, K. M. Some major developments related to chemical tests for intoxication. *Police,* 1957, **2**(2), 54–56.
22. Dubowski, K. M. Necessary scientific safeguards in breath alcohol analysis. *J. forensic Sci.,* 1960, **5,** 422–433.
23. Dubowski, K. M., and Withrow, J. R. A photometric microdetermination method for ethyl alcohol in biological materials. *Proc. Amer. Acad. forensic Sci.,* 1952, **2,** 323–337.
24. Elbel, H., and Schleyer, F. *Blutalkohol.* (Blood alcohol.) (2d ed.) Stuttgart: Georg Thieme Verlag, 1956. Pp. 117–121.
25. Erwin, R. E. Trial of a drunk driving case—defense viewpoint. *Trauma,* 1959, **1**(3), 47–127.
26. Etzlinger, L. Personal communication, Jan. 25, 1961.
27. Fitzgerald, Mabel P., and Haldane, J. S. The normal alveolar carbonic acid pressure in man. *J. Physiol.,* 1905, **32,** 486–494.
28. Forrester, G. C. *The use of chemical tests for alcohol in traffic law enforcement.* Springfield, Ill.: Charles C Thomas, 1950.
29. Friedemann, T. E., and Dubowski, K. M. Chemical testing procedures for the determination of ethyl alcohol. *J. Amer. med. Ass.,* 1959, **170,** 47–71.
30. Gardner, D. S. Breath-tests for alcohol: a sampling study of mechanical evidence. *Texas Law Rev.,* 1953, **31,** 289–306.
31. Goldberg, L. Tolerance to alcohol in moderate and heavy drinkers and its significance to alcohol and traffic. In *Proceedings of First International Conference on Alcohol and Road Traffic.* Stockholm: Kugelbergs Boktryckeri, 1951. Pp. 85–106.
32. Goodman, L. S., and Gilman, A. *The pharmacological basis of therapeutics.* (2d ed.) New York: Macmillan, 1955.
33. Greenberg, L. A. Physiological factors affecting breath samples. *J. forensic Sci.,* 1960, **5,** 411–422.
34. Greenberg, L. A., and Keator, F. W. A portable automatic apparatus for the indirect determination of the concentration of alcohol in the blood. *Quart. J. Stud. Alc.,* 1941, **2,** 57–72.
35. Greenberg, L. A., and Lester, D. Alcohol breath tests and breath deodorization by chlorophyll derivatives. *Quart. J. Stud. Alc.,* 1954, **15,** 16–20.
36. Grosskopf, K. Die Atemalkohol-Bestimmung als analytische Aufgabe. (Breath alcohol determination as an analytical task.) *Angew. Chem.,* 1954, **66,** 295–297.
37. Grosskopf, K. Die Atemalkohol-Bestimmung als analytische Aufgabe. (Breath alcohol determination as an analytical task.) *Chemikerztg,* 1954, **78,** 351–356.
38. Grüner, O. Die Verteilung des Alkohols im Blut. (The distribution of alcohol in the blood.) *Dtsch. Z. ges. gerichtl. Med.,* 1957, **46,** 10–17.
39. Haggard, H. W., and Greenberg, L. A. Studies in the absorption, distribution, and elimination of ethyl alcohol. II. The excretion of alcohol in urine and expired air; and the distribution of alcohol between air and water, blood, and urine. *J. Pharmacol.,* 1934, **52,** 150–166.
40. Haggard, H. W., Greenberg, L. A., Carroll, R. P., and Miller, D. P. The use of urine in the chemical test for intoxication. Possible errors and their avoidance. *J. Amer. med. Ass.,* 1940, **115,** 1680–1683.

41. Haggard, H. W., Greenberg, L. A., Miller, D. P., and Carroll, R. P. The alcohol of the lung air as an index of alcohol in the blood. *J. Lab. clin. Med.,* 1941, **26,** 1527–1541.

42. Haldane, J. S., and Priestley, J. G. The regulation of the lung-ventilation. *J. Physiol.,* 1905, **32,** 224–266.

43. Harger, R. N. "Debunking" the Drunkometer. *Quart. Bull. Ind. Univ. med. Cent.,* 1949, **11,** 69–73.

44. Harger, R. N. Comments on the article "Medico-legal aspects of chemical tests of alcoholic intoxication," by Dr. I. M. Rabinowitch, which appeared in the December 1955 issue of this journal. *Canad. Serv. med. J.*, 1956, **12,** 808–818.

45. Harger, R. N. Distribution of absorbed alcohol; body materials which yield reliable results. *J. forensic Sci.*, 1956, 1(2), 27–38.

46. Harger, R. N., Forney, R. B., and Baker, R. S. Estimation of the level of blood alcohol from analysis of breath. II. Use of rebreathed air. *Quart. J. Stud. Alc.,* 1956, **17,** 1–18.

47. Harger, R. N., Forney, R. B., and Barnes, Helen B. Estimation of the level of blood alcohol from analysis of breath. *J. Lab. clin. Med.*, 1950, **36,** 306–318.

48. Harger, R. N., and Goss, Anna L. The so-called normal alcohol of the body. *Amer. J. Physiol.*, 1935, **112,** 374–382.

49. Harger, R. N., and Hulpieu, H. R. The pharmacology of alcohol. In G. N. Thompson (Ed.), *Alcoholism.* Springfield, Ill.; Charles C Thomas, 1956. Pp. 103–232.

50. Harger, R. N., Lamb, E. B., and Hulpieu, H. R. A rapid chemical test for intoxication employing breath. A new reagent for alcohol and a procedure for estimating the concentration of alcohol in the body from the ratio of alcohol to carbon dioxide in the breath. *J. Amer. med. Ass.*, 1938, **110,** 779–785.

51. Harger, R. N., Raney, B. B., Bridwell, E. G., and Kitchel, Mary F. The partition ratio of alcohol between air and water, urine and blood; estimation and identification of alcohol in these liquids from analysis of air equilibrated with them. *J. biol. Chem.*, 1950, **183,** 197–213.

52. Henderson, Y., and Haggard, H. W. *Noxious gases and the principles of respiration influencing their action.* (2d ed.) New York: Reinhold, 1943.

53. Jetter, W. W., and Forrester, G. C. The perchlorate method for determining concentration of alcohol in expired air as a medicolegal test. *Arch. Path.* (*Lab. Med.*), 1941, **32,** 828–842.

54. Jetter, W. W., Moore, M., and Forrester, G. C. Studies in alcohol. IV. A new method for determination of breath alcohol. Description and examination of the perchlorate method for breath alcohol determinations. *Amer. J. clin. Path., tech. Suppl.,* 1941, **5,** 75–89.

55. Kalow, W., Lucas, G. H. W., and McColl, J. D. Containers for breath samples for alcohol analysis. In *Proceedings of the Second International Conference on Alcohol and Road Traffic.* Toronto: Brewers' Warehousing Co. Ltd., 1955. Pp. 137–138.

56. Kent-Jones, D. W., and Taylor, G. Determination of alcohol in blood and urine. *Analyst,* 1954, **79,** 121–136.

57. Kirwin, T. J., and Hawes, G. A. The diagnostic value of residual urine estimation. *J. Urol.,* 1939, **41,** 413–430.

58. Liljestrand, G., and Linde, P. Über die Ausscheidung des Alkohols mit der Expirationsluft. (On the identification of alcohol by expired air.) *Skand. Arch. Physiol.,* 1930, **60,** 273–298.

59. Linck, K. Blut-, Urin- und Liquoralkoholkurve des Menschen bei akuter Alkoholvergiftung und der Zeitpunkt des Todeseintritts. (Blood, urine, and

serum alcohol curves in man with acute alcohol poisoning and the time of death.) *Dtsch. Z. ges. gerichtl. Med.*, 1949, **39,** 514–528.
60. Lundquist, F., and Wolthers, H. The kinetics of alcohol elimination in man. *Acta pharmacol., Kbh.*, 1958, **14,** 265–289.
61. Marshall, E. K., and Fritz, W. F. The metabolism of ethyl alcohol. *J. Pharmacol.*, 1953, **109,** 431–443.
62. Mellanby, E. Alcohol. Its absorption into and disappearance from the blood under different conditions. Special Report Series No. 31, Medical Research Committee. London: Oxford University Press, 1919.
63. Moritz, A. R., and Jetter, W. W. Antemortem and postmortem diffusion of alcohol through the mucosa of the bladder. *Arch. Path.* (*Lab. Med.*), 1942, **33,** 939–948.
64. Muehlberger, C. W. *Test for alcohol.* Chicago: University of Chicago Press, 1934.
65. Muehlberger, C. W. Medicolegal aspects of alcohol intoxication. *Mich. St. Bar J.*, 1956, **35,** 36 (February).
66. Mulrow, P. J., Huvos, A., and Buchanan, D. L. Measurement of residual urine with I^{131}-labeled Diodrast. *J. Lab. clin. Med.*, 1961, **57,** 109–113.
67. Newman, H. W. *Acute alcoholic intoxication. A critical review.* Stanford, Calif.: Stanford University Press, 1941.
68. Newman, H. W. Research on alcohol. *Stanf. med. Bull.*, 1955, **13,** 98–105.
69. Peters, J. P., and Van Slyke, D. D. *Quantitative clinical chemistry. Vol. II—Methods.* Baltimore: Williams & Wilkins, 1932.
70. Ponsold, A., and Heite, H.-J. Statistische Untersuchung über die Höhe des Blutalkoholabfallwertes ("Abbauwertes") im Hinblick auf die Rückrechnung. (Statistical investigation of the magnitude of the rate of decline of blood alcohol in relation to back calculation.) *Dtsch. Z. ges. gerichtl. Med.*, 1960, **50,** 228–234.
71. Rabinowitch, I. M. Medico-legal aspects of chemical tests of alcoholic intoxication. *Canad. Serv. med. J.*, 1955, **11,** 844–891.
72. Rabinowitch, I. M. Medico-legal aspects of chemical tests of alcoholic intoxication. *Obiter Dicta* (Osgoode Hall Law School Journal), 1955, **29,** 15–56.
73. Salem, H., Lucas, G. H. W., and Lucas, D. M. Saran plastic bags as containers for breath samples. *Canad. med. Ass. J.*, 1960, **82,** 682–683.
74. Seifert, P. Erkennung einer Alkoholintoxikation aus dem Alkoholgehalt der Atemluft. (Recognition of alcohol intoxication from the alcohol content of breath.) *Arch. exp. Path. Pharmak.*, 1952, **216,** 558–562.
75. Seifert, P. Grundsätzliches zur Atem-Alkoholbestimmung. (The basis of breath alcohol determination.) *Dtsch. Z. ges. gerichtl. Med.*, 1954, **43,** 424–427.
76. Seifert, P. *Grundlagen der Blutalkoholforschung.* (Foundations of blood alcohol investigation.) Leipzig: Barth Verlag, 1955.
77. Seifert, P., and Günther, H. Alkoholintoxikation und Atemalkohol. (Alcohol intoxication and breath alcohol.) *Arch. exp. Path. Pharmak.*, 1951, **213,** 37–43.
78. Sillery, R. J., Williams, L. A., and Langtry, A. C. Correlation between ethyl alcohol levels in venous blood and alveolar air samples. *J. Lab. clin. Med.*, 1959, **54,** 613–616.
79. Smith, H. W. The specificity of the desiccation method for determining alcohol in biological fluids. *J. Lab. clin. Med.*, 1951, **38,** 762–766.
80. Smith, H. W., and Lucas, D. M. Breath tests for alcohol. *Criminal Law Quart.*, 1958, **1,** 25–45.
81. Smith, J. C. The avoidance of biologic variables in breath tests for alcohol in blood. *Amer. J. clin. Path.*, 1959, **32,** 34–40.
82. Sollmann, T. H. *A manual of pharmacology and its applications to therapeutics and toxicology.* (8th ed.) Philadelphia: W. B. Saunders, 1957.

83. Turkel, H. W., and Gifford, H. Erroneous blood alcohol findings at autopsy. Avoidance by proper sampling technique. *J. Amer. med. Ass.*, 1957, **164**, 1077–1079.
84. Turner, R. F., Bennett, W. B., Cestaric, E. S., and Muehlberger, C. W. *Evaluating chemical tests for intoxication.* Chicago: Committee on Tests for Intoxication, National Safety Council, 1953.
85. U.S. Bureau of Medicine and Surgery. *Submarine medicine practice.* Washington: Government Printing Office, 1956. NAVMED–P 5054.
86. Westerfeld, W. W., and Schulman, M. P. Metabolism and caloric value of alcohol. *J. Amer. med. Ass.*, 1959, **170**, 197–203.
87. Widmark, E. M. P. *Die theoretischen Grundlagen und die praktische Verwendbarkeit der gerichtlich-medizinischen Alkoholbestimmung.* (The theoretical foundations and the practical application of forensic-medical alcohol determination.) Berlin: Wien, Urban & Schwartzenberg, 1932.

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CHAPTER V

Alcohol Ingestion and Traffic Accidents—Some Biochemical Considerations

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The mobile society of America today relies heavily on the automobile for the bulk of transportation. In addition, this mobile society makes great use of beverage alcohol as a social adjunct, as a tranquilizer, as an antidote to boredom, and, all too often, as an expression of personality disorder. The recognized relationship between these two facts is attested to by the wealth of statistics concerning the role alcohol plays in traffic accidents, and by the tremendous number of studies of the effects of alcohol on central nervous system function. Some of these are discussed elsewhere in this book.

There are some specific aspects of the alcohol-traffic problem that deserve further attention. One is the effect that preexisting central nervous system disorders may have on an individual's response to alcohol ingestion. Another is the possibility that chronic alcoholism may, after a long period of time, produce cumulative, irreversible brain damage so that driving skill and judgment are impaired even in the absence of alcohol ingestion. One final aspect to be considered is the oft-ephemeral one of mood and judgment. It is very likely that a large number of alcohol-induced traffic accidents are not statistically listed as alcohol based because of the legal definition of drunken driving. It is well known that neuromuscular coordination, vision, and other functions are impaired in an increasing fashion by ascending levels of alcohol in the blood. What remains to be clarified is the likelihood that amounts of alcohol too small to produce any measurable or reproducible change in either of these moieties may have an effect on personality that, for some, increases the risks of driving.

Alcohol and Preexisting Central Nervous System Disorders

As a prelude to a discussion of the central nervous system effects of alcohol in disease states, a brief consideration of what is known about effects in the normal would be helpful. It is safe to say that alcohol taken by mouth very quickly finds its way inside the cells of the brain and spinal cord, and it is here that the effects of alcohol on central nervous system function take place. These effects have been studied from both the point of view of alterations in the overall physiology of the cell and also from the point of view of the specific changes in the electrophysiology of the nerve cell.

Central Nervous System Cellular Physiology of Alcohol

It appears that alcohol inside the brain cell is in equilibrium with the total body water. That amount of alcohol that enters the central nervous system cell, however, does not appear to be oxidized or in any way chemically altered. The amount of alcohol inside the brain cell at any one time, then, is the resultant of the ingestion of alcohol introducing the substance into the bloodstream, on the one hand, and oxidation of alcohol by the liver to dispose of it, on the other.

Even though alcohol itself is not metabolized by the brain, it appears from studies on animal and man that alcohol is capable of decreasing the ability of the brain to take up oxygen, so necessary for normal function. Alcohol ingestion can, however, affect the brain indirectly. This substance is oxidized by the liver and disposed of in this fashion. As a consequence of this oxidation, however, the liver pours into the circulating blood increased amounts of organic acids, particularly pyruvic and lactic. This is the most likely cause of the acidosis that complicates alcoholism.

Some more recent observations of central nervous system physiology have to do with two chemicals manufactured by the body. The first one is known as serotonin. Its chemical structure is included in the appendix of this paper. It is a substance that is ultimately formed from an amino acid in the diet. This amino acid, tryptophan, is, after ingestion, carried to the liver by the bloodstream. Here it is converted to 5-hydroxytryptophan. This substance is then carried to the brain stem where it enters the cells of the brain stem. Inside these cells, it is converted to 5-hydroxytryptamine or serotonin. It is manufactured in such a fashion that it is bound to protein inside the brain cells and is therefore inactive. A very small amount of this substance is freed from the bound state periodically and it is in this free state that it is capable of producing its effects. The amount that is free in the brain at any one time is kept very small because of the fact that serotonin is converted to its final inactive product, 5-hydroxyindole acetic acid, almost as quickly as it is formed. Increasing the amounts of free serotonin in the brain stem of human beings produces some very strange changes in mood. When one gives to humans a drug capable of raising the amount of free serotonin in the brain stem, one will produce a state of "drunkenness" characterized by exaggerated imagination and fantasy.

Norepinephrine is another chemical manufactured by the body of great importance in central nervous system control mechanisms. Many different kinds of evidence suggest that one important role of norepinephrine in the brain stem is that of preparing the central nervous system for vigorous action either in terms of flight or engaging in combat.

Some authorities have suggested that norepinephrine and serotonin in the brain tend to balance each other in their effects on mood. They suggest that the release of free serotonin produces a languid, drowsy state of mood ideal for recuperation. On the other hand, the release of free norepinephrine prepares the body for vigorous action in response to some crisis. The theory, as it is suggested, is that serotonin, then, is the mediator of "trophotropic" [1] impulses and norepinephrine is the mediator of "ergotropic" [1] impulses.

If this hypothesis is valid, it is then possible to explain the effects of those drugs now in great use called "tranquilizers," and "central nervous system activators." A tranquilizer could act by (*a*) imitating the action of free serotonin; (*b*) cause the release of serotonin to the free, and therefore active, state; or (*c*) slow down the rate of destruction of free serotonin. A "central nervous system activator" could exert its effect on mood by (*a*) mimicking the effect of norepinephrine; (*b*) causing the release of norepinephrine to the free state; or (*c*) blocking the chemical removal of active, free norepinephrine. Some of the studies supporting this hypothesis are summarized in the appendix. These studies, then, and this background information on the proposed mode of action of serotonin and norepinephrine, give us a framework in which to consider some of our recent investigations as regards the effect of alcohol on mood.

Within this framework, two recent, somewhat parallel, lines of investigation are of interest. The first (*26*) has to do with the acute effects of alcohol on brain-stem norepinephrine and serotonin levels in the experimental animal. Adult rabbits were given ethanol by intravenous injection in comparatively large doses; i.e., 2 grams per kilogram in normal saline in a 5- to 10-minute period. The animals were then sacrificed at various intervals after the administration of the drug to determine the effect of this treatment on brain-stem levels of norepinephrine and serotonin. The rise and fall of blood alcohol level was likewise studied, as a function of time after administration. Blood alcohol reached an expected maximum of 120 mg percent within 30 minutes of the time of administration and then fell slowly, in a linear fashion, reaching zero at 5 hours after the infusion. The changes in brain-stem serotonin level were quite dramatic. It must be emphasized here that the serotonin measured by this technique was the total amount of the substance present, as the method used (*7*) is not capable of distinguishing between combined and free forms. The amount of serotonin present in the brain stem dropped from a control level of 0.67 microgram per gram of brain stem to 40 percent of this control value, or approximately 0.27 microgram per gram of brain stem, within 30 minutes. Within 1 hour after administration of alcohol, the brain-stem level had risen to 0.33 microgram per gram of brain stem and then began a very slow return to

[1] See appendix, pp. 131–133, for discussion of these terms.

normal. This return was complete in about 6 days. Brain-stem norepinephrine concentrations likewise changed in striking fashion, although not to quite this degree. The control level of approximately 0.46 microgram per gram dropped to 0.25 microgram per gram within 1 hour and slowly climbed, reaching normal in about 4 to 5 days.

The resemblance between these effects of administered alcohol and those of reserpine (see appendix, pp. 130–131) scarcely needs emphasizing. Here is a substance, alcohol, that is capable of producing an abrupt, profound decrease in brain-stem levels of both serotonin and norepinephrine. Data clearly defining the mechanism of this action are not at present available, but it is tempting to assume that the modus operandi is similar to, or identical with, that of reserpine. If this were indeed the case, a great deal would be explained about the effect of alcohol on mood. By releasing both bound serotonin and bound norepinephrine, alcohol might well be capable of acting as a tranquilizer in the same fashion as reserpine. Since the effect of alcohol on brain-stem norepinephrine and serotonin is measurable long after alcohol has disappeared from both blood and brain, it is likewise reasonable to assume that alcohol might well be capable of blocking further binding of newly formed serotonin and norepinephrine after the moment of release. If this were true, we would be confronted with a situation in which the amount of the free amines present would be in a steady state, once again determined by the rates of formation and the rates of destruction. Since the rate of formation of serotonin is much more rapid than that of norepinephrine, we would again be dealing with a situation in which the overall effect would be serotonin predominant in type. The tranquilizing effects of beverage alcohol, fabled in song and story, would then be capable of easy explanation. The decreased responsiveness to environmental stimuli that is characteristic of trophotropic predominance would be an obvious danger in driving a motor vehicle. Many auto accidents in which bystanders report a driver's failure to respond to an obvious danger would then be understandable.

One further note of speculation is likewise in order. These data were gathered with the rabbit as an experimental animal. In this situation, serotonin synthesis predominates over norephinephrine synthesis, and rate of fall in the levels of the two amines was roughly parallel. It is not unreasonable to consider that species differences could well exist between the rabbit and the human. Indeed, differences between individuals in the comparative rate of formation and destruction of these two amines could result in great differences in steady state levels of these two important substances. The resultant effect on the subcortical neurohumoral control mechanism would then be due to the particular amine that predominated. If the predominant free amine were serotonin, the clinical result would be the placid, tranquil, easily amused state that some humans manifest in moderate alcohol intoxication. If, on the other hand, norepinephrine were predominant, an ergotropic state would produce the hostile, combative, hyperreactive, often vicious type of personality pattern occasionally seen in moderate alcohol intoxication. There is very little need to emphasize the fact that either the trophotropic or the ergotropic state, if marked, would measurably add to the danger, already great, if the driver of an automobile has these subcortical effects superimposed on the delayed reaction time and other previously described effects of alcohol ingestion on neuromuscular function. It is unfortunate that presently available techniques do not permit of minute-to-minute measurement of changes in human brain-stem level in these potent neurohumoral regulators.

Another line of investigation, in our laboratory, suggests that the chronic alcoholic has to contend with underlying defects in serotonin metabolism in addition to the acute changes postulated from the above described animal data (*39*). Brain-stem serotonin is derived from dietary tryptophan.[2]

Since a diseased state characterized by mood disturbances, such as alcoholism, is likely to have a disturbance in neurohumoral mood-determining mechanisms, this area was selected for investigation. The method of study consisted of assessing serotonin formation by measuring the rate of excretion of its metabolic end product, 5-hydroxyindole acetic acid, in the urine. This was done under circumstances where the dietary supply was approximately constant at 1 gram of tryptophan per day. This was measured in both normal patients and in 34 patients in whom the diagnosis of alcoholism had been made by the criteria recommended by the World Health Organization (*52*). It was found that the 5-hydroxyindole acetic acid excretion in 16 normal controls was 6.4 ± 1.4 mg per 24 hours. Thirty-four alcoholic patients under the same conditions excreted 2.5 ± 1.0 mg of 5-hydroxyindole acetic acid per 24 hours. The second phase of this investigation included response to a test load of orally administered DL-tryptophan, given in the post-absorptive state. After this loading, the 16 normal controls excreted a mean of 11.6 ± 5.7 mg per 24 hours, while the 34 alcoholic patients excreted 5.7 ± 2.9 mg of 5-hydroxyindole acetic acid per 24 hours. Careful dietary histories and refeeding, when necessary, helped to rule out deficiencies of pyridoxine (vitamin B_6) or nicotinic acid as contributing to these differences. These possibilities were made less likely by studies of xanthurenic acid excretion as an index of pyridoxine (vitamin B_6) nutrition and N-methyl-nicotinamide excretion as an evidence of nicotinic acid nutritional status. With both of these indices the alcoholic group was not significantly different from the normal.

It would appear from these studies, then, that the patient with chronic alcoholism only excretes approximately half as much 5-hydroxyindole acetic

[2] Present concepts of this pathway include formation of 5-hydroxytryptophan in the liver, which is then carried in the bloodstream to the brain stem. This substance is capable of entering the brain stem and is here decarboxylated to form bound 5-hydroxytryptamine (serotonin) by a pyridoxine dependent reaction. Bound 5-hydroxytryptamine (serotonin), after release to the free state, is converted by monoamine oxidase action to 5-hydroxyindole acetic acid, an inert substance rapidly transported to the kidneys via the bloodstream and excreted in the urine.

acid in his urine from a given tryptophan load as the normal. It is important to point out that excretion levels are not necessarily valid indices of steady-state levels of either free or bound serotonin in the brain stem. It is not unlikely, however, that in this, as in many biological situations, rate of synthesis is an important aspect of control of steady-state level. It might then be safe to assume that the chronic alcoholic patient has a decreased level of serotonin in his brain stem even before he subjects himself to the effects of ingested beverage alcohol.

The foregoing material, then, can be summarized as follows: (*a*) alcohol itself is probably not metabolized by brain tissue to any significant degree; (*b*) direct effects on the usual indicators of brain cell metabolism are scant and occur only when levels of alcohol are at exceedingly high levels; (*c*) there is growing, though early, evidence that alcohol has a profound effect on subcortical, humoral factors of major importance in integration of brain function. It must be emphasized, however, that the above data do not, in the light of present knowledge, cast any light on the metabolic mechanism whereby chronic exposure to alcohol results in permanent brain damage.

The Effect of Alcohol on Central Nervous System Electrophysiology

The effect of alcohol on electrical activity of the central nervous system, as measured by electroencephalographic tracings, has been studied and reported voluminously. It is not within the scope of this paper to review this literature in detail, but a brief summary may be in order. Gibbs et al. in 1937 (*23*) reported that a patient in alcoholic coma showed high-voltage delta activity similar to that found in coma due to other causes. Other workers confirm these observations, and Kaufman et al. (*32*) reported that moderate alcohol ingestion produced no effects in patients previously normal. In 16 epileptic patients, however, alpha rhythm became more prominent as a result of alcohol. Marinacci (*35*) studied 63 patients to whom he administered alcohol in small to moderate doses of alcohol beverage. Electroencephalograms were taken before, during, and after administration of the drug. Of his patients, 33 showed no electroencephalographic changes whatsoever; 15 showed a combination of fast and slow activity in proportion to the amount of alcohol given; 12 showed electrical seizure discharges. Of the 12 that showed seizure discharges with alcohol, only 2 had normal electroencephalograms prior to the administration of the drug. Of the 12 patients who showed electrical seizure discharges as a result of alcohol, 2 had major convulsions, 2 had psychomotor manifestations, 3 showed mental confusion, and 5 showed no clinical manifestation. Wikler et al. (*50*) reported the effect of prolonged alcoholic intoxication on three volunteer subjects. During the period of gradual increase in chronic alcohol ingestion, electroencephalographic slowing was noted parallel to the effect of the alcohol on the mental state of the subject. At a time that the patient clinically showed adaptation to a given blood alcohol level, the electroencephalogram returned toward normal. Withdrawal of alcohol intake resulted in the development of classical delirium tremens. This was accompanied, in one patient, by generalized convulsion. No specific electroencephalographic changes correlated with these withdrawal clinical signs.

In brief, it is safe to say that the evidences of the effect of alcohol on the central nervous system as manifested by electrical studies are disappointing. Some slowing is noted that correlates with clinical state. Those patients with a predisposition to convulsive discharges seemed to have a greater tendency to these electrical seizure discharges as a result of alcohol ingestion.

Summation

It is possible to draw only the broadest of conclusions from this brief summary of data and speculations on the effect of alcohol on central nervous system function. The known biochemical effects of alcohol on cellular physiology of the brain are not such as to lead one to expect permanent damage or accentuation of preexisting impairment to result from its use. From the effects on subcortical regulatory mechanisms, however, it is possible to be somewhat more specific. If alcohol is capable of producing the effects described above on neurohumoral integrative mechanisms, it is then to be expected that any chronic brain disease could be symptomatically made worse by alcohol ingestion. Thus, any disorder with lesions widespread enough to result in interference in association pathways and mechanisms, and in symptoms arising therefrom, would have added to its underlying clinical picture the new symptomatology of impairment of this neurohumoral functional, rather than structural, association mechanism. In support of this proposition is the observation, familiar to this observer and to many others familiar with chronic alcoholism, that patients who develop chronic brain damage develop a concurrent decrease in alcohol tolerance. Hence, as brain damage progresses, the patient becomes much more manifestly intoxicated with gradually decreasing doses of alcohol.

As regards the effect of alcohol on preexisting convulsive disorders, the data cited, plus other literature references not alluded to, make it a questionable procedure for at least some patients subject to convulsive disorders to ingest alcohol. The available data suggest that the likelihood of convulsive seizures of any type may be increased by alcohol ingestion. The driving of a motor vehicle is attended by already real risks in patients with a tendency to convulsive disorders, and the addition of alcohol ingestion can only be expected to add to the risks, if it affects them at all, whether substantially or in small degree.

Alcohol and Brain Damage

The abundant literature descriptions of Korsakoff's psychosis and other clinical syndromes attributed to chronic, progressive, diffuse deterioration of the brain stem is evidence of the intense and continuing interest in this field. The large number of studies of acute and chronic alcohol effects on microstructure of the brain further indicates the continuing attempts to correlate changes in functions with alterations in structure. Structural changes in the brain as a result of the acute effects of alcohol are disappointingly few. Patients who die because of a lethal dose of alcohol or who die for some other reason while under the influence of large quantities of alcohol show, on autopsy, few changes in the brain. The brain itself will be found to be enlarged, boggy, and with suggestive flattening of the convolutions. The vessels of the pia are engorged and petechiae may be seen throughout the brain and brain stem, on section. Microscopic examination is equally unrewarding. The spaces around the vessels and neurons may appear slightly widened and the neurons themselves may be somewhat swollen (*15*).

In chronic alcoholism, the evidences of diffuse and permanent damage are manifold. Alcoholic patients demonstrate a high incidence of persistent electroencephalographic changes. Bennett and his coworkers (*5*) studied 95 chronic alcoholics. The changes in acute alcoholic intoxication were similar to those described above, and disappeared on return to sobriety. The changes of chronic alcoholism, however, did not disappear with treatment and consisted of fast activity, to a greater or lesser degree, particularly over the frontal and parietal areas. Spike discharges are also seen, as is slow activity. These latter two changes seem to be more common in the more deteriorated patients. Bennett's group, in a more recent publication (*6*), presents clinical and electroencephalographic observations of 227 patients admitted to the psychiatric wards for alcoholism. These workers point out that there is a recognizable intermediate stage of brain damage resulting from chronic alcoholism. Their thesis is to the effect that acute electroencephalographic changes clear fairly promptly after the termination of the acute brain syndrome, while changes due to permanent brain damage persist. The intermediate stage is said by them to exist when electroencephalographic changes seen during the acute brain syndrome persist for months after sobriety is accomplished, and clear only very gradually.

The literature abounds with descriptions of microscopic changes in the brain seen in chronic alcoholism. Wernicke's syndrome, characterized by petechial hemorrhages in the mammillary bodies and the periventricular gray matter around the third ventricle, is well known. The facts that this disorder (*a*) is due to thiamine (vitamin B_1) deficiency, and (*b*) may produce very widespread petechial damage to the brain, need no further elaboration here. Korsakoff's psychosis is likewise familiar. It is characterized, on microscopic examination (*13*), by an increase in lipochrome of all the nerve cells of the brain and chromatolysis in the larger cells, especially those in the cortical layer of Betz. It is not unreasonable here to postulate that the diffuse lesions characterizing the late stages of alcoholism may well represent cumulative, subclinical bouts of thiamine (vitamin B_1) deficiency. This is not a new concept, but clinical experience and data in the literature would support it.

Lemere (*33*) has summarized some of the literature dealing with brain damage and chronic alcoholism, and points to the pneumoencephalographic indications of cortical atrophy often found in deteriorated alcoholics. Neuberger reports data obtained from the histologic examinations of the brains of 42 alcoholics (*37*). He points out that the picture in Wernicke's syndrome of petechial hemorrhages in the brain about the third ventricle is diminishing in frequency, and is actually becoming quite rare. It is being replaced by a more or less severe, but nonspecific, degeneration of the granular layer of the cerebellum.

The clinical evidences of persistent brain damage in chronic alcoholism are likewise striking. Bennett et al. (*6*) discuss their findings in 227 alcoholics. The data obtained by psychological testing indicate a defect in perceptual organization and evidences of deterioration of intellect and personality. In addition, there seems to be an impairment of abstraction. These workers describe the personality pattern of the chronic alcoholic suffering from brain damage as being characterized by poor judgment, emotional lability, infantile behavior, hostility, defiance, and denial of illness—all of these accompanied by almost complete lack of insight. The authors likewise make the point that these symptoms are too often ascribed to a sociopathic personality of the patient where, as an actual fact, they are caused by chronic toxic effects of the ingested beverage alcohol.

In summary, then, it is possible to say that the literature descriptions of clinical and pathologic changes seen in a person with chronic alcoholism indicate a progressive deterioration of mental function. For this reason, it would appear that the chronic alcoholic represents a driving hazard not only while he is under the influence of alcohol but also when sober. The destruction of the cells of the cerebral cortex and of the cerebellum cannot but produce the personality changes so familiar to all observers. The patient with deterioration of intellect and cerebellar function is a driving hazard even without the all too often present acute alcoholic intoxication.

Alcohol, Mood, and Traffic Accidents

In a recent publication, Selzer (*43*) has pointed out that the effect of alcohol on neuromuscular function is not the only factor to be considered in traffic accidents caused by alcoholic drivers. The patient who is suffering from alcoholism is said by many observers to manifest poor control of hostility, depression, and feelings of omnipotence and invulnerability. Ingestion of alcohol is said to release these feelings and to cause them to become operative in directing the behavior of the patient. If it occurs, the release of these mood factors can very properly be expected to increase the dangers confronting the intoxicated, driving, chronic alcoholic.

It is not inappropriate at this time to extrapolate from these observations on the chronic alcoholic to the person who is not so afflicted, but is driving under the influence of alcohol. Particularly in view of the effects of alcohol ingestion on subcortical neurohumoral regulating mechanisms, the effect of alcohol ingestion upon mood deserves considerably more emphasis as a causative factor in automobile accidents. It is well known to all that the effects of alcohol ingestion upon mood vary greatly from individual to individual. Many people, when even slightly intoxicated, manifest exhilaration and feelings of invulnerability. It is well within the realm of possibility that these feelings can be a release of underlying personality drives, brought about by alterations in brain-stem level of neurohumoral amines, as described above. It is indeed certain that feelings of invulnerability would be a dangerous alteration of judgment when driving an automobile in heavy traffic. It goes without saying, likewise, that the person who has a basic tendency to depression may have it magnified in a similar fashion. Inasmuch as this mood always has its suicidal overtones, it is apparent that this, too, would be a dangerous one with which to approach the hazards of the open road.

This particular approach to the study of the effect of alcohol on behavior is at the moment one of great importance. A number of publications concerning this area of investigation (e.g., *36*), some with contradictory results (*31*, p. 71), are currently in the literature.

The writer believes that the observations cited above support the position that it is not possible to ingest *any* amount of beverage alcohol without having at least some shade of effect on mood and judgment, if not upon neuromuscular function. It is suggested, at this point, that it is not unreasonable to take the position that driving an automobile after having ingested any amount of alcohol is tantamount to reckless driving. Driving with broken headlights, obstructions of windshield visibility, inadequate brakes, driving without due respect for traffic signals—these all constitute reckless driving in the eyes of the law. Would it not be reasonable to suggest that the laws concerning driving under the influence of alcohol should be subjected to careful scrutiny as regards the possibility of altering them in this direction? Driving under the influence of alcohol is now considered to be an offense, depending on the legal system, when physical examination or blood alcohol levels indicate that neuromuscular impairment or driving impairment is obvious. We have few, if any, valid or practical tests for alterations in judgment, but it is apparent from the foregoing discussion that these effects of alcohol may be more marked and may occur much earlier than those upon neuromuscular function. Would it not be reasonable, then, to change the statutes of the land to the effect that driving under the influence of any alcohol at all is at least as reckless as ignoring stop signs or driving at night without headlights? It is the writer's contention, not subject to proof at the present time, that the effects of small amounts of alcohol upon judgment probably represent a tremendously important cause of traffic accidents—more often than we realize. Such a change in our laws could very well have a beneficial effect upon this potential driving hazard.

Summary

In these pages, a presentation has been given of some of the literature pertaining to the effect of alcohol ingestion on some aspects of the function of an individual as the driver of a motor vehicle. In an attempt to determine a mechanism whereby alcohol might or might not have an effect on preexisting nervous system disorders, the metabolic data pertaining to the cellular physiology of alcohol were summarized. It was apparent that presently available data are far from adequate to explain the effects of alcohol on central nervous system function. Our own studies of the effects of alcohol on subcortical neurohumoral substances, i.e., serotonin and norepinephrine, were likewise reviewed. It is apparent that this particular area represents a possibly fruitful one for explaining some of the known effects of alcohol on brain function. It was possible to conclude that patients with preexisting brain damage would be very likely to manifest accentuation of whatever impairment of brain function was already present, if for no other reason than that of adding a profound alteration of a subcortical neurohumoral integrative system to already diffuse lesions. It was likewise possible to conclude from a brief review of the electrophysiologic effects of alcohol that the danger of drinking and driving may be heightened for the person with a preexisting convulsive disorder. The next aspect considered was the effect of chronic alcohol ingestion on the brain, per se. It was possible to conclude that the chronic alcoholic is a traffic hazard even if he is not under the influence of alcohol because of the manifest and well-described brain damage sustained by most patients with this disorder. Finally, a brief discussion of the impact of alcohol ingestion on mood and its ability to impair judgment was given. This concluded with a plea that thought be given to the possibility that driving an automobile after ingestion of *any* amount of alcohol represents at least reckless driving, if for no other reason than this deterioration of mood-judgment relationship that can amount, at times, to a lethal "third hand on the wheel."

Appendix

Some Details of the Pharmacologic Effects of Alcohol on the Central Nervous System

Alcohol and Preexisting Central Nervous System Disorders

The ingestion of alcohol and the attainment thereby of measurable concentrations of alcohol in the blood has both direct and indirect effects upon the central nervous system, producing the changes in function so well studied already. The fact that the concentration of alcohol in the brain rapidly approaches that in the plasma (*19*) clearly indicates that the likelihood of an intracellular focus for direct effects is great. As a prelude to a discussion of the central nervous system effects of alcohol in disease states, a brief consideration of what is known about effects in the normal would be helpful. This can be approached from the cellular physiological and the electrophysiological points of view.

Central nervous system cellular physiology of alcohol. The brain cell possesses the full set of enzymes and structures necessary for the oxidation of alcohol to carbon dioxide and water. This has been admirably summarized elsewhere (*28*) in detail. This fact in no way means that the brain necessarily will oxidize alcohol. The data of Bartlett and Barnet (*3*), showing no $C^{14}O_2$ production from C^{14}-labeled alcohol by slices of brain, strongly suggest that this is not the case. No $C^{14}O_2$ was produced by brain slices with this substrate, though diaphragm muscle, heart muscle, liver, and kidney gave positive results. Earlier studies by Dewan, however, did suggest that brain homogenates were able to metabolize alcohol to acetaldehyde and acetate (*17, 18*).

Other *in vitro* data suggest that, whether alcohol is metabolized by the brain or not, its presence in the medium does have an effect on the metabolism of that tissue. Fuhrman and Field (*20*) have shown that alcohol in increasing levels raises the oxygen consumption of brain tissues *in vitro*. Levels above 2 percent, however, inhibit oxygen uptake. The ability of alcohol to affect brain metabolism is further attested to by the observation of Himwich and his coworkers that the respiratory quotient of minced brain drops from a level close to 1.0 to one of 0.87 in the presence of alcohol (*29*).

Though the above data do not resolve the problem concerning the direct metabolism of alcohol by brain tissue, they do suggest that alcohol has a direct effect on the metabolic processes of that tissue. *In vivo* studies support this latter concept. Alcohol is not an adequate substrate for brain tissue and cannot replace glucose in this respect (*25, 34*). Though these contributions also fail to answer the question of whether alcohol is metabolized by the brain, other *in vivo* studies do confirm the *in vitro* suggestion that alcohol affects brain metabolism. Goldfarb and his coworkers (*24*) have shown that the cerebral arteriovenous O_2 differences are abnormally low in acute alcoholic coma. These observations have been confirmed and extended by Battey et al. (*4*), who showed that cerebral blood flow is increased in severe alcoholic intoxication, but that the uptake of oxygen by the brain is diminished in these circumstances.

In summary, then, the question of direct metabolism of alcohol by the brain remains unanswered. Both *in vitro* and *in vivo* data do show, however, that alcohol is capable of altering the oxygen uptake of the brain. It must be borne in mind, however, that the dosage levels in which these effects are seen are quite high. For example, *in vitro* decrease of O_2 uptake does not occur until the alcohol concentration passes 2 percent—a range incalculably beyond obtainable pharmacologic ranges. *In vivo,* the effects seen were at levels of severe intoxication and add little to our knowledge of effects of mild alcohol dosage on cerebral oxidative processes.

Alcohol is a substance that is rapidly metabolized by the total mammalian organism, and the results of this process may well be able to affect the chemical processes inside the brain cells. Thus, the indirect effects of alcohol metabolism on brain cellular physiology are worthy of scrutiny. Alcohol that has been ingested is distributed through total body water (see above). In small to moderate amounts, this alcohol is disposed of primarily by oxidation (*2*), as only negligible amounts can be accounted for by excretory pathways. In this oxidative process, the first step is dehydrogenation to acetaldehyde. This occurs chiefly in the liver, though the data of Clark et al. (*14*) suggest that the abdominal viscera may play some small role. The ingestion of alcohol is capable of elevating the blood level of acetaldehyde from its normal range, 0.02–0.04 mg percent, to as high as 0.4–0.5 mg percent. The next step, the conversion of acetaldehyde to acetate, is much more rapid than the first (*49*), and accounts for the comparatively low levels of acetaldehyde in the blood, even in the face of a high level of blood alcohol. This intermediate, however, must be considered a potential mediator in the induction of at least some of the consequences of alcohol intoxication. The vasodilatation that acetaldehyde produces by means of stimulation of sympathetic vasodilator receptors (*30*) may be an indication of broader effects on the central nervous system.

The next step in the process is the conversion of acetaldehyde to acetic acid. This is mediated by the enzyme aldehyde dehydrogenase which occurs chiefly in the liver, which organ is therefore the probable site for this step (*41*). The further steps in the conversion of acetate to carbon dioxide and water by way of acetyl Co A need no further elucidation here.

One result of this stepwise oxidation of alcohol to carbon dioxide and water that does deserve mention, however, is the accelerated production of organic acids, pyruvic, and, especially, lactic. Though the blood level of lactic acid is not altered significantly after ingestion of small amounts of alcohol, moderate or large amounts taken by mouth will result in significant elevation of the amount of this organic acid in the extracellular fluid (*29*). It is likely that this is the cause of the acidosis, hyperventilation, and diminished blood bicarbonate content frequently seen in alcohol intoxication. This acidosis, plus the complicating dehydration that may result from diuresis (*38*), represents conditions capable of altering central nervous system cell physiology by means of changes in the extracellular milieu.

These changes in blood levels of acetaldehyde, lactate, hydrogen ion, and bicarbonate are direct consequences of alcohol metabolism. They represent potential mechanisms whereby events outside the central nervous system are capable of altering its function by indirect means.

One final note to be included in a discussion of the effect of alcohol on central nervous system function concerns the possible role of humoral substances. Here one is referred to the animal studies of the alterations in brain-stem serotonin and norepinephrine content induced by alcohol administration. Serotonin is an amine first extracted from serum (*40*). Its structure, as shown in figure 1, was first clearly elucidated in 1949 by Rapport (*42*). This substance was found capable of causing contraction of smooth muscle and, indeed, the bio-assays for this substance in serum depend upon this faculty. In 1954, Amin, Crawford, and Gaddum (*1*) found that the brain contained relatively large quantities of serotonin. When they mapped the concentrations of serotonin in different parts of the brain, they were able to demonstrate that its distribution closely followed that of norepinephrine.

In 1938, lysergic acid diethylamide was synthesized by Stoll and Hofmann in Switzerland (*46*). This substance, whose structural formula is shown in figure 2, was found by Gaddum (*21*) to be an antagonist to the action of serotonin on the rat uterus. Subsequently, in 1943, Hofmann inadvertently inhaled a minute amount of d-lysergic acid diethylamide. He described the result as a peculiar state of "drunkenness" characterized by exaggerated imagination. He stated that, with his eyes closed, fantastic pictures of extraordinary plasticity and intense color seemed to surge toward him. This effect passed off after about 2 hours. In 1954, Woolley and Shaw (*51*) and, later, and quite independently, Gaddum (*22*) postulated the role of serotonin in mental processes. Important in the development of this concept was the observation that many substances that are capable of antagonizing serotonin, as regards the ability of the latter substance to cause the contraction of smooth muscle, are capable of causing psychiatric or mental aberrations in humans to whom they are administered. D-lysergic acid diethylamide is an example par excellence of such a substance.

Further data supporting the role of serotonin in central nervous system function have come from the reserpine studies of Shore and his coworkers, as recently summarized (*44*). This substance, a Rauwolfia alkaloid, is a well-known tranquilizer, and these workers, in studying its mode of action, observed that serotonin is present in the body in two forms. The largest quantity is present in a bound and inactive form, and there is a very small amount in a free and active form. Administration of reserpine resulted in release of serotonin from all of the depots in which it was bound. For example, the administration of 5 mg/kg of reserpine to a rabbit re-

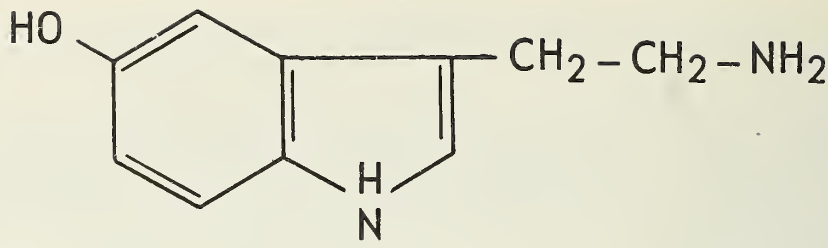
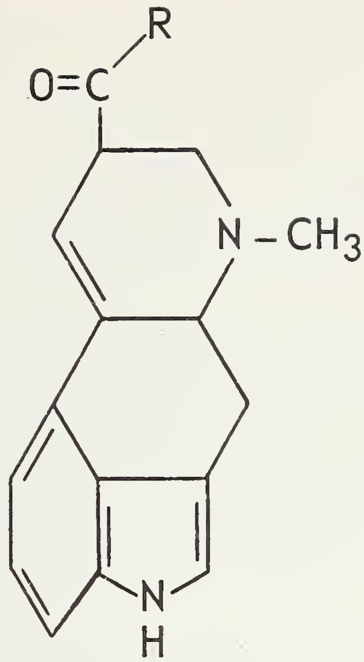


Figure 1. 5-Hydroxytryptamine (Serotonin).

sulted in the continuous release of serotonin from the small intestine and platelets for a period of about 16 hours. When the concentration of serotonin in these depots reached about 10 percent of the normal value, the release stopped, and the concentration remained at this low level for about 30 hours, after which time it gradually rose, reaching the original level in 5 to 7 days. Serotonin in the brain is especially sensitive to reserpine. A measurable decline in the amount of serotonin in the brain occurred within 10 minutes after administration of the alkaloid, and within 30 minutes it had declined by about 80 percent. The maximum decline, about 90 percent, had been reached within 4 hours. A return toward normal began after approximately 36 hours. Of special interest in this regard is the fact that the pharmacological effects of reserpine in the rabbit persisted long after the alkaloid itself could no longer be demonstrated in the brain. In actual fact, these pharmacologic effects are related in time to the change in concentration of brain serotonin and not to the concentration of brain reserpine. It is Shore's opinion that the free serotonin released by the irreversible blockage of the serotonin binding sites by reserpine is the actual tranquilizing agent. To support this contention, he cites other data indicating that the lowering of the total brain content of bound serotonin is of no effect, while the actual release of free serotonin is indeed a cause of sedation.

An interesting extrapolation of these observations is the work of Brodie and his coworkers (*8*), which indicates that free serotonin in the brain stem is capable of truly biphasic effects. Free serotonin is destroyed in the brain by the action of an enzyme known as monoamine oxidase, which converts it to the inactive 5-hydroxyindoleacetic acid which is excreted in the urine. Iproniazid is known to be capable of inhibiting this action. Accordingly, animals were pretreated with iproniazid alone and evinced no overt symptoms and, within the time limits of the experiments, little change in brain serotonin. When animals pretreated with iproniazid were given reserpine, again little change in the total brain-stem serotonin content occurred. This, of course, indicated that the released serotonin had not been metabolized. The pharmacological effects, however, were dramatic, and the reverse of the usual effects of reserpine. The rabbits were now considerably excited with many evidences of sympathetic stimulation. Udenfriend and his coworkers (*47*) have added further observations to support this latter point. When administered intraveneously, 5-hydroxytryptophan is capable of entering the central nervous system rapidly, where it is decarboxylated to serotonin. In experimental animals, it has been possible to raise the central nervous system content of serotonin as high as 10 to 20 times normal by administration of 5-hydroxytryptophan in this fashion. Because the binding sites are saturated, the level of free serotonin in the brain stem in these circumstances must, of course, be quite high. It is therefore not surprising that the animals in this state are also tremulous and excited, with marked sympathetic effects.

Though the role of serotonin in human emotional disorders remains to be clarified, it is clear from the above that this substance must certainly be of major importance in central nervous system function. It would, therefore, follow that any substance



(R = diethylamino)

Figure 2. Lysergic acid diethylamide.

capable of altering the central nervous system content of free serotonin would, more than likely, produce marked changes in brain function. Alcohol appears to be such a substance, as will be discussed further below.

Norepinephrine, the formula of which is shown in figure 3, is another substance of great potential importance as a central neurohormone. Vogt (*48*) has demonstrated that norepinephrine is present in high concentrations in the brain stem and in the highest concentration in the hypothalamus. Indeed, the distribution of this substance is reminiscent of that of serotonin. Brodie and his coworkers (*9, 10*) have reviewed the data pertinent to the concept of norepinephrine's role as a central nervous system transmitter. They make use of the conceptions of Hess (*27*) as a framework for the description of the role of norepinephrine as a central nervous system mediator. The latter worker postulated that reactions of the organism to environmental changes were effected by a subcortical system coordinating autonomic, somatic, and psychic functions. It was his proposition that this subcortical system consisted of separate and antagonistic divisions, the ergotropic and trophotropic. The former division was said to integrate sympathetic with somatomotor activities in such a fashion as to prepare the body for positive action. Thus, in a state of ergotropic predominance, one would see increased sympathetic nervous system activity, increased muscular tone, increased reactivity to sensory stimuli, and a psychic state characterized by alertness and ready responsiveness. The resemblance of this condition to the "fight or flight" preparedness of the "sympathetic state" postulated by earlier workers is obvious. The trophotropic division, in this theory, is held to be responsible for producing reaction patterns that are recuperative in nature. Thus, predominance of this divison would produce lower responsiveness to external stimuli, drowsiness, increased parasympathetic activity, and decreased muscle tone and activity. Brodie and his group have suggested that the ergotropic division (*10*) is an adrenergic system with norepinephrine serving as its neurohormone. He has listed a number of criteria for such a role that norepinephrine does indeed fulfill: (*a*) norepinephrine is localized in a bound, inactive form in those areas where autonomic integrations occur; (*b*) there is an enzyme, monoamine oxidase, which is present to prevent accumulation of the free amine; (*c*) enzymes are present for the synthesis of

688–396 O—63——10

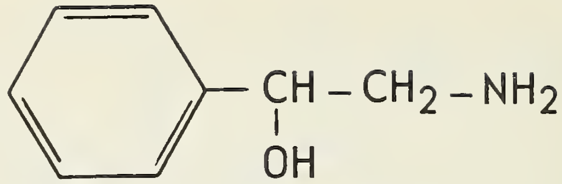


Figure 3. Norepinephrine.

norepinephrine in these sites (in support of this point, he lists the fact that two of the enzymes necessary for the metabolism of 3,4-dihydroxyphenylalanine, an amino acid precursor of norepinephrine, are present in a distribution pattern generally parallel to that of norepinephrine in the brain); (*d*) the compounds that inhibit the destruction of norepinephrine by blocking the enzyme monoamine oxidase exert clear-cut psychic stimulatory effects; and (*e*) compounds that appear to act as central adrenergic blocking agents produce effects almost exactly opposite to those of ergotropic predominance.

Norepinephrine itself is a highly polar compound and for this reason does not enter the central nervous system readily when administered intravenously. Dihydroxyphenylalanine, however, is able to enter the central nervous system. The administration of this material to animals causes a marked increase in its level in the brain, without particularly affecting the brain level of norepinephrine. If the animal is pretreated with iproniazid, a monoamine oxidase inhibitor, the level of dihydroxyphenylalanine in the brain after administration is raised and, in addition, the brain level of norepinephrine is likewise elevated. This increased accumulation of catecholamines in the brain and the observed marked increase in central excitation caused by dihydroxyphenylalanine after iproniazid led Carlsson (*12*) to postulate that the central excitation in this case is not produced by dihydroxyphenylalanine as much as by the amines formed from it, principally norepinephrine. Chlorpromazine, on the other hand, a known hypotensive and sedative drug, is capable of blocking the peripheral effects of epinephrine (*10*). It is capable of counteracting the pharmacologic effects of such substances as dihydroxyphenylalanine and amphetamine, which are thought to act through ergotropic stimulation. In support of this proposition, Brodie cites the work of Dasgupta and Werner (*16*), who demonstrated that chlorpromazine is capable of lowering blood pressure and antagonizing the carotid pressor reflex when given intracisternally in doses too small to alter the pressor effects of administered norepinephrine. The work of Spector and his group (*45*), in which sedation, relaxation of the nictitating membrane, miosis, and bradycardia were seen from the intraventricular injection of chlorpromazine in amounts too small to produce these effects if given intravenously, was further cited to support this position. These writings, and others too numerous to mention here, support the hypothesis that there is a subcortical integrating system in the central nervous system that is mediated by neurohormones. It is attractive to consider norepinephrine as the mediator of the ergotropic division and serotonin as the mediator of the trophotropic division. Thus, if this were the case, tranquilizers and energizers could be expected to exert their action by one of several mechanisms. A tranquilizer could be capable of acting as such if it were to (*a*) mimic the action of free serotonin; (*b*) cause the release of bound, inactive serotonin to the free and therefore active state; and (*c*) prevent the destruction of free serotonin by blocking the monoamine oxidase enzymes responsible. A tranquilizer could also act as such through effects on the ergotropic division in a manner analogous to that of chlorpromazine's postulated modus operandi; i.e., by blocking the effect of free norepinephrine. It would also be possible for a tranquilizer to act as such by preventing the release of bound and therefore inactive norepinephrine, thereby accelerating its rate of destruction. An "activator" could likewise exert its action in a fashion reciprocal to those listed above for tranquilizers. One could then conceive of drugs capable of affecting both systems so that the end result in terms of type of action would be determined by the overall balance of ergotropic versus trophotropic actions. It is only within this "balance of power" framework that the tranquilizing effects of reserpine can be understood. This substance has the effects on serotonin levels in the brain described above, and, in addition, causes the release of bound norepinephrine and renders the tissues incapable of taking up amines that are further produced (*11*). Brodie et al. (*10*) use this observation to explain the fact that reserpine, though producing similar effects on both serotonin and norepinephrine, is capable of acting as a tranquilizer. Since it is postulated that the level of the free amine is responsible for its central nervous system action, the rates of formation of the two amines would then be the determinant of the predominant action. Reserpine causes the release of bound serotonin and norepinephrine and then blocks further binding for several hours after reserpine has disappeared from the central nervous system altogether. The amount of free amines then present would be a steady state determined by the rates of formation and the rates of destruction. Brodie points out that the rate of formation of serotonin is much more rapid than that of norepinephrine, so that the resultant tranquilized state could be expected because the steady-state level of serotonin would therefore be higher than that of norepinephrine, by virtue of its more rapid rate of synthesis.

Attractive as this hypothesis appears, it is important to emphasize the warning of Brodie that the evidence by no means adds up to rigorous proof. Some inconsistencies in the literature emphasize this point (*31*, p. 71). The final word on the central nervous system role of both serotonin and norepinephrine has, of course, not been written. Nonetheless, it appears from the above-described observations that both of these substances have potent biologic activities, and that drugs capable of altering their levels in the central nervous system may be expected to have profound effects on mood and other moieties of central nervous system function.

References

1. Amin, A. H., Crawford, T. B. B., and Gaddum, J. H. The distribution of substance P and 5-hydroxytryptamine in the central nervous system of the dog. *J. Physiol.*, 1954, **126,** 596–618.
2. Atwater, W. O., and Benedict, F. G. An experimental inquiry regarding the nutritive value of alcohol. *Mem. nat. Acad. Sci.*, 1902, **8,** 231.
3. Bartlett, G. R., and Barnet, H. N. Some observations on alcohol metabolism with radioactive ethyl alcohol. *Quart. J. Stud. Alc.*, 1949, **10,** 381–397.
4. Battey, L. L., Heyman, Alberta, and Patterson, J. L., Jr. Effects of ethyl alcohol on cerebral blood flow and metabolism. *J. Amer. med. Ass.*, 1953, **152,** 6–10.
5. Bennett, A. E., Doi, L. T., and Mowery, G. L. The value of electroencephalography in alcoholism. *J. nerv. ment. Dis.*, 1956, **124,** 27–32.
6. Bennett, A. E., Mowery, G. L., and Fort, J. T. Brain damage from chronic alcoholism: the diagnosis of intermediate stage of alcoholic brain disease. *Amer. J. Psychiat.*, 1960, **116,** 705–711.
7. Bogdanski, D. F., Pletscher, A., Brodie, B. B., and Udenfriend, S. Identification and assay of serotonin in brain. *J. Pharmacol.*, 1956, **117,** 82–88.
8. Brodie, B. B., Pletscher, A., and Shore, P. A. Possible role of serotonin in brain function and in reserpine action. Paper read at meeting of the American Society for Pharmacology and Experimental Therapeutics, Iowa City, Iowa, Sept. 6–8, 1955. Abstracted in *J. Pharmacol.*, 1956, **116,** 9.

9. Brodie, B. B., and Shore, P. A. A concept for a role of serotonin and norepinephrine as chemical mediators in the brain. *Ann. N.Y. Acad. Sci.*, 1957, **66**, 631–642.
10. Brodie, B. B., Spector, S., and Shore, P.A. Interaction of drugs with norepinephrine in the brain. *Pharmacol. Rev.*, 1959, **11**, 548–564.
11. Brodie, B. B., Tomich, E. G., Kuntzman, R., and Shore, P. A. On the mechanism of action of reserpine: effect of reserpine on capacity of tissues to bind serotonin. *J. Pharmacol.*, 1957, **119**, 461–467.
12. Carlsson, A. The occurrence, distribution and physiological role of catecholamines in the nervous system. *Pharmacol. Rev.*, 1959, **11**, 490–493.
13. Carmichael, E. A., and Stern, Ruby O. Korsakoff's syndrome: its histopathology. *Brain*, 1931, **54**, 189–213.
14. Clark, B. B., Morrissey, R. W., Fazekas, J. F., and Welch, C. S. The role of insulin and the liver in alcohol metabolism. *Quart. J. Stud. Alc.*, 1941, **1**, 663–683.
15. Courville, C. B. *Pathology of the central nervous system.* (3d ed.) Mountain View, Calif.: Pacific Press, 1950. Pp. 326–327. Cited by H. A. Edmundson, E. M. Hall, and R. O. Myers, Pathology of alcoholism. In G. N. Thompson (Ed.), *Alcoholism.* Springfield, Ill.: Charles C Thomas, 1956. Pp. 233–290.
16. Dasgupta, S. R., and Werner, G. Inhibition of hypothalamic, medullary and reflex vasomotor responses by chlorpromazine. *Brit. J. Pharmacol.*, 1954, **9**, 389–391. Cited by B. B. Brodie and P. A. Shore, A concept for a role of serotonin and norepinephrine as chemical mediators in the brain. *Ann. N.Y. Acad. Sci.*, 1957, **66**, 631–642.
17. Dewan, J. G. An alcohol detoxication mechanism in the central nervous system. *Amer. J. Psychiat.*, 1943, **99**, 565–568.
18. Dewan, J. G. Chemical steps in the metabolism of alcohol by brain in vitro. *Quart. J. Stud. Alc.*, 1943, **4**, 357–361.
19. Eggleton, M. Grace. Determination of the metabolic rate of alcohol. *J. Physiol.*, 1940, **98**, 228–238.
20. Fuhrman, F. A., and Field, J., 2d. Inhibition of brain respiration by ethyl alcohol at varied temperature levels. *Proc. Soc. exp. Biol., N.Y.*, 1948, **69**, 331–332.
21. Gaddum, J. H. Antagonism between lysergic acid diethylamide and 5-hydroxytryptamine. Abstracted in Proceedings of The Physiological Society, Apr. 10–11, 1953. *J. Physiol.*, 1953, **121**, 15P.
22. Gaddum, J. H. Drugs antagonistic to 5-hydroxytryptamine. In *Ciba Foundation symposium on hypertension.* Boston: Little, Brown, 1954. Pp. 75–77.
23. Gibbs, F. A., Gibbs, E. L., and Lennox, W. G. Effect on the electroencephalogram of certain drugs which influence nervous activity. *Arch. intern. Med.*, 1937, **60**, 154–166.
24. Goldfarb, W., Bowman, K. M., and Wortis, J. The effect of alcohol on cerebral metabolism. *Amer. J. Psychiat.*, 1940, **97**, 384–387.
25. Goldfarb, W., and Wortis, J. The availability of ethyl alcohol for human brain oxidations. *Quart. J. Stud. Alc.*, 1940, **1**, 268–271.
26. Gursey, D., and Olson, R. E. Depression of serotonin and norepinephrine levels in brain stem of rabbit by ethanol. *Proc. Soc. exp. Biol., N.Y.*, 1960, **104**, 280–281.
27. Hess, W. R. *Diencephalon, autonomic and extrapyramidal functions.* New York: Grune & Stratton, 1954.
28. Himwich, H. E. Alcohol and brain physiology. In G. N. Thompson (Ed.), *Alcoholism.* Springfield, Ill.: Charles C Thomas, 1956. Pp. 291–408.

29. Himwich, H. E., Nahum, L. H., Rakieten, N., Fazekas, J. F., Du Bois, D., and Gildea, E. F. The metabolism of alcohol. *J. Amer. med. Ass.*. 1933, **100**, 651–654.
30. Jokivartio, E. Effect of iron preparations on "antabuse"-alcohol toxicosis. *Quart. J. Stud. Alc.*, 1950, **11**, 183–189.
31. Kalant, H. Some recent physiological and biochemical investigations on alcohol and alcoholism. A review. *Quart. J. Stud. Alc.*, 1962, **23**, 52–93.
32. Kaufman, I. C., Marshall, C., and Walker, A. E. Activated electroencephalography. *Arch. Neurol. Psychiat., Chicago*, 1947, **58**, 533–549.
33. Lemere, F. The nature and significance of brain damage from alcoholism. *Amer. J. Psychiat.*, 1956, **113**, 361–362.
34. Mann, F. C. The effects of complete and of partial removal of the liver. *Medicine, Baltimore*, 1927, **6**, 419–511.
35. Marinacci, A. A. Electroencephalography in alcoholism. In G. N. Thompson (Ed.), *Alcoholism.* Springfield, Ill.: Charles C Thomas, 1956. Pp. 484–536.
36. Naess, K. Alkohol frigjør serotonin og noradrenalin i hjernen. (Alcohol frees serotonin and noradrenalin in the brain.) *Nord. Med.*, 1960, **64**, 1616–1617.
37. Neubuerger, K. T. The changing neuropathologic picture of chronic alcoholism. *A.M.A. Arch. Path.*, 1957, **63**, 1–6.
38. Nicholson, W. M., and Taylor, H. M. The effect of alcohol on the water and electrolyte balance in man. *J. clin. Invest.*, 1938, **17**, 279–285.
39. Olson, R. E., Gursey, D., and Vester, J. W. Evidence for a defect in tryptophan metabolism in chronic alcoholism. *New Engl. J. Med.*, 1960, **263**, 1169–1174.
40. Page, I. H. Neurochemistry and serotonin: a chemical fugue. *Ann. N.Y. Acad. Sci.*, 1957, **66**, 592–601.
41. Pringsheim, J. Chemische Untersuchungen über das Wesen der Alkoholtoleranz. (Chemical investigations on the nature of alcohol tolerance.) *Biochem. Z.*, 1908, **12**, 143–192.
42. Rapport, M. M. Serum vasoconstrictor (serotonin). V. The presence of creatinine in the complex. A proposed structure of the vasoconstrictor principle. *J. biol. Chem.*, 1949, **180**, 961–969.
43. Selzer, M. L. Personality versus intoxication as critical factor in accidents caused by alcoholic drivers. *J. nerv. ment. Dis.*, 1961, **132**, 298–303.
44. Shore, P. A., Pletscher, A., Tomich, E. G., Carlsson, A., Kuntzman, R., and Brodie, B. B. Role of brain serotonin in reserpine action. *Ann. N.Y. Acad. Sci.*, 1957, **66**, 609–615.
45. Spector, S., Bogdanski, D. F., and Brodie, B. B. Evidence that chlorpromazine exerts a generalized central sympatholytic action. Paper read at 47th Annual Meeting of the American Society for Pharmacology and Experimental Therapeutics, Chicago, Ill., Apr. 15–19, 1957. Abstracted in *Fed. Proc.*, 1957, **16**, 337.
46. Stoll, A., and Hofmann, A. Partialsynthese des Ergobasins, eines natürlichen Mutterkornalkaloids sowie seines optischen Antipoden. 3. Mitteilung über Mutterkornalkaloide. (Partial synthesis of ergobasin, a natural ergot alkaloid, and its optical isomer. 3. Report on ergot alkaloids.) *Hoppe-Seyl. Z.*, 1938, **251**, 155–163.
47. Udenfriend, S., Bogdanski, D. F., and Weissbach, H. Increase in tissue serotonin by administration of its precursor, 5-hydroxytryptophan. Paper read at 46th Annual Meeting of the American Society for Pharmacology and Experimental Therapeutics, Atlantic City, N.J., Apr. 16–20, 1956. Abstracted in *Fed. Proc.*, 1956, **15**, 493.
48. Vogt, Marthe. Catecholamines in brain. *Pharmacol. Rev.*, 1959, **11**, 483–489.
49. Westerfeld, W. W., Stotz, E., and Berg, R. L. The coupled oxidation-reduction of alcohol and pyruvate in vivo. *J. biol. Chem.*, 1943, **149**, 237–243.

50. Wikler, A., Pescor, F. T., Fraser, H. F., and Isbell, H. Electroencephalographic changes associated with chronic alcoholic intoxication and the alcohol abstinence syndrome. *Amer. J. Psychiat.*, 1956, **113**, 106–114.
51. Woolley, D. W., and Shaw, E. A biochemical and pharmacological suggestion about certain mental disorders. Paper read at Annual Meeting of the National Academy of Sciences, Washington, D.C., Apr. 26–28, 1954. Abstracted in *Science*, 1954, **119**, 587–588.
52. World Health Organization expert committee on mental health, alcoholism subcommittee. Second report. *Tech. Rep. Wld Hlth Org.*, 1952, No. 48.

CHAPTER VI

Problems of Enforcement and Prosecution

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Introduction

Whenever alcohol and transportation meet, there is friction. In all cultures, even back to buried civilizations, the clash between intoxicants and modes of locomotion has been violent and pronounced. Even the Bible, in recounting the voyage of Noah during the Flood, gives evidence of the troublesome effects of alcohol. Noah's manifest of two of every living thing did not include the yeast germ, but the little fellow was aboard nonetheless. He stowed away in a pile of Noah's grapes, industriously produced a quantity of wine for his captain, and left a legacy of conflict between alcohol and operation of vehicles that has lasted to this day.

The troublesome effects of liquor aboard ship were not confined to the voyage of the ark alone. History is replete with examples of disasters, both on the high seas and inland waters, which were attributable to poor judgment of mariners under the influence of alcohol. These disasters were so common that it gradually became a practice on passenger-carrying vessels to deny the crew any alcoholic beverages at sea and to allow restricted rations only to certain officers. This early form of liquor control manifested itself in the requirement that "chits" be signed for the liquor rather than spot cash sale so vessel owners could check the drinking habits of their employees (*80*).

The situation was no better on land. Despite the "horse sense" of animals of burden and the difficulty of imposing the aggressiveness of an inebriated

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driver upon his milder mannered beast, there were mishaps involving animal-drawn vehicles. Rome had its share of chariot upsets, stagecoach and buggy lines were bedeviled by mishaps from time to time, and the violent-tongued "drunken mule-skinner" was a common character in tales of the 19th century (*75*). Stanley Atkinson, justice of the peace for London, publicly denounced drunken mothers who were causing accidents to horses and carriages by allowing their unattended children to run in the streets (*3*).

The difficulties of the past faded to nothing with the introduction of the mechanical transportation devices of the early 19th century. The brutal and bloody meeting of modern transportation and ethyl alcohol has continued to this day.

Soon after he invented the steam locomotive, George Stephenson became bitter over the sale of liquor in railway stations, and cited accident hazards caused by crews who drank and neglected their duties (*74*). The early American railroads, aware of the same problem, attempted to meet the situation by establishing operating rules prohibiting intoxicants among employees and contractors on the right-of-way.

On May 8, 1837, the river packet *Ben Sherrod* burned, destroying her crew and scores of passengers (*53*). Evidence showed that the boat met this disaster while engaged in a drunken race with the river boat *Prairie,* catching fire while attempting to overtake and pass its competitor. As a result, stringent regulations governing drinking by crews on both freight and passenger steamships followed.

The situation became of such public concern that by 1899 the famous Rule G, prohibiting drinking while on duty, was adopted by the American Railway Association (*1*). Three years later, railroad employee brotherhoods were adopting and enforcing their own rules restricting the use of alcohol among their members (*66*).

Then the Age of the Motorcar dawned.

Laws prohibiting the operation of motor vehicles while under the influence of alcohol evolved rather slowly. The lag was due in part to the slow development of the automobile as a means of mass transportation, also to the effects of national prohibition.

However, by 1924, the Connecticut Motor Vehicle Commission concluded that—

> . . . for the protection of all, any person who buys drinks and then operates a motor vehicle must be considered drunk. For all purposes of police enforcement a broad principle is laid down that no person who has been drinking ought to be allowed to operate a car. (*17*)

In an address before the British Society for the Study of Inebriety, Sir James Purves-Stewart, quoted in the *British Medical Journal* of January 17, 1928, stated the views of his society:

> At what stage of alcoholic intoxication is a man to be considered as drunk? According to a legal dictionary, no statutory definition of drunkenness exists, and a man may be held drunk in connection with one offense when he would not be held drunk

in connection with another. The degree of intoxication which would make an engine driver drunk if he were driving an express train would not legally make him drunk if he were walking along a country lane. (*68*)

In the United States, Henry Ford warned in 1929:

If the law [prohibition] were changed, we'd have to shut down our plants. Everything in the United States is keyed up to a new pace . . . . The speed at which we run our motor cars, operate our intricate machinery, and generally live would be impossible with liquor. (*24*)

These are but a few of the subjective opinions that were drawn from the experience of observing cause and effect between alcohol and accidents. There was no scientific validity to these observations. However, the fact that alcohol turned up so frequently in accidents of the day stimulated scientific curiosity.

Early research in the problem was conducted by Widmark in Sweden between 1914 and 1932 on the definition of alcoholic impairment of drivers (*82, 83, 84, 85*). This work proceeded in two directions: the examination of drivers by subjecting them to certain psychosensory and psychomotor tests to demonstrate physical impairment if present, and the simultaneous chemical testing of body materials to measure the alcohol level. Neither the use of the physical nor the chemical tests was new. The use of physical tests of motor reactions to diagnose central nervous disorders, such as locomotor ataxia, was well known long before the 20th century. The Romberg sign, commonly used to this day, was observed during the 19th century (*43, 81*). Other tests, many still in daily use, were developed during this period to show disturbances, both sensory and motor, to the central nervous system. These well-known methods were adapted to study the problem of alcohol impairment in greater depth, but were not originated for this express purpose. They were primarily neurological tools, in this case put to special use. It was for Widmark to bring them together with chemical tests for the singular purpose of definitely diagnosing alcoholic influence. The shortcoming of the use of neurological tests alone for this purpose was that they displayed a disturbance of the central nervous system, but could not definitely attribute the presence of the disturbance to alcohol (*85*).

The chemical test to measure levels of alcohol in the higher nerve centers of the body through analysis of body material was also known before 1900. Several competent methods for the quantitative measure of alcohol in biologic material, such as brain, blood, or urine, were devised during the last quarter of the 19th century. Again, it remained for Widmark to correlate these two methodologies for the purpose of creating the alcoholic influence syndrome (*85*).

Paralleling Widmark during 1914–1932 was the work of Dr. Herman Heise in the United States (*40, 41*). Heise attempted to correlate driver behavior with alcohol in urine samples. (Both Widmark and Heise originally used urine because of the ease of specimen collection; Heise to this day prefers urine for this reason.) Widmark, recognizing the shortcomings of the use of urine, preferred the use of blood, but was faced with the difficult problem of obtaining samples of sufficient quantity for the analytic methods then in use.

By 1922 Widmark had achieved a breakthrough on this problem by developing the well-known Widmark microdiffusion method (*84*), making possible the analysis of a few drops of fingertip or earlobe blood with a high degree of reliability and precision. The development of this small-quantity method was a step in the continual effort to simplify the specimen-collecting procedure. For this method a special capillary tube to collect blood samples from fingertip or earlobe punctures was developed.

During this same period, in the United States, Heise was examining drivers suspected of operating under the influence of alcohol for the Pennsylvania State Police. At first his examinations were based on physical tests and observations without chemical tests for alcohol. Bitter courtroom experience rapidly taught him the need for showing the cause for abnormal behavior. He turned to the work being conducted in Sweden by Widmark. Thus the Widmark philosophy was brought to the United States.

As a result of this chain of events, the pattern of the approach to the problem was quite firmly established, comprising a battery of psychophysical tests to demonstrate impairment, coupled with a chemical test to show the presence of alcohol as the cause. This form remains substantially the same today.

During the early stages of Heise's work, the problem of alcohol and road traffic was suppressed to minimal levels by the effects of national prohibition. In general, there was little interest in the type of activity in which Heise was engaged. However, with the impending repeal of the Volstead Act, interest began to awaken. In 1932, Carlson, Muehlberger, et al. completed their work on the effects of 3.2 percent beer (*14*). Their conclusions were that 3.2 percent beer (3.2 percent by weight or 4 percent by volume) was not an intoxicating beverage. Muehlberger has later stated

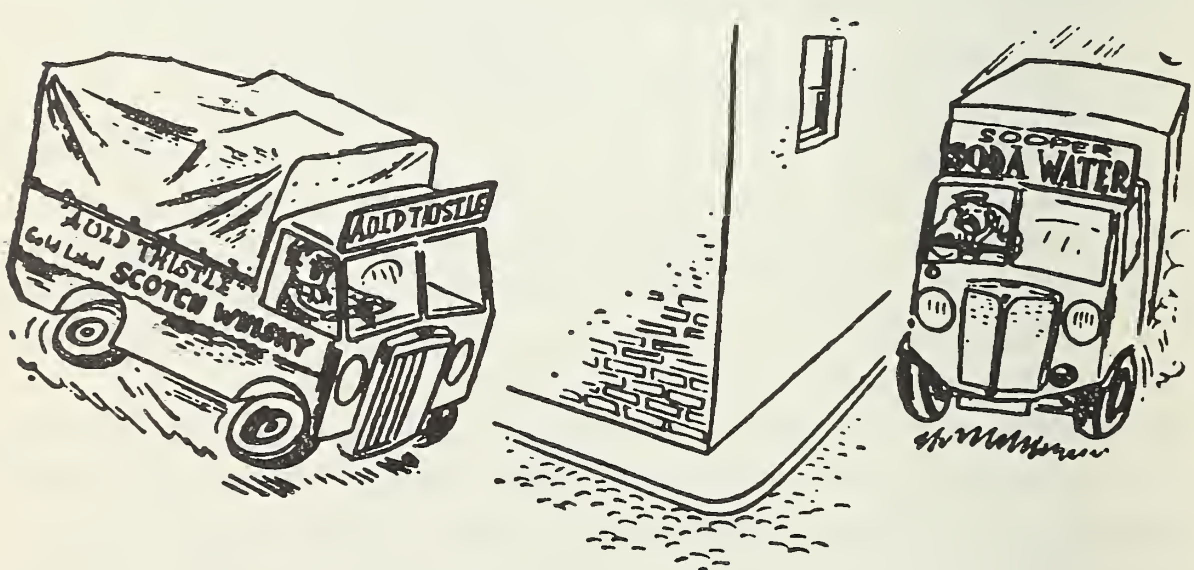

Figure 1

that the conclusions on this matter are those of Professor Carlson and not his (*59*). The study was published in 1934, the year of total national repeal, although the work had been performed some 2 years before. This study warrants description and comment because it was one of the earliest pieces of work employing a battery of psychophysical tests to show behavioral changes after the ingestion of alcohol, and also because it was one of the pioneer research efforts of this type in this country.

The repeal of prohibition stimulated a series of actions whose effects are still very much in evidence. Heise, through his regeneration of Widmark's work in this country, provided a method which was, by 1935, standardized to a point that it could be marketed as a "package laboratory" for practical use (*56*). This kit, still available today, was sold under the name of "The LaMotte Outfit for Determining the Concentration of Alcohol in Blood and Urine." The system reflected Heise's preference for urine as a sample material for the reasons mentioned, despite Widmark's earlier switching to blood.

During the early 1930's, another worker was investigating the possibility of the use of easily obtainable breath as a body material for alcoholic determination. Dr. R. N. Harger, at the Indiana University School of Medicine, developed the first practical breath-alcohol testing procedure (*35*). His method was based on the constant ratio between alveolar breath and blood which had been set out by Cushny (*19*) in England, and also on the attempts to develop breath analysis procedures by Bogen (*7*) in the United States and Liljestrand and Linde (*51*) in Sweden.

By 1938, Harger's method, another "package laboratory," was in routine police use under the name of the "Harger Drunkometer." The sampling and analytic procedures were so simple that it became practical to train police officers to administer this test competently. Thus a tool was placed in the hands of enforcement agencies enabling them to obtain rapid, reliable results for use during routine traffic investigation. The method, still in use under the same name, enjoys widespread popularity.

The stir of interest created by this complex of events:

1. Prohibition and repeal;
2. Carlson-Muehlberger's study of 3.2 percent beer (*14*);
3. Heise's research and commercially available device (*40*);
4. Harger's Drunkometer (*38*);
5. An awakening of interest in other scientific works (*7, 33*);

coupled with the National Safety Council's interest in promoting safety in a period of skyrocketing motor vehicle registrations, precipitated the formation of a special group within the National Safety Council called the National Safety Council Committee on Tests for Intoxication. It is still very active under the name of the Committee on Alcohol and Drugs. About the same time the American Medical Association recognized its responsibilities in this area and established a similar committee. These committees made their mark in a cooperative effort with the Northwestern University

Traffic Institute and Richard Holcomb in conducting the Evanston, Ill., survey of 1936 (*42*). This survey was one of the earliest studies of the significance of alcohol as a factor in traffic problems. It employed mass testing in the normal traffic flow to establish a control background showing both frequency and extent of alcoholic influence in the driving public. The frequency and extent of occurrence of alcohol in accident drivers were compared statistically with the control group's. A startling increase in accident involvement of drinking drivers was exposed.

One of the first projects of the National Safety Council's committee was the formulation and adoption of an investigative report form for the systematic recording of all factual information disclosed during the course of interrogation and examination of drivers suspected of being under the influence. This was the forerunner of the currently revised Alcoholic Influence Report Form (*62*).

Another project undertaken by the committee was the creating of standards interpreting the significance of blood alcohol levels. The committee recommendations were published in 1938. As a result of this activity, in 1939 the first "enabling legislation" was passed by the State of Indiana. The text of the original act as passed is:

> Evidence that there was, at that time, five hundredths [0.05] percent, or less, by weight of alcohol in his blood, is prima facie evidence that the defendant was not under the influence of intoxicating liquor sufficiently to lessen his driving ability within the meaning of the statutory definitions of the offenses. Evidence that there was, at the time, from five hundredths [0.05] percent to fifteen hundredths [0.15] percent by weight of alcohol in his blood is relevant evidence but is not to be given prima facie effect in indicating whether or not the defendant was under the influence of intoxicating liquor within the meaning of this act. Evidence that there was, at the time, fifteen hundredths [0.15] percent, or more, by weight of alcohol in his blood, is prima facie evidence that the defendant was under the influence of intoxicating liquor sufficiently to lessen his driving ability within the meaning of the statutory definitions of the offenses. (*44*, p. 309)

This type of legislation, in substantially the same form, was soon adopted as part of the Uniform Vehicle Code (*79*).

These advancements of the late 1930's were accompanied by a surge of scientific research and method development. More body-liquid methods and modifications appeared. More work was carried out on the correlation of clinical findings (i.e., psychoneurological tests coupled with chemical determinations for alcohol). In 1941 two additional breath methods were announced: the Alcometer (*29*), by Greenberg and Keator; and the Intoximeter (*45*), by Jetter, Moore, and Forrester. This latter apparatus was unique in that it provided a portable sample-collecting test packet that could be used at the scene of an accident or arrest. A preliminary test reading was available to assist the officers in making decisions as to alcohol involvement. The balance of the packet could be sent to a laboratory for further and more critical analysis.

Following World War II the increased traffic safety problems posed by the enormous increases in number, power, and speed of motor vehicles caused a demand for closer control of accident-causing factors. The activities of the Committee on Tests for Intoxication were spurred by recommendations of the President's Highway Safety Conference. The use of chemical tests mushroomed across the country. More and more States fell into line with the adoption of "enabling legislation."

A new development in 1953 was the adoption in New York of the so-called "implied consent" legislation. This act, now passed in many other jurisdictions, is based on the assumption that a motorist in applying for his driver's permit implies that he will submit to a chemical test when requested to do so by a police officer who has arrested him for operating a motor vehicle while under the influence of intoxicating beverages (*64*). Failure to comply can result in administrative revocation of his driving privilege.

Along with these increases in need, acceptance, and usage of remedial and preventive methods was a definite resurgence in controlled scientific research. This work followed three patterns:

1. Laboratory experiments employing psychological tests examining the psychomotor and psychosensory processes used in the operation of motor vehicles. This is in line with standard experimental procedure, since under laboratory conditions the various factors can be isolated and examined separately, thus making critical evaluation possible.
2. Actual driving experiments under controlled conditions comparing driving performance before and after alcohol. These tests are not as easily controlled as the laboratory experiments, but are capable of easier explanation to the public.
3. Surveys of frequency of occurrence of alcohol in accidents. In those areas where 100 percent reporting is available, the statistical results of such surveys become a measure of the frequency of involvement of alcohol in accidents.

In the first category, the physical tests include the classical neurological tests, such as the Romberg, which bear no direct relation to the exact skill of operating a motorcar; also included is simulated operation of vehicles, either by the manipulation of models or by employing full-scale driving simulators. These include the laboratory tests of Goldberg (*28*), and the more simulated tests of Loomis (*54*), using small-scale models, and Drew (*21*), using a full-scale simulator.

Goldberg's work involved a battery of six tests measuring the effects of various blood alcohol levels on groups of subjects classified as to their drinking habits. This study showed that while there is considerable variation between groups with varying drinking experience at low blood alcohol levels, this difference tends to disappear as blood alcohol levels reach 0.10 percent.

The choice of tests that may be used in such experimental work is quite critical. Eggleton found that alcohol does not deteriorate highly learned skills such as operating a motor vehicle as rapidly as it does some newly learned operative skills (*22*).

Examples of actual driving tests indicated as category 2 were conducted by Bjerver and Goldberg in Sweden (*5*), and by the Royal Canadian Mounted Police in Canada (*16*). These tests involved the operation of a motor vehicle under controlled conditions, making possible the observation of changes in driver behavior before and after alcohol. These experiments were conducted on controlled driving courses, not in normal traffic patterns.

Probably the most graphic of all research is the survey. This comprises a study of the real-life situation. It involves going into the actual traffic pattern and the results of accident investigation to determine the frequency of involvement of alcohol-impaired drivers.

There have been noteworthy attempts to provide control groups of systematically sampled motorists passing by. By this technique, a comparison is possible between the accident group and a like-situated control group, testing whether or not in accident cases there is a correlation with alcohol occurrence. This type of survey was carried out in Evanston and Toronto (*42,72*).

An outstanding example of the survey technique investigating alcohol as an accident cause was the effort of Haddon and Bradess in Westchester County, N.Y. (*32*). This survey was restricted to single-car fatal accidents, tending to fix responsibility for the accidents on drivers who were presumably victims of their own misjudgment.

The reasons underlying this post-World War II explosion of research activity are several. This activity provided objective evidence to help gain support in the fight against this basic accident cause. Since drinking of alcoholic beverages does not generally carry a serious social stigma, an unspoken "drinking partnership" was recognized to exist between a large segment of the public and the drinking-driver defendant. This affinity often results in less-than-energetic prosecution of this conduct that is dangerous from the traffic safety standpoint. Thus, one of the basic reasons for the extensive research efforts has been to attempt to dramatize the enormity of the problem and the seriousness of its effects on a complex and fast-moving society.

The press and other mass media constitute an important weapon that, if used effectively, can do much to help contain this problem. Positive thinking in both text and headlines can exert enormous influence. Rune Andreasson, M.D., Motorforarnas Helnykterhetsforbund, Vasagatan 9, Stockholm, Sweden, has stated that the effectiveness of Swedish control of the drinking driver is due in great part to an exceedingly cooperative press. Many American newspapers and newsmen exhibit this same type of cooperation.

Despite the intended fairness and impartiality of the press, in many cases the line between factual reporting and muffled editorializing has been

Figure 2

stretched quite thin. Some reporters have seized the opportunity to exaggerate, often sarcastically, a negative viewpoint. At the same time, opportunities to mention the positive aspects of chemical test programs are neglected or ignored. In cases where this difficulty has arisen, it has taken the form of a feature story, with unsupported opinion being accorded the prominence and stature of a straight news story.

Those journalists who use ridicule as a weapon have selected the chemical test as one of their targets. It would appear that these few writers enjoy the opportunity to indulge in what they conceive as a public "game," and their treatment of events concerning this problem reflects this "sporty" attitude. A particularly sore spot has been created by the injudicious use of flippant, misleading, and otherwise distorted headlines and captions. The

Figure 3

effect has been to create distrust, resulting from misunderstanding between chemical test groups and the usually cooperative press. The negative incidents that are permitted to take place still draw a disproportionate amount of attention to the fallacious material they present.

Except for isolated cases of personal malice or vindictiveness, the bulk of the ill-informed stories are written with a misunderstanding of the purpose of law-enforcement efforts to control the drinking driver. The press often fails to recognize this destructive effect and thereby shirks its responsibility to assist in the enlightenment of the public that would tend to promote understanding and appreciation of the programs.

In order to study the effectiveness of public media in educating and impressing audiences with the problem of the drinking driver, an opinion poll was conducted throughout the State of Indiana. This State has had an active program of chemical testing since 1937, and was the State of origin of the "enabling" legislation. A series of questions was asked and responses were returned through a portable anonymous immediate-response testing device, the Mentometer. The individuals in the group indicated their opinions by quietly depressing switches held secretly in their hands; the individual alone knew when he depressed the switch (*9*). By this method, complete anonymity was preserved. At the same time, an immediate response was recorded on a master-meter that reflected the answers in terms of percentage of the responding group.

The results showed that only 30 percent of the people surveyed believed in the reliability of chemical tests for intoxication. Only 60 percent stated they would take such a test voluntarily if they had had a bottle or two of beer. Practically none of the survey group agreed with the State law that required a mandatory 1-year license suspension upon conviction of operating under the influence. A very large majority of the group felt that suspension for 30 to 60 days was in order, but they were adamant in repudiating the law in effect. Of those who did not profess to be teetotalers, about 70 percent claimed that after drinking four or five cocktails the only reason they would not drive was the fear of apprehension.

Public attitudes indicated by depth studies such as this contribute to lax law enforcement and judicial indifference. One solution may be the cutting of the bond between the "respectable" moderate drinker and persons who defy the community's best interests by driving while under the influence of alcohol. Little planned action has been taken in this specific area, with the consequence that the situation has, if anything, deteriorated since World War II. Even the National Safety Council has not moved deliberately to divide this partnership attitude. The slogan "If you drive, don't drink; if you drink, don't drive" has not solved the problem, perhaps because it appeals particularly to the teetotaler or already informed person who hardly needs reminding.

The fact that the problem remains in spite of the efforts of professional and law enforcement groups indicates that a new and carefully calculated program must be evolved. The enforcement action alone can hardly cope with the situation as a control device. Sheehe reports that the number of arrests, not specifically driving under the influence, as compared with the number of violations is less than one-tenth of 1 percent (*70*). The mustering of all forces—first, to cause the immoderate drinking-driver group to become a well-defined "outgroup" against which social pressure can be effectively exerted; second, the arming of law enforcement agencies with adequate tools to insure vigorous and effective prosecution of violators; and, third, the gaining of the support of all civic-minded citizens—is indispensable.

By far, all energy has not been misdirected. There are many courts throughout the country striking at the heart of the problem. Some have gone so far as to retain special consultants. An example of this is the Clinic of the Recorder's Court of Detroit (*57*), a system that gives the court

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the advantage of trained, professional advice. The effectiveness of such judicial approaches can be greatly enhanced by positive journalists.

Other aspects of the problem have advanced rapidly. During this period chemical tests by body liquids have multiplied. Additional breath methods have appeared. In 1953 Kitagawa and Kobayashi of Tokyo announced a screening test, the Drunkotester (*46*). It is semiquantitative and not designed to produce evidence-quality results. In 1962 a prototype of a newer development of this instrument appeared, aimed at quantitative results. It will be tested for consistency and validity in 1963. A device comparable to the original Drunkotester was developed in Germany in 1954 by Grosskopf (*31*). Named the Alcotester, it is also semiquantitative and subject to the same limitations as the Drunkotester.

The Breathalyzer, a quantitative photoelectric instrument, was first shown in 1954. This method, developed by Borkenstein, uses a potassium dichromate-sulfuric acid reagent under carefully controlled conditions (*47*). Harger modified his Drunkometer in 1956 to use rebreathed air, a simplification of his original method (*37*). In 1958 Forrester introduced the Photoelectric Intoximeter (*25*). This instrument is another photoelectric device using two breath samples taken simultaneously, one for immediate answer, the other for later confirmation. In this respect it parallels the 1941 Intoximeter, with the addition of the photoelectric device. With increased emphasis on the problem, more methods are bound to appear.

Legal Problems

The criminal law in Anglo-American jurisprudence concerns itself with the proscription of socially dangerous conduct. To qualify as a crime, an act must be well recognized as socially dangerous and a clear menace to the community. No one today seriously questions including rape and murder in the criminal code. But there are many who will argue over traffic regulations, feeling that such rules are social welfare regulations and not crimes in the classical sense since they lack the element of criminal intent. Therefore, they argue, some other reason for considering them criminal offenses must be found. To satisfy this argument the justification is proposed that the complexities of modern society require all persons to relinquish a little of their freedom, on the highway for example, and concede the overall supervision of transportation to the government. Thus, the loss of a little freedom is the price paid for gregarious living (*69*). However, this conscripted freedom is not entirely lost, but is relabeled a revocable privilege, making possible placing conditions on its continued use.

This theory of social welfare legislation, while a comparatively new device, now affects every citizen in many ways. The "privilege" theory has been justified and upheld in practically every court in which the question has arisen. Yet, in the justification of this regulation by privilege, certain forms of expedient conduct have developed. These expediencies are due to the lag between legislated regulations and popular acceptance and understanding of the needs for such regulation. The motor age did not grow gently on the American scene; it burst as a torrential downpour. The rapidity with which its problems swept the country did not leave the average person time to adapt himself to the needs and concepts of a new notion of speed—the speed of a horse is still well within the memory of many citizens as the measure of the pace of life.

This is by no means peculiar to the problem of the drinking driver. Transportation as a social device is required to move men and material as rapidly as possible in reasonable safety. The burst of regulatory legislation made necessary by the sudden increase in rapidity of transportation to promote reasonable safety commensurate with drastically increased speed was many years in advance of public understanding and acceptance. People who abhor murder and burglary often do not see the overriding need for speed regulation. They recognize the dangers inherent in passing on blind hills and curves. But they do not understand the underlying reasoning for speed regulation on a straight road. Thus, people who would never pass improperly, for example, will drive grossly in excess of posted speed limits on roads which do not present to them immediately recognizable hazards justifying the lower limits. Their wrath when arrested is well known to every traffic officer. Such nonacceptance of regulation through ignorance of the latent hazard is living proof of the schism between legislated regulation and public acceptance and support of those regulations.

The lack of acceptance of driving while under the influence of alcohol as an accident cause is another example of this principle. Ordinarily reasonable drivers who would never knowingly pass on a hillcrest will defend and justify their ability to drink and drive. They have not accepted the dangers of the drinking driver. Such nonrecognition is the root of the troubles with legal provisions. The protections of the legal system are hard to apply to a group that does not understand and consequently does not want those protections. Jurisprudence in the Anglo-American concept implies self-policing by the community. This is accomplished under criminal law by endowing the final decision as to guilt or innocence, in spite of the written law, in a jury of the defendant's peers. Thus, a lag between advanced legislation and public acceptance results in ineffective prosecution, and this can easily call for expedient remedy. An example is the adoption in several States of the so-called "implied consent" legislation (*64*). The demands of informed groups that something be done to curb the drinking driver have been far ahead of popular public demand for the same controls. In an attempt to close the gap between carnage on the road and the slowness of public recognition and acceptance of self-control, legislation is passed which "does what the people would want done had they thought of it." The basic difficulty is that the protagonists of the legislation did think of it first. Consequently, passage of such legislation calls forceful attention to the gap between need and understanding.

Legislation adopted in the face of public disinterest becomes highly unpopular when members of the public are brought face to face with it. They have not bothered to give the problem much thought, neither did they pay any particular attention to the hearings preceding legislative enactment. Most legislation is passed because of the interest of special groups, organized to have a single loud voice, speaking through lobbies and through spokesmen appearing eagerly and voluntarily before legislative study committees. When the average citizen encounters the law in the role of a violator, this conflict of law and personal concern results in a situation that is highly charged emotionally, rendering clear reasoning improbable.

The "implied consent" laws, the "privilege" theory, the "point system" legislation are attempts to close the gap by removing potentially unpopular legislation from direct public control through subjective courts and juries and putting the matter in the hands of informed, objective, professional administrative officers.

An example of the results of nonobjective courts and juries dealing too softly with drinking drivers is found in police attitudes. Many police agencies, recognizing the dangers of the drinking driver and anxious to fulfill their obligations to protect life and property, often resort to methods of their own. Their approach, based on frustration caused by what they see as a basic flaw in our sociopolitical organization, takes the form of harassment of arrestees in as many ways as can be done without exposure to civil suit.

Many police departments, embittered by years of experience of losing obvious cases in the courtroom, finally lose perspective of their true role in society and become, in addition to investigators, a "preliminary court." They go out of their way to insure that all persons arrested for driving under the influence are booked, fingerprinted, photographed, a criminal file ostentatiously opened, and the violator transported to jail. Once in jail they may try, by devious methods, to make his stay there as unpleasant as possible by keeping him in a "bullpen" with common drunks and attempting to keep him incarcerated as long as possible.

Taken independently, each of these police actions is not necessarily harassing; on the contrary, it is routine police procedure. Collectively, these acts are often performed by the police because of repeated failure in the courtroom. They are inspired to this action because of their having witnessed the infliction of death, destruction, and misery by the drinking driver. After going to considerable personal risk to apprehend him, only to see him turned loose to repeat his act with apparent impunity, it is humanly understandable why the police officer adopts this attitude.

There is no question but that it is detrimental to society to force police agencies into such a position. To permit police departments to engage in extrajudicial harshness strikes at the very cornerstone of freedom. Most people are unaware of the intensity of feeling in their police agencies on this problem or that this type of action is taking place—or the reasons why. Such administration of "justice" is not justice under the law but rather vigilante action.

The use of such measures is not confined to police agencies alone. In various levels of the judicial system, expedients, artifacts, and rationalizations are used to bridge the gap between the law that is not understood and public reactions.

Even at the appellate level the courts are quick to justify conclusions. A prime example is the case of *Breihaupt* v. *Abram,* in which the question of taking blood samples from an unconscious defendant without consent was considered. The Supreme Court of the United States, in upholding the conviction, held the intrusion of the body to be within due process when weighed against the disasters of the highway:

> Basically the distinction rests on the fact that there is nothing "brutal" or "offensive" in the taking of a sample of blood when done, as in this case, under the protective eye of a physician. To be sure, the driver here was unconscious when the blood was taken, but *the absence of conscious consent, without more, does not necessarily render the taking a violation of a constitutional right;* and certainly the test as administered here would not be considered offensive by even the most delicate. (*11,* pp. 435, 436)

The Court went on to recite the everyday uses of blood samples taken for assorted reasons and concluded that—

> . . . a blood test taken by a skilled technician is not such "conduct that shocks the conscience" . . . nor such a method of obtaining evidence that it offends a "sense of justice" . . . . (*11,* p. 437)

They went on, to justify the affirmation of conviction:

> Modern community living requires modern scientific methods of crime detection lest the public go unprotected. *The increasing slaughter on our highways, most of which should be avoidable, now reaches the astounding figures only heard of on the battlefield. . . .*
>
> *As against the right of an individual that his person be held inviolable,* even against so slight an intrusion as is involved in applying a blood test of the kind to which millions of Americans submit as a matter of course nearly every day, *must be set the interest of society in the scientific determination of intoxication,* one of the great causes of the mortal hazards of the road. And the more so since the test likewise may establish innocence, thus affording protection against the treachery of judgment based on one or more of the senses. *Furthermore, since our criminal law is to no small extent justified by the assumption of deterrence, the individual's right to immunity from such invasion of the body as is involved in a properly safeguarded blood test is far outweighed by the value of its deterrent effect due to public realization that the issue of driving while under the influence of alcohol can often by this method be taken out of the confusion of conflicting contentions.* (*11,* pp. 439, 440) [Italics supplied.]

This action of the Supreme Court, admittedly applied in a case loaded with emotional impact (three persons died in the collision from which this case grew), is an example of a sharp turn in judicial interpretation reflecting the changing needs of a society becoming more and more complex with new demands on rapidity in transportation. Physical intrusion of the body by a syringe is rendered no less an intrusion by the presence of a physician. As against this admitted intrusion is thrown the specter of highway death and disaster. The Court assumed that public interest outweighs the right of inviolability of the body. The actions of the high courts often collide with social mores. Laws are the codified rules of society. When a sharp turn is taken in the interpretation of these laws, especially a turn that alters traditional patterns, rebellion by the public and the bar are almost certain to result. During this transitional period the public is reluctant to accept loss of a traditional freedom. Courts are often unwilling to embrace the high-court rulings, interpreting the law according to their own philosophies. Defense counsels make full use of these points of friction between the older traditional interpretations and the new. The crack produced by these factors is pried open by the use of apparently logical attacks.

Careful review of cases on drinking-driving indicates a definite pattern of "waves of popularity" of various expedient arguments by defense attorneys. There has been a steady procession of arguments that attack the scientific validity of methods, per se. After a flurry of such attacks all around the country in rapid succession, the attack dies down, only to be replaced by a sudden rise in attacks on the basis of constitutional issues as unreasonable search and self-incrimination. After these attacks have subsided, a new wave or argument appears, based on ineptitude or error on the part of the administering technician. Following this pattern a group of cases will, practically simultaneously, focus on potential errors in individual tests. A recent wave swept the country in which the pattern appeared to be attacking the reagent solutions which were used in the chemical tests. From time to time arguments are made that despite all else, a particular defendant has such tolerance to alcohol that, regardless of the test, he, of all persons, is not impaired by drinking a specific quantity of alcoholic beverage.

Such attacks and lines of defense raise two points: The first is that they are obvious distractions to the main question before the jury. This is in line with the classical defense theory of raising sufficient questions to provide a reasonable doubt. Confusion, even if purposely induced, can raise such a doubt, especially during the period between high-court decision and ultimate public acceptance. The second is based on capitalizing on the general suspicion and misunderstanding surrounding chemical tests and the effects of alcohol on driving ability. From a defense standpoint, the less known about such matters, the easier to confuse and thereby gain acquittals.

Material of value to a defense theory, be it authentic, questionable, or downright perjurious, is rapidly assimilated into defense arguments across the country with almost brushfire rapidity. The information is transmitted through law journals, newspaper reports, and word of mouth. Enterprising attorneys are often ardent readers of scientific journals.

As a result, nationally speaking, control of the drinking driver has not been accomplished. Drinking drivers still show up regularly in serious accidents. Ineffective prosecution conjures up the image of impunity for the drinking driver. Harsher legislation is advocated as a panacea. Then convictions are more difficult to obtain.

The public at large appears unaware of its responsibilities. It is submitted that this shirking of responsibility is actually the root of the trouble in the administration of traffic safety regulations today. A complex legal code is difficult enough to administer; it is courting disaster when that system must mushroom with additional legislation and more complexities.

It is further submitted that the public suffers from what can be termed a form of mass schizophrenia, capable of verbalizing its awareness of the dangers of the immoderate drinking-driver group as a whole, but at the same time, when faced with passing on the fate of an individual drinking driver, they as members of juries are quite capable of rationalizing their way into freeing the defendant. This is particularly true in nonaccident arrests and after accidents in which no one was injured or there was at worst slight property damage. This phenomenon of solidarity against the outgroup crumbling when individuals enter the jury box is well known to officials of the legal system. There are jurisdictions in which no successful prosecution for "operating under the influence" has resulted before a jury during periods up to years unless there were some outside factors entering the case that rendered it particularly aggravating to the public conscience.

This disregard of civic responsibility by the public and jury toward the individual is the key to the entire difficulty of the legal system's coping with the problem. The apparent schizophrenia takes many forms. People want violations of traffic laws to be counted as criminal offenses except when they themselves become involved. Then they are quite capable of rationalizing their conduct to remove the stigma from their minds. This attitude toward traffic law enforcement is generalized to include the drinking driver.

Enforcement action is taken for granted by the public, which expects that coercive enforcement techniques will be carried out against community "undesirables" with whom the average citizen does not associate himself. This failure to identify personally with the problem is the root of all troubles with public acceptance of law enforcement, not traffic matters alone. It becomes particularly troublesome in traffic regulation because of the great number of people constituting the driving public. There is no such thing as the average man who thinks he is a poor driver. Vehicle operation is so common that people consider it a basic living skill comparable with walking. The longer they go accident free, the more confident they become of their ability. As a consequence, when they finally are brought to task by the police, they are doubly infuriated, partly because of the shock of arrest and partly because of the implication of ineptitude in so basic a skill.

This attitude is exploited by defense counsel in "operating under the influence" trials. A common defense tactic is to ignore the drinking element and to stress the point that the defendant is a "good, careful driver who has never had an accident." An appeal of this sort touches the heart of the average man who feels the same way about his own personal skill, reinforcing the affinitive feeling toward the defendant and making it very easy for a juror to rationalize an acquittal. It is the end result of the "there but for the grace of God go I" attitude.

In the process of aligning with the drinking-driver defendant, the average person takes special pains to rationalize his own drinking habits. He consciously or subconsciously construes a trial of drinking-driving as an assault on his own personal drinking habits. The only real departure from this attitude is the ardent prohibitionist or the person who has had a bitter personal loss at the hands of a drinking driver.

The whole answer to the legal problems of handling drinking-driving is not in legislation. Much new legislation is designed to "solve the problem in spite of the people" and as a result calls for more strenuous penalties. Faced with the alternative of submitting a fellow man to a stringent penalty (which they vicariously feel to be inflicted upon themselves) or rationalizing the position that no real harm was done and therefore the offender can go away scared (i.e., educated), juries will choose acquittal and salve their consciences.

It is only by informing the public of the intemperate quantities of alcoholic beverages that must be consumed to reach a level at which drinking drivers are regularly prosecuted that the average moderate drinker can dissociate himself from the defendant in the trial. The split thinking in which the public indulges itself must be replaced by a community awareness of the seriousness of the problem and the definite personal threat it poses to each and every person. Every individual, including the police officer, the prosecutor, and the judge, must assume that he himself is a "moderate, tolerant, understanding, intelligent" drinker who separates his drinking from driving, and that the defendant is none of these. Once he can dissociate, he can view objectively and dispassionately. Once he can adopt this objective attitude toward an "outgroup" member, it is easy for him to attend to his responsibilities in the courtroom.

Police agencies are paid to enforce often unpopular laws. They take understandable pride in their position as defenders of the community's interest, even at times when the community shows no interest in protecting itself. But there is a limit to their authority and responsibility. It is the chief of police who officially sets the enforcement pattern for a community. However, in practice, it is the composite of the court system, consisting of the judges, prosecutors, and juries, that unofficially influences the execution of this pattern by individual police officers. If disinterest is apparent to the officers in the form of a steady string of acquittals, either from the bench or the jury box, it will not be long until the police agencies do one of two things. They will either adopt the same standards that the community at large has adopted and ignore the problem, or they will take measures that have the same spirit as condoned semiofficial lynchings. Neither is satisfactory. The total picture then becomes one of weakness in enforcement because of indifference of the legal system charged with handling the problem for the community's best interest. It rapidly becomes a vicious circle from which there is no escape short of total reeducation or the imposition of a system of administrative justice that does not rely on public popularity. There are many facets of social regulation in which the law, as expounded by the legislators, is actually better for the public good than the public thinks it is. It is an unfortunate situation when the community does not recognize this. The answer is to educate the community up to the level of the intent of the law.

Popular law is the bedrock of democracy. In a democratically oriented nation such as ours it is virtually impossible to enforce an unpopular law; e.g., the Volstead Act. This does not imply that unpopularity means perpetual hostility toward a law. The eventual change of attitude toward the abolition of slavery in the United States is a good example. When appealed to by proper means, the "collective common sense" of the people will prevail. An unpopular law paired with negative reinforcement in the form of rigid police action can result in a high degree of resentment. However, time, patience, and positive action will change public attitudes from hostility to acceptance. A massive education effort may be required, involving the use of every medium of expression available.

Enforcement Problems

Explosive rapidity in the increase of number of motor vehicles on our streets and highways, coupled with the speed and complexity of modern society, has compelled rigid control of use of the highways to insure survival. This regulation expresses itself in traffic laws, codes, and ordinances requiring enforcement to make them effective as social control devices. The existence of enforcement agencies is therefore mandated, be it sheriff, police, marshal, or State highway patrol. Whatever its title, the function of an enforcement agency in enforcing traffic regulations is tripartite: (1) prevention, (2) investigation, and (3) prosecution.

Illustrating the necessity for some form of traffic regulation, in Kansas City shortly after the turn of the century, there were only two automobiles. They were involved in a head-on collision on the main street of the city (*58*). One can imagine the chaos an accident rate of similar proportions would create in this day of over 70 million registrations.

Most traffic violations are the result of an overt action of some sort, easily describable. Consider the typical moving violation; there is little room for argument in the average case of failure to heed a stop signal, improper passing, or improper or inadequate equipment.

This ease of detection and recognition of the offense is often lacking in "operating under the influence" cases. There exists room for argument and doubt on practically every element of a drinking-driving case, even on basic definitions of the offense.

Authorities in the field generally agree that the best definition of the meaning of the key words in typical statutes prescribing the offense was laid down by the Supreme Court of Arizona:

> The expression "under the influence of intoxicating liquor" covers not only all the well-known and easily recognized conditions and degrees of intoxication, but any abnormal mental or physical condition which is the result of indulging in any degree in intoxicating liquors, and which tends to deprive him [the driver] of that clearness of intellect and control of himself which he would otherwise possess. If the ability of the driver of an automobile has been lessened in the slightest degree by the use of intoxicating liquors, then the driver is deemed to be under the influence of intoxicating liquor. The mere fact that a driver [of an automobile] has taken a drink does not place him under the ban of the statute unless such drink has some influence upon him, lessening in some degree his ability to handle said automobile. (*73,* p. 618)

The language of this case does not equate "under the influence" with "common drunkenness." The semantics and parlance used across the country to describe this offense give rise to many difficulties of understanding. A large part of the blame rests squarely on enforcement officers who habitually refer to this offense as "DD" or "drunken driving." The origin may have been in the police penchant to abbreviate or encode common phrases in police work. Despite its origin, this improper symbolism has crept into the common public parlance. It has invaded the newspapers, always quick to adopt "catch phrases" or breezy expressions. The result is that the mind of the public equates "under the influence" or comparable statutory language with "public intoxication," "common drunk," or just plain "drunk." In such a situation, attention is focused on the grossness of the impairment for its own sake and not on its relation to the operation of a motor vehicle.

This discussion is not intended to be a play on words. It has serious meaning for the enforcement effort. By continuous association of the offense itself with the common conception of drunkenness, the public often misses the basic element of the offense. They envision "drunken driving" as a gross, easily discernible offense in which the operator is reeking, ill-mannered, and generally incapable of doing anything with accuracy. Juries, very often imbued with this concept of gross impairment by association with gross words, hesitate to convict in the absence of evidence of exaggerated drunken behavior.

The confusion surrounding definition of the offense reflects itself in the investigative phase of enforcement. Operating a motor vehicle under the influence of alcohol is an offense. Proof of the offense requires investigation. The elementary problem in the investigation of operating under the influence cases is recognition of the offense. Is it a car lurching down the road, weaving, jerking, erratic? Is it operation at a reckless speed, or sometimes at a snail's pace on a clear road? Is it any conduct which is extremely out of the ordinary in the normal flow of traffic? The problem of recognition of the symbol is heightened because of the popular concept of the offense symbol as an extreme in conduct. This is a reflection on the language symbolism already mentioned which equates "under the influence" with gross intoxication. An example of the commonly accepted symbols of the offense are those cited in the enforcement guide, *The Drinking Driver,* by the California Highway Patrol (*13*). Listed are some 14 deviations from normal driving patterns to which their officers should be attuned as symbols of the potential commission of the offense:

1. Unreasonable speed (high).
2. Driving in spurts, slow, then fast, then slow, etc.
3. Frequent lane changing with excessive speed.
4. Improper passing with insufficient clearance, also taking too long or swerving too much in overtaking and passing; i.e., overcontrol.
5. Overshooting or disregarding traffic control signals.
6. Approaching signals unreasonably fast or slow and stopping or attempting to stop with uneven motion.
7. Driving at night without lights. Delay in turning lights on when starting from a parked position.
8. Failure to dim lights to oncoming traffic.
9. Driving in lower gears without apparent reason, or repeatedly clashing gears.
10. Jerky starting or stopping.
11. Driving unreasonably slow.
12. Driving too close to shoulders or curbs, or appearing to hug the edge of the road, or continually straddling the centerline.
13. Driving with windows down in cold weather.
14. Driving or riding with head partly or completely out of the window.

There are many other ways in which the symbol may be manifested, but the common recognition factor is out-of-the-ordinary driving performance.

There are actually two parts to this general problem of recognition. The first involves recognizing driving behavior measuring up to the symbol. The second and more difficult is postarrest recognition of alcohol as a probable cause of violation. An example of this is stopping a driver for excessive speed, then discovering that he is actually under the influence. Another example is stopping a motorist for an equipment violation, totally unrelated to actual driving skill, and then discovering that the driver has been drinking excessively.

Police-violator contacts during routine patrol are made on a highly selective basis. Under normal circumstances only those drinkers who commit some violation are brought to the attention of the police (*67*). Other drinking drivers, potentially just as dangerous, are disregarded because they do not conform to the classical symbol structure. This selectivity is to be contrasted with blockade apprehensions which will now be considered.

Traffic policing's function is to keep the maximum amount of traffic flowing, with a minimum of interruptions, in reasonable safety. Routine patrol, in removing only drivers who display the classical symbol from the traffic flow, is not fulfilling its preventive function. If the drinkers have already been in accidents, the function is one of investigation and prosecution. If they have not yet been involved in accidents but are so grossly impaired that they meet the symbolic standard, they are usually recognized by alert drivers who adjust their driving to meet the danger. Under such circumstances, it is probably only a matter of time until they are apprehended.

Another danger lies in the less coordinated driver whose decision making is impaired, but whose physical coordination might not yet have become noticeably affected. These drivers do not conform to the classical symbol. Neither the police nor other operators are aware of their presence and of the dangers they pose until a critical decision situation develops. Under these conditions, the probability of a wrong decision due to the influence of alcohol rises sharply. But until the time of danger, routine patrol does not ferret out these menaces.

The difficulty with patrol as a means of controlling these drivers is that it acts only on those motorists who obviously conform to the grosser symbol patterns. In a blockade effort, on the other hand, all drivers, violators and nonviolators alike, are subjected to scrutiny. The nonviolators are passed through the blockade, while violators who may not yet have displayed classical symbol patterns are detained. Hence, the patrol approach constitutes "treatment" of cases already in serious trouble, while the blockade technique offers a measure of "prevention."

Some consideration should be given at this point to the blockade program as a patrol screening device. Some of the advantages of the blockade are—

1. It permits apprehension of impaired drivers *before* they are involved in accidents or other negative situations.
2. It serves notice to *all* drivers of the certainty of apprehension, thereby becoming a deterrent.
3. It provides a means whereby many traffic regulations may be enforced with minimal police effort. This refers to the common experience of finding unlicensed drivers, persons operating while suspended, equipment violations otherwise unnoticed, etc.

Most judicial quarters nurture a violent distaste for the blockade technique. Many courts will not permit filing of charges of driving while under the influence unless there is an accident or a serious act of recklessness connected with the offense. Such an attitude interferes with accident prevention measures. However, in spite of the lack of acceptance by prosecution and courts, some police agencies have employed the blockade technique very effectively as a deterrent. It is not uncommon for municipal police departments to set up blockades during the Christmas holidays when drinking is at a peak.

The Connecticut State Police have employed the blockade to discourage young people between the ages of 18 and 21 from going to New York and frequenting bars, such sales being legal in New York but illegal in Connecticut (*48*). It is obvious that they would be driving under the influence upon returning. One of the troopers said that the roadblock had taken "some of the spark out of the kids from Connecticut." A typical reaction of one of these young people when questioned about having been drinking by Connecticut troopers was, "We knew about this roadblock; do you think we're crazy?" The nonacceptance of blockades in this country may be contrasted with their success in Sweden (*52, 60*). What are the reasons for this dislike of blockades? There are three points that seem to sum up the antipathy:

1. The driver has committed no act of recklessness, nor is he being stopped for having violated a law.
2. There is fear that even one bottle of beer could cause embarrassment and inconvenience because of the nonquantitative character of the odor on the breath.
3. People inherently dislike being stopped and screened, and consider it an invasion of privacy.

As regards the nonquantitative character of a cursory examination for alcohol at a blockade, this is easily solved by an on-the-spot chemical testing program to clear those with blood alcohol levels not sufficiently high to indicate impairment. The inconvenience of waiting through a check point and taking a chemical test is the price a driver must pay to operate a vehicle on "one beer." This problem is more one of emotion than it is of reason.

The greater challenge lies in gaining public acceptance of being stopped in a blockade. In addition to imposing inconvenience, the police have not exerted their best efforts to make the contacts palatable. Officers, so long accustomed to officer-violator contacts, forget that a blackade is an officer-citizen contact, and not necessarily one in which they have complete psychological supremacy. If the blockade officer would avoid a "violator" complex and would concentrate on positive human relations and an educational approach, greater public acceptance would undoubtedly ensue. Contacts with nonviolators must be punctuated with courteous gestures on the part of the police officer. This would go a long way in making the experience a pleasant one for the motorist and would be positive reinforcement of the desire to drive carefully and avoid negative contacts with the police.

The key to this public relations approach is the individual officer. Informing the public en masse is a major police weapon, but in the final analysis it is the individual officer in his contact with the individual driver who sets the tone of police-public relations. He can contact the masses for his superiors, but he does this on a one-at-a-time basis.

In view of the benefits to be derived from blockade-type patrol, we recommend that police administrators readjust their thinking and policies and "make a case" for the blockade. It is very easy to be negative, as several courts have been. The blockade system works in Scandanavian countries remarkably well, and it is unrealistic to infer that they are any less liberty loving than we.

The blockade system provides for balancing two results of the investigation—prosecution and prevention. Police activity can be adjusted to any desired balance between the various facets, in this relation:

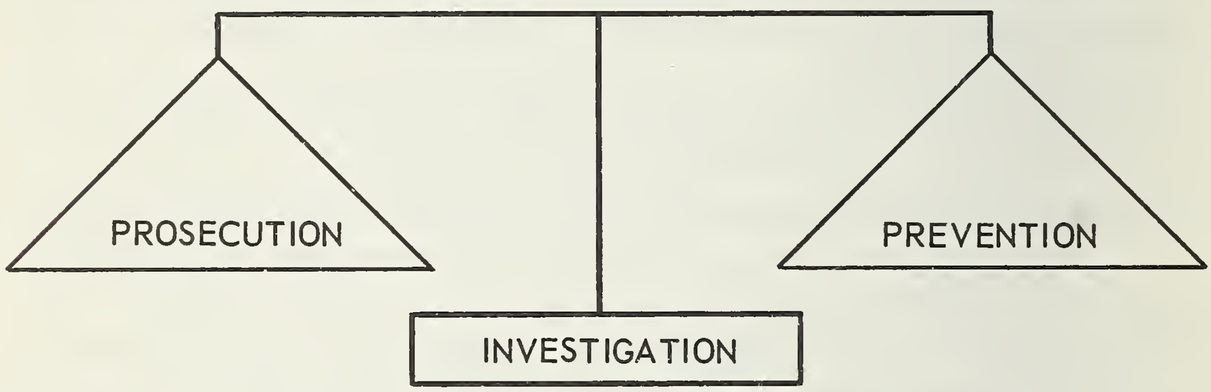

Figure 4

The question is often posed: Why single out driving under the influence of alcohol as an offense? Why penalize the driver whose ability may be slightly impaired by alcohol, when nothing is done to the driver who manifests the same impairment by reason of sleepiness or physical disease? If one attempts to cut accidents, why single out the drinker as a criminal? His impairment is really no different from that of a stubborn driver who wants to "drive straight through" without sleeping.

The answer to this question lies in the Anglo-American theory of criminal law. The essence of crimes is that they are products of acts of volition, freely entered into with an awareness of the consequences (*34*). This element of volition or intent is the *mens rea* in felony cases, and has the same meaning for drinking-driving as it does for murder. Operating under the influence is a criminal act only in that ingestion of alcohol is a voluntary act and sane persons are held responsible for the consequences of their volitional conduct. The ingestion of alcohol and "enjoyment" of its effects are considered overt acts of intention to render oneself less alert. It is in the interest of the state that operators of motor vehicles be at the peak of their powers to promote safety. Therein lies the reason why drinkers are penalized through the criminal law, whereas sleepy drivers usually are not.

Police records seldom reflect with accuracy the frequency of alcohol involvement in accidents or convictions resulting from arrests and prosecutions for this offense. Prosecutions for "operating under the influence" are by no means a valid index of the number of arrests made for that offense.

While the charge of driving under the influence does not require a complex of elements, some jurisdictions require, in addition to the charge of driving under the influence, a parallel one of reckless driving, public intoxication, or similar "included" offenses. The presence of such additional charges leaves considerable room for attorneys and prosecution officials to "bargain," and only too often a flagrantly guilty violator is actually tried and convicted of a lesser charge. These procedures account for a large number of nolle prosequi dispositions in many jurisdictions. Thus a police department keeping "average" records will show a high rate of convictions, but the fact of the matter is that the convictions are on charges other than "driving under the influence" unless the department has an industrious records officer (and there are many of these). One of the motivating forces for keeping traffic records is to satisfy the requirements of the National Safety Council's Annual Traffic Inventory. This inventory stresses volume of arrests and convictions for these arrests as a measure of enforcement efficiency. Pending cases are classed as convictions, an artifact because many pending cases will never come to trial.

A barometer of the efficiency of police records in showing the true picture was expressed in the 1956 survey by the Association of Casualty and Surety Companies covering 45 States (*20*). One State reported 1 percent alcohol involvement in fatal accident cases, while the others ranged up to 50 percent. The same association has stated publicly that police accident records are little more than guesswork.

There are a few police agencies in the United States that have switched to the use of electronic data processing to correlate this information. This gives them much more sensitive control in the handling of records as well as the details of the records. This promises to be a means of controlling the artifacts that now plague current records systems. The use of improved records forms and electronic data processing can certainly improve administrative control.[2]

Traditionally the police technique to detect impairment has been the use of a simple battery of tests to demonstrate gross incoordination. Such devices as the Romberg sign, finger-to-nose test, picking up coins, repeating tongue-twister phrases, sorting cards, walking lines, etc., have been in the police repertory for years. These tests suffer from a basic defect in handling this problem; they show little impairment short of the gross stage.

Prior to the onset of motor paralysis causing physical incoordination, there is a phase which impairs judgment, inhibitions, and the more subtle mental processes. This amounts to a chemical lobotomy. Interference with the finer decision-making processes of the brain occurs long before physical incoordination sets in. The use of the standard coordination tests hardly touches this phase, yet it is in this stage that great danger can lie. A cursory examination of such a subject by an officer, using the basic tests and routine observation, generally indicates little or no impairment, and the

[2] **Los Angeles Police Department; Indiana State Police, Indianapolis, Ind.**

police will usually discharge the subject. In their view, he displayed no symptoms of impairment and therefore had to be released.

The inability to judge such cases efficiently is not confined to police officers alone. Liljestrand, in a 1940 study, reviewed 700 cases examined by physicians on police request. The 700 cases were drawn, 100 each, from the files of 7 different examining physicians. The table indicates rather dramatically that doctors of medicine are notoriously inconsistent in conducting similar-type examinations (*50*).

TABLE I. *Percentage of cases being "under the influence" at different blood alcohol concentration; 700 cases, examined by 7 different physicians. Adapted from Liljestrand* (*50*)

Blood alcohol (percent)	Physicians						
	1	2	3	4	5	6	7
0–0.05	......	25	0	50	0	0	25
0.05–0.10	100	50	78	50	60	0	25
0.10–0.15	91	72	77	86	57	63	43
0.15–0.20	100	97	100	94	83	69	77
0.20–0.25	100	100	100	93	100	79	95
0.25–0.30	100	100	100	86	100	100	90
Over 0.30	100	100	100	100	100	100	100

NOTE.—This table shows the percentage of 700 arrested Swedish drivers in various blood alcohol zones judged under the influence of alcohol by 7 physicians. Each physician examined a hundred drivers. The blood alcohol figures were not available to the physician at the time of the examination. Note the difference between physicians Nos. 1 and 6.

This discussion is not intended to embarrass either policemen or doctors. It only illustrates the fallacy of examination by physical tests alone because of the considerable degree of latitude in making subjective decisions. In such a situation, knowing the great danger that the preincoordinated drinker presents, what should a conscientious officer do?

Training Problems

An effective chemical testing program demands a high level of training and inspection to insure accuracy and public acceptance. The test itself is no better than the person who controls it. Control is not confined to the operator of the device in use, but goes beyond the testing room to encompass every person in the enforcement chain.

The key to control is training. To maintain an effective program, regardless of how automatic the chemical testing method may be, every person who has any relation to it must be adequately trained in his duties and responsibilities. Adequate training is a definite responsibility of administration in the enforcement agency.

There exist at least four discernible levels of training demanding attention. They are, in descending order:

1. Departmental administration.
2. Expert witness.
3. Operator-technician.
4. Patrol force.

Departmental administration. Training at this level actually takes the form of attitude development. The administrator must be aware of the broad scope of the drinking-driving problem and must be determined to act positively.

The administrator must be somewhat familiar with literature on the overall subject. Although it is unnecessary for him to have a deep knowledge of the scientific details, he should be current regarding traffic problems, especially as they concern the drinking driver.

He must wholeheartedly support training for every member of his organization concerned in the program. In addition, he must reexamine his departmental policies, practices, and facilities. This includes reviewing the physical facilities where the chemical tests are administered. If they are inconveniently located, unscientific in atmosphere, or if they otherwise create an impression of departmental laxity, consideration must be given to renovation or relocation. It is by attention to matters such as these that the well-trained, interested administrator contributes to the success of the chemical testing program. This tangible evidence of support stimulates subordinates to carry on their programs confident of administrative backing.

Many administrators in the past have taken a "pushbutton" view of chemical testing. They invest in expensive, intricate equipment. Then without further preparation they proclaim that "their departments are now as well equipped as money can buy" and "they are ready to take on the drinking driver." They sit back and await convictions. They do not realize that the equipment is but a tool. They have not taken on the responsibility of providing adequate training to the men who have been assigned this duty. Training in these instances comprises little more than reading the instruction manual. The men so "trained" are the "technicians." When the first contested case results in defeat, they are confused and embittered. The program has gotten off to as bad a start as it possibly could. It is continued principally to justify the initial equipment expenditure. This is a classical picture in many places today.

The modern police administrator is not too proud to seek professional advice in matters scientific. The handling of the drinking driver has medical and scientific connotations. Professional advice, blended with practical knowledge from within the police department, results in strength that tends to give a solid foundation to a program that otherwise might be

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oversimplified to the point of weakness. The result of such an advisory approach is selection of reliable instrumentation and the ascertaining of training needs that will meet operational and courtroom requirements.

Recognition of the problem and various approaches to its solution have been matters communicated to police administrators by the International Association of Chiefs of Police, the National Safety Council, the Northwestern University Traffic Institute, the American Medical Association, and the American Bar Association by various media such as academy training, journals, traffic court conferences, convention presentations, etc. The effectiveness of this training can be considered only moderately successful in view of the still prevalent "pushbutton" attitude on the part of so many chiefs. A real challenge exists in furthering training at this level (*18*).

Expert witness. The expert witness brings acceptance and adds weight to scientific evidence in the courtroom. It is he who is able to translate methodology and science into lay terms for the jury. It is his responsibility to explain the significance of the test. He is the logical person to convince the laity that alcoholic impairment can and does exist in drivers at levels below gross intoxication. He assumes that position by virtue of his status of respect in the community and his professional knowledge. Explanations of science and theory are accepted from him while they would have far less weight if given by others of lesser scientific stature.

The expert witness should be specially trained in the actual techniques of the test employed so he can testify from firsthand knowledge about its accuracy and specificity. He should also receive special instruction in the effects of alcohol on the human body. Acquisition of this status implies working knowledge of the literature in this field, including controversial material, so that he may successfully counter courtroom attacks.

Some institutions have recognized the need for training of the expert witness and have made efforts toward closing the gap at this level. Indiana University through its development of the Chemical Test Supervisors' Conference and its presentation of the Symposium on Alcohol and Road Traffic, the Southern Police Institute, certain medical colleges, the American Medical Association through its Committee on Medicolegal Problems, the American Bar Association, and others have all made progress in formal training programs for improvement of the expert witness class.

Technician-operator. The greatest training effort has been made at the actual operation level. The time when an officer "read the book" and then assumed responsibility for the testing program is rapidly disappearing. In its place have grown several formal training programs, usually institutionalized, ranging in duration up to several weeks. Institutions such as the Indiana University Medical School, the Northwestern University Traffic Institute, the Southern Police Institute, and many others offer formal instruction courses for technician-operators.[3] Their offerings paral-

[3] Training sessions are held regularly at these institutions for police technicians and trainees.

lel each other in that instruction joins a certain amount of theory with extensive practical laboratory work under supervision.

Harger and others have observed that highly satisfactory results have been obtained in public health agencies by using nonprofessional workers to perform certain laboratory tests. The technicians did not receive extensive training in the underlying theory, but were closely supervised in their laboratory technique until they could perform the tests with precision. As a result, they were able to perform detailed clinical tests with adequate accuracy, subject to occasional review and spot checking.

The same principle, with improvements, is used in chemical-test technician training. The National Safety Council's Committee on Alcohol and Drugs recommends a 44-hour course that is substantially the same as those now in effect in the major training institutions and the larger departments which often establish their own training programs (*61*).

Greatest care must be taken in selection and training of personnel for technician duty. The Indiana University Medical School utilizes a screening test on all applicants for technician training. The test emphasizes applicant aptitude in mathematics.

Periodic retraining sessions are required, as are spot-check reviews and inspections.

Nonpolice training. The previous discussion has been oriented toward the use of breath tests, human engineered to require minimum scientific skill for their successful operation. However, there are many thousand tests performed annually across the Nation employing biological materials other than breath, requiring laboratory analysis. The techniques used, while delicate because of the small measures involved, are really quite simple in principle. It is too often assumed that the average clinical laboratory technician can perform these tests reliably without any special training. Each technique, while simple, has its own idiosyncrasies, and any laboratory undertaking such tests should carefully standardize and check the procedure for accuracy, specificity, and reliability. The American Academy of Forensic Sciences (Toxicology Section) has undertaken to monitor laboratories voluntarily requesting this service. Early samplings have shown a shocking need for training in this area (*55*).

Chemical testing programs within police departments can hardly exist successfully if public, prosecutor, and court have not been trained to receive and understand the information provided by the chemical test. The American Bar Association has attempted, through the various regional traffic court conferences, to provide training to judges and prosecutors.[4] The American Medical Association, through its Committee on Medicolegal Problems, has attempted to inform doctors and lawyers of chemical tests for intoxication by symposia conducted in various parts of the country and by the publication of a comprehensive manual. The National Safety

[4] Traffic court conferences sponsored by the American Bar Association traffic court program.

Council through public information has attempted to train the public at large.

Patrol force. A chemical testing program, ironically, does not decrease but actually multiplies the patrol division's responsibilities. The patrol force is increased in sensitivity to situations that require use of the chemical test. Their acuity of perception must be sharpened to insure that maximum use is made of the new equipment and techniques as part of a total accident reduction program. Training is necessary to define the broader range of drinking drivers that it is now possible to apprehend.

In this training requirement, a reevaluation must be made of patrol case-handling techniques. Patrol officers must be trained to the realization that the presence of a chemical test program does not relieve them of responsibility for good investigation. The solution to this training lies in the *syndrome approach* (*10*).

Despite present and future efforts in education and reorientation of drivers' attitudes toward mixing alcohol and driving, some motorists will continue to operate vehicles while under the influence of alcoholic beverages. When they come to the attention of the enforcement authority, either by apprehension by a patrol unit or through postaccident or incident investigation, the police emphasis shifts violently toward the investigative and prosecutive phases of enforcement. This is to be expected. Successful prosecution requires effective and substantial evidence of commission of the offense charged. This general problem is particularly emphasized in "operating under the influence" cases. Too many cases are lost in prosecution because of the failure to put together a coordinated, well-rounded, well-documented picture of the facts. Efforts to obtain convictions for operating a motor vehicle under the influence of intoxicating liquor on the basis of testimony concerning driving behavior alone, physiological symptoms alone, witness testimony alone, or chemical tests alone have met with regular failure.

This pattern of failure of the independent elements demonstrates the necessity for the development and use of a syndrome approach to "driving while under the influence of alcoholic beverages." The use of a syndrome rather than a single element is logically sound, particularly when based on highly objective elements. The syndrome comprises evidence of abnormal behavior in most of the elements observed, plus a chemical test to show whether the alcohol level of the accused is sufficiently high to account for these abnormalities.

The principal parts of the syndrome are threefold:

1. Unusual driving behavior.
2. Observations of police and lay witnesses.
3. Chemical tests.

These can be further analyzed into five elements:

1. Behavior prior to arrest or accident.
2. Behavior immediately following accident or arrest.

3. Behavior while being subjected to psychosensory and psychomotor tests commonly used by police and physicians.
4. Responses to questionnaires.
5. Results of chemical tests to determine the blood alcohol level.

To rely on one or two elements of proof to establish the existence of the syndrome throws a proportionately greater burden on what evidence there is. To illustrate: When physical symptoms and odorous breath alone are used, nothing short of gross staggering, instability, and extreme behavior ordinarily suffices to convict. Use of a chemical test alone means next to nothing in many courts unless it is considerably in excess of 0.15 percent. Many courts even require "confidence factors" above this often-termed "borderline" (*78*).

Available information and research point out repeatedly the fact that there are individuals whose driving ability is dangerously impaired at blood alcohol levels as low as 0.05 percent. Yet, unless every possible shred of available evidence is linked to this information *to form a syndrome,* without depending unduly on the blood alcohol level, such individuals usually escape well-warranted prosecution.

The chemical test, of all the elements, is the least subjective. It reduces the expression of alcoholic influence to numerical form. Under these circumstances it is readily apparent why attempts are continually made to use chemical test results to the exclusion of other information, no matter how relevant. Such presentation throws an undue burden on the chemical test, forcing it to "carry the entire case" while other information, equally convincing if properly presented, is ignored.

It therefore becomes imperative that the elements of the total mass of evidence be formalized and properly utilized so each may carry its proper weight in case presentation. Effective evidence constitutes the answer to these questions:

1. *What happened before the accident or apprehension?* This entails a description of the mode of driving, statements of witnesses who knew or observed the activities of the subject for some time prior to the arrest or incident, and a careful description of the violation (in nonaccident cases) that attracted the officer's attention. The particular driving offense or characteristic might have been abnormal weaving or lurching, or some readily definable offense such as improper passing, but it should be capable of careful description by the officer (*13*). In accident investigation cases, the reconstruction of preimpact events, through examination of physical evidence and statements of eyewitnesses, can materially aid the officer in presenting this phase of the case. An investigation of the subject's activities for up to 12 hours preceding arrest or accident can be most helpful, particularly if it proves "barhopping." Character and background investigations expose the personal habits and characteristics of the accused. Examination should be made of prior arrest and conviction records, if any. All this gives greater weight and meaning to the arrest.

At this point alcoholic influence may or may not have been detected or even suspected. All that is necessary to provide meaning to this section is abnormal driving or a violation.

2. *How did the driver behave immediately after arrest or the accident?* This phase is of particular importance because it is generally at this point that the officer makes the decision to arrest or release the subject. In the course of investigation he evaluates the behavior and personality of the subject (*67*). He smells his breath. He looks for bottles or other evidence of recent drinking in and around the car. If the driver displays signs of undue aggressiveness, if he is overtalkative, if he exudes the odor of alcoholic beverage, if bottles or other drinking paraphernalia are present, the officer must decide whether or not to effect an arrest. This decision is made on the basis that he has reasonable grounds to believe that the subject is under the influence of alcoholic beverages to an extent that impairs his driving ability. Further investigation in depth will prove the detailed elements, but by this point in time the officer must have observed enough to form, reasonably, an opinion as to extent of influence and impairment.

Facilities are available that aid the officer in implementing his analysis in this phase through instrumental technique. Quick field chemical tests are available that may be administered by him at the scene. Among these tests are the Portable Intoximeter Preliminary Test (*45*), the Drunkotest (*46*), and the Alcotest (*31*). These facilities offer semiquantitative answers, helping the officer to form an opinion as to whether or not alcoholic influence may be considered as a factor. It must be pointed out that, because of the relatively crude analytical methods and semiquantitativeness of these tests, they must be considered *only* as preliminary efforts.

3. *How did the driver behave when subjected to psychomotor and psychosensory tests and questionnaires?* An attempt has been made to formalize this phase of the investigative process by use of the so-called National Safety Council Alcoholic Influence Report Form.[5] The questionnaire's value is to help bring out the reasons for the impairment that was previously observed or that might be brought out as a result of the physical tests described in the form. These tests are the well-known coordination tests—Romberg, finger-to-nose, walking a straight line, etc. The questionnaire portion is designed to elicit information from the subject as to whether he had been drinking; what, when, how much, etc. It makes inquiry into any possible illnesses, injuries, or preexistent physical disabilities that might produce symptoms similar to alcoholic influence and thereby account for the subject's conduct and actions. Knowledge of time and place is tested. An inqury is directed to the possibility of ingestion of something other than ethyl alcohol, or the use of medications that might interfere with the test. The value of all such questions is that they add to the specificity of the

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[5] The National Safety Council's Committee on Tests for Intoxication at its February 1952 meeting officially adopted the Alcoholic Influence Report Form. (See fig. 5 for the form currently in use.)

subsequent chemical test. It is invaluable in closing the door to any "alibis" that might follow. There is nothing produced spontaneously by the human body except the products of untreated diabetes that will give false positive results, and many methods are insensitive even to these. The questionnaire brings out possible interfering materials voluntarily taken by the subject.

Wide experience has shown that most alcohol-impaired subjects will have lost their sense of caution or reserve and will answer the questions to the limit of their ability if properly approached. The only notable deviation from this is in response to inquiry as to amount of alcoholic beverage consumed; in this case the answers are usually ridiculously low.

As important as this phase of the investigation is, it showed almost no progress for decades. The tests included in the original report form were designed for conditions that existed 25 years ago and were hardly sensitive enough to detect the preincoordinative phase of alcoholic impairment. The Traffic Committee of the International Association of Chiefs of Police in 1959 recommended revision of the form. The National Safety Council's Committee on Alcohol and Drugs adopted a revision in 1962. This form is intended to supplement, not replace, other records.

Many officers use this form as a substitute for their own personal investigative judgment, limiting their observations to those elicited by the form. The report form has often become a "crutch" in presenting cases in the courtroom. The very nature of the form tends to stereotype the recorded data. Continued reliance on the form produces two side effects. First, the language clusters in the form connote gross symbolisms. Repetition of the phrases in case after case desensitizes the officer's ability to describe nuances effectively. Second, continued use of stereotyped language establishes a pattern that eventually causes the court to infer that police officers attempt to categorize all defendants in these classes in the face of the court's knowledge of the variability of human behavior. Boredom at repeatedly hearing the same evidence reflects itself in a lessening of the weight of testimony.

At the recent Symposium on Alcohol and Road Traffic at Indiana University, Newman concluded that no tests could be devised to measure incoordination between the 0.05–0.10 percent levels because of the need for establishing a norm for each subject (*63*). He thought this impractical because of the danger of subjective control in tests under field conditions, conducted *after* sobering up to be used for comparison with tests made *during* alcoholic influence.

Forster has suggested that accelerated rotational nystagmus offers a measure of alcoholic influence beyond subjective control (*26*). If good correlation between this factor and driving impairment can be established, it may offer the opportunity to implement this phase by making possible the establishment of a reliable norm after the subject has recovered his sobriety. Such a test could replace the crude battery now being administered by physicians and enforcement officials.

In several programs the symptoms displayed in the tests are recorded by use of motion pictures, both silent and sound, still photography, and tape and wire recordings of the subject's voice during the examination. These approaches have been useful in eliciting guilty pleas from subjects in advanced stages of intoxication. Their drawback lies in the fact that at the levels short of gross incoordination, they show little observable impairment and thus are not as dramatic as they might be. This poses a serious tactical problem in courtroom presentations. Once a department

(Check)	(Check)	ALCOHOLIC INFLUENCE REPORT FORM	
☐ Driver	☐ Accident		Police Dept. ______
☐ Pedestrian	☐ Violation		Arrest No. ______
☐ Passenger	☐ Other		Accident No. ______
Date and time of Accident or Violation ______ am/pm			Arresting Officer ______
			Date and time in custody ______ am/pm

Name ______ Address ______

Age ______ Sex ______ Race ______ Approx. Wt. ______ Operator Lic. No. ______ State ______

OBSERVATIONS:

CLOTHES	**Describe: (Type & Color)**	Hat or Cap ______				
		Jacket or Coat ______				
		Shirt or Dress ______				
		Pants or Skirt ______				
	Condition:	☐ Disorderly	☐ Disarranged	☐ Soiled	☐ Mussed	☐ Orderly
		(Describe) ______				
BREATH	**Odor of Alcoholic Beverage:** ☐ strong	☐ moderate	☐ faint	☐ none		
ATTITUDE	☐ Excited	☐ Hilarious	☐ Talkative	☐ Carefree	☐ Sleepy	☐ Profanity
	☐ Combative	☐ Indifferent	☐ Insulting	☐ Cocky	☐ Cooperative	☐ Polite
UNUSUAL ACTIONS	☐ Hiccoughing	☐ Belching	☐ Vomiting	☐ Fighting	☐ Crying	☐ Laughing
SPEECH	☐ Not Understandable	☐ Mumbled	☐ Slurred	☐ Mush Mouthed	☐ Confused	
	☐ Thick Tongued	☐ Stuttered	☐ Accent	☐ Fair	☐ Good	

Indicate other unusual actions or statements, including when first observed: ______

Signs or complaint of illness or injury:

PERFORMANCE TESTS: (Note—See departmental instructions for conducting these tests)

Check Squares If Not Made	Check appropriate square before word describing condition observed					
☐ **BALANCE**	☐ Falling	☐ Needed Support	☐ Wobbling	☐ Swaying	☐ Unsure	☐ Sure
☐ **WALKING**	☐ Falling	☐ Staggering	☐ Stumbling	☐ Swaying	☐ Unsure	☐ Sure
☐ **TURNING**	☐ Falling	☐ Staggering	☐ Hesitant	☐ Swaying	☐ Unsure	☐ Sure
☐ **FINGER-TO-NOSE**	Right: ☐ Completely Missed	☐ Hesitant	☐ Sure			
	Left: ☐ Completely Missed	☐ Hesitant	☐ Sure			
☐ **COINS**	☐ Unable	☐ Fumbling	☐ Slow	☐ Sure	☐ (Other) ______	
	(Balance during coin test) ______					
Ability to understand instructions: ☐ Poor	☐ Fair	☐ Good	Tests performed: Date	Time	am/pm	

OBSERVER'S OPINION:

Effects of alcohol: ☐ extreme	☐ obvious	☐ slight	☐ none	Ability to drive: ☐ unfit	☐ fit

Indicate briefly what first led you to suspect alcoholic influence: ______

Observed by: ______ Assignment: ______

Witnessed by: ______ Date ______ Time ______ am/pm

CHEMICAL TEST DATA:

Specimen: ☐ Blood ☐ Breath ☐ Saliva ☐ Urine ☐ None ☐ Refused ☐ Unable	Analysis result:
	If Breath, what instrument?

If refused, why? ______

Figure 5

has instituted the practice of photorecording and presents it in evidence, courts rapidly expect to see this material in every case, even in those instances where the subject was not grossly incoordinated but yet deceptively dangerous as a driver.

These tests merely show abnormality. None of them show alcohol as the cause. This is the purpose of the chemical test.

The chemical test. This part of the syndrome shows whether or not alcohol is present in the body in sufficient quantity to account for the rest of the evidence. Its significance is dependent on the entire mass of evidence in which it is included, especially when its results lie between 0.05

INTERVIEW:

Were you operating a vehicle? ____ Where were you going? ____

What street or highway were you on? ____ Direction of travel? ____

Where did you start from? ____ What time did you start? ____

What time is it now? ____ What city (county) are you in now? ____

What is the date? ____ What day of the week is it? ____

INTERVIEWER TO FILL IN ACTUAL: ____ am/pm ____ ____ ____
Time — Day — Date — Interviewer's Name

When did you last eat? ____ What did you eat? ____

What were you doing during the last three hours? ____

Have you been drinking? ____ What? ____ How much? ____

Where? ____ Started? ____ am/pm Stopped? ____ am/pm

Are you under the influence of an alcoholic beverage now? ____

What is your occupation? ____ When did you last work? ____

Do you have any physical defects? ____ If so, what? ____

Are you ill? ____ If so, what's wrong? ____

Do you limp? ____ Have you been injured lately? ____ If so, what's wrong? ____

Did you get a bump on the head? ____ Were you involved in an accident today? ____

Have you had any alcoholic beverage since the accident? ____ If so, what? ____

Where? ____ How much? ____ When? ____

Have you seen a doctor or dentist lately? ____ If so, who? ____ When? ____

What for? ____ Are you taking tranquilizers, pills or medicines of any kind? ____

If so, what kind? (Get sample) ____ Last dose? ____ am/pm Do you have epilepsy? ____

Diabetes? ____ Do you take insulin? ____ If so, last dose? ____ am/pm

Have you had any injections of any other drugs recently? ____ If so, what for? ____

What kind of drug? ____ Last dose? ____ am/pm When did you last sleep? ____

How much sleep did you have? ____ Are you wearing false teeth? ____ Do you have a glass eye? ____

HANDWRITING SPECIMEN
Signature and/or anything he chooses.

REMARKS: ____

SUPPLEMENTARY DATA: **(Note—Get witnesses, including officers who observed, to prove driving)**

WITNESSES			Was Suspect Driving or Operating	What Was His Condition	Where Observed
Name	Address	Tel. No.			

Passengers In Suspect's Vehicle	Name	Address	Condition

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Figure 5a

and 0.20 percent. Because of its high degree of objectivity, there is a great tendency to use it in place of the other evidence. This may be practical in very advanced levels, above 0.20 percent, but at levels between 0.05 and 0.20 percent, most courts and juries insist on proof in all four areas unless they are not all obtainable due to injury of the subject. Many a driver impaired by alcohol has escaped prosecution because of injury. He could not be given the usual tests to demonstrate that alcohol shown by the chemical test was really causing impairment.

Efforts to implement this part of the evidence with instrumentation are far out of proportion to the other areas.

The use of breath tests to determine blood alcohol percentage enables the officer to have an answer to this decisive part of the evidence promptly—soon after arrest—when he needs the information most to help him in making a decision. It may cause him to decide to send the subject to the hospital instead of to jail; it may reinforce his decision to prosecute the subject for driving under the influence of alcohol, or it may cause him to charge the driver with the observed violation only. When used under these conditions the chemical test for intoxication becomes an indispensable element of the proof—not a lone accuser.

Conclusion. It is quite evident from the attempts at coping with this situation through logic that the American public to some degree recognizes the social problem of the drinking driver and his increased accident proneness. This recognition is sociological, but fails to carry its impact over to prosecution of the individual for the offense. Means of mass persuasion must be devised to make the American public consider the driver who becomes antisocial through excessive drinking as an outcast in every sense. Under these conditions the current three-zone interpretation of blood alcohol results would become, in our opinion, very practical and would be completely adequate. However, there are forces currently at work attempting to impose a "speed limit" type of legislation. This involves the establishment of a single blood alcohol level above which it would be illegal to operate a motor vehicle. The usually suggested level is based on the most acceptable drivers' "safe" limit, 0.05 percent. Such legislation, while desirable from the enforcement officer's viewpoint, would be highly impractical in the face of violent public objection—unless public acceptance could be assured by adequate systematic public information and persuasion. This is the challenge that faces the scientist, the sociologist, the legislators, the prosecution forces, and the courts.

The Chemical Tests

It is logical in a situation such as this that the principles of legal medicine come into play. Death by poison has long been proven by showing the presence of poison in sufficient quantity to account for death. The same principle applies here. If a condition is suspected of being alcohol induced, sufficient alcohol must be shown to be present to account for the condition.

It is in a situation such as this that chemical tests can provide their greatest help. There are basically two reasons for chemical tests for intoxication:

1. If there are observable signs of impairment, there is no proof that presence of alcohol as determined by odor on the breath or by the admissions of the subject is accounting for the symptoms.
2. Scientific research has demonstrated that accident proneness increases drastically at blood alcohol levels far below those causing gross physical incoordination.

Quantitative analysis for the presence of alcohol in biologic materials was well known in the last century (*2, 30, 49, 65, 76*). It was this type of examination that Widmark adopted for his research.

The earliest methods of testing involved the use of large samples of body material. From the very inception of the tests there were three recognizable trends:

1. Simplification of the sampling procedures.
2. Improvement of the analytical procedures, including the trend toward directness, specificity, reliability, and accuracy.
3. Shortening the time elapsing between sampling and availability of of the results.

Widmark himself adopted the Nicloux method, i.e., distillation and titration, in 1914 (*82*). Because of the large samples required, he used urine as a body material although he indicated a preference for blood. Finally, in 1922, he reported his own microdiffusion method that cleared the way for use of blood because of the very simple sample collection technique involved (*84*).

Analytically, the problems involved in any method are twofold:

1. Physical separation of alcohol from a measured amount of body material.
2. Analytical measurement of the alcohol so separated and translation into a numerical blood alcohol figure.

Since the amount of alcohol in body material is so small, the measurement must be done by indirect methods. There are three commonly accepted methods of separating alcohol from the host body material:

1. Distillation.
2. Desiccation.
3. Aeration.

In nearly every method, a known amount of an oxidizing agent acts on the alcohol so separated. The alcohol reduces part of the oxidant, and the amount of the oxidant remaining is measured by one of the following methods:

4. Photoelectric measurement.
5. Titration.
6. Comparison with color standards.

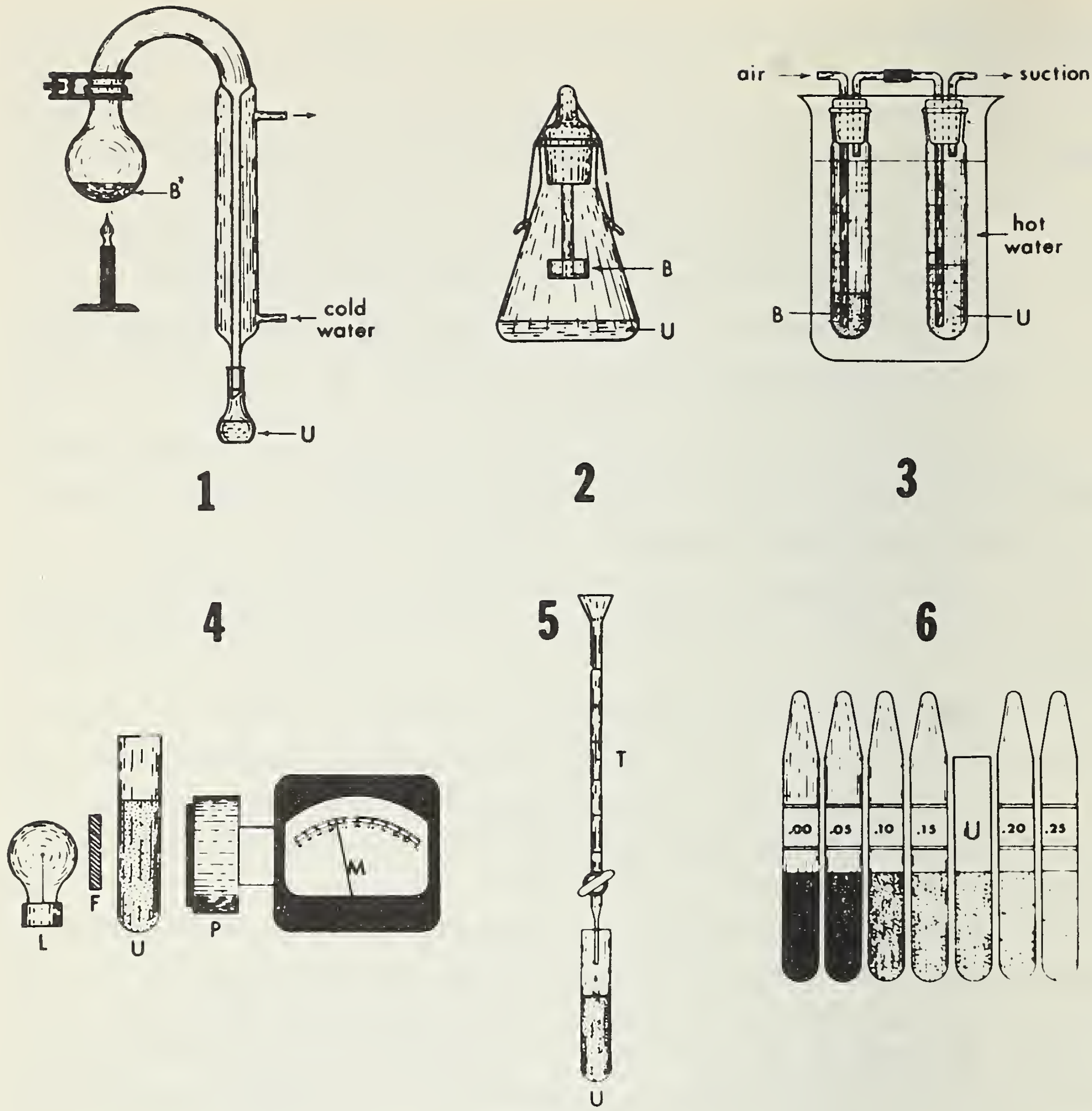

Figure 6

Practically every known method (and there are literally hundreds of them) comprises one element from each group. As examples, Heise's method comprises distillation and comparison with color standards (*40*). The Harger micromethod uses distillation and titration (*36*). Shupe-Dubowski's technique combines distillation and photoelectric measurement (*71*). Widmark used desiccation and titration (*84*). Bogen used aeration and color standards (*6*). The list could go on for pages, but the point is made nonetheless: that practically every system uses an element from each grouping.

There are a few exceptions to this rule. Friedemann reported a saliva test utilizing precipitation of the solids from saliva in place of conventional separating techniques (*27*). Redetzki's (*12*) ADH method does not require separation, although that of Bonnichsen and Theorell does (*8*). This is because the enzymes used in the process involved do not attack the proteins in the blood in the manner that a sulfuric acid-dichromate reagent does.

There has been a long-range move by workers to devise methods adapted to the problems of practical traffic enforcement. These methods require simple sampling procedures. This has taken the form of either settling on large samples that are easily collected, such as urine, and designing tests that capitalize on this ease but that demand a large sample, or devising blood methods that utilize samples sufficiently small to be drawn from a fingertip or earlobe puncture. The overriding objective in blood methods to be used routinely in traffic enforcement has been to retreat from the syringe. The dreaded needle did much to spur research into new techniques.

In the early stages gross samples were required because of relatively crude analytical methods. With progress, techniques, methods, and devices were designed to reduce the sample requirements.

Another tendency in test development has been toward greater specificity. It is most important to show with as great a certainty as possible that the material involved is in fact ethyl alcohol to the exclusion of possible interfering materials. This has been accomplished by several means. The dichromate reaction has been controlled through acid concentration, time, and temperature to be reasonably specific. In living subjects, possible interfering materials are few and can be effectively ruled out of consideration. Possible acetone in the blood of diabetics is the principal cause of concern. This is resolved largely by controlling the conditions of the analysis and direct inquiry of the subject being tested. Acetone is very difficult to oxidize in comparison with ethyl alcohol, and by control of the analytical conditions, its oxidation can be suppressed and the ethyl alcohol determined selectively. Some aeration methods and one distillation method accomplish this by holding the acetone back by using the Scott-Wilson reagent.

One noble attempt at specificity has been the use of ADH (alcohol dehydrogenase), an enzyme extracted from liver or yeast that acts quite specifically on ethyl alcohol. The product of this action is measured in an ultraviolet spectrophotometer (*4*). Gas chromatography is becoming more and more popular because of its ability to separate ethyl alcohol from practically any combination with the materials.

The use of breath as a body material for chemical analysis has become very popular for two reasons. First, the sampling and analytical procedures are simple enough for a trained police officer to perform reliably. Second, test results are available shortly after arrest and testing when they are most needed.

The breath tests, in order to fulfill their mandate—speed, simplicity, and adequate accuracy—must be instrumentally engineered and human engineered so that they may be used by policemen-technicians. While there were two breath methods (*6, 51*) used earlier, the first method conceived based on the above requirements was that of Harger (*38*), now widely known as the Drunkometer (1938). This method was followed by the Intoximeter (*45*) (Forrester, 1941); the Alcometer (*29*) (Greenberg and Keator, 1941); the Breathalyzer (*47*) (Borkenstein, 1954); and the Photoelectric Intoximeter (*25*) (Forrester, 1958).

The Intoximeter Preliminary Test, the Alcotest, and the Drunkotester are all semiquantitative screening tests and do not produce evidence-quality results.

A discussion of the theory underlying the breath methods and the various instruments currently available will illustrate the reasons for their widespread acceptance. Detailed descriptions of the various methods may be found in the appendix to this chapter.

Blood contains 2,100 times as much alcohol as alveolar breath (*77*). The relationship is in compliance with Henry's law. The breath alcohol methods establish a ratio between alcohol and breath. When this is known, the alcohol level in the blood can be computed.

Only the alveolar phase of an exhalation is in complete equilibrium with the blood, yet an ordinary exhalation is only partially alveolar. Obtaining appropriate breath for analysis is the basic problem in breath tests. This is achieved in four ways:

1. By collecting a total exhalation in a container and assuming that it is about two-thirds alveolar air. This mixture is variable according to the manner in which the container is filled.
2. By collecting a total exhalation in a container and assuming that the alveolar part of the breath mixture contains 5.5 percent of its volume as carbon dioxide (*23*). The carbon dioxide can be collected and weighed during a test, and this weight can be used to determine the amount of alveolar air used in the test.
3. By collecting a portion of the last breath to leave the mouth during a forced exhalation. This breath is almost pure alveolar air.
4. By rebreathing a total exhalation a number of times. Each time the air is rebreathed, the amount of dead-space air is reduced. After about five rebreathings, the air has practically all come into contact with the alveolar surfaces.

The newer Drunkometer (*37*) (rebreathed air) and the newer Photoelectric Intoximeter (*25*) both have made unnecessary the collecting of CO_2 from the sample and have substituted pure alveolar air for mixed expired air. The Alcometer (*29*), Breathalyzer (*47*), and the Photoelectric Intoximeter (*26*) have never used the CO_2 technique.

The actual measurement of the alcohol is in every case accomplished by oxidation. The reagents used are potassium permanganate (Drunkometer), iodine pentoxide (Alcometer), and potassium dichromate (Breathalyzer and Photoelectric Intoximeter).

In the earliest method, the Drunkometer, a visual color change occurring in the strongly colored potassium permanganate solution constitutes the measurement. This titration is retained in the latest (rebreathing) Drunkometer. With some practice, a high degree of standardization can be attained (*37*).

The Portable Intoximeter relies on a standard laboratory technique, entirely independent of the device, to make the alcohol determination. It is, in effect, a sample-collecting device.

The Alcometer (*29*) depends on the photoelectric measurement of the blueness developed in a starch-potassium iodide solution by quantitative amounts of iodine freed during the oxidation of alcohol in the breath sample by hot iodine pentoxide.

The answers in the Breathalyzer and Photoelectric Intoximeter are based on the photoelectric measurement of the change in yellowness of a solution of potassium dichromate and sulfuric acid. The Breathalyzer employs a self-compensating photometer, geometrically designed to render the system independent of the dichromate strength of the solution, centering confidence in the stability of the instrumental test. The Photoelectric Intoximeter absorbs alcohol from the breath contained in a second sample chamber into a tube of magnesium perchlorate for later laboratory confirmation.

The future may hold the adapting of techniques such as gas chromatography or infrared absorption spectrophotometry to this field. Specificity for ethyl alcohol in the analysis would be the advantage. However, the mandate of the breath tests—speed, simplicity, and adequate accuracy—must be maintained, otherwise complexity will neutralize their effectiveness.

The breath methods, each requiring its own kind of maintenance and calibration, will, if used by properly trained operators, yield reliable results (*15, 77*).

Appendix

Current Breath Methods and Instruments

The Harger Drunkometer. The Harger Drunkometer in current use comprises two tests—one using total expired air and the other alveolar air as measured by its carbon dioxide content. The total expired air used to furnish a fixed amount of alcohol is measured volumetrically. The alveolar portion of this breath is determined by the weight of carbon dioxide collected in a preweighed tube containing ascarite. Thus two answers are obtained. While the test based on mixed expired air may vary according to the manner in which the balloon is inflated, and while the carbon dioxide content may vary under certain conditions, if the two compare closely as they usually do, the conditions that could cause physiological errors can be ignored (*39*).

The test involves collecting a sample of total expired breath in a balloon and titrating this breath into a reagent composed of 1 ml of N/20 potassium permanganate in 10 ml of 16 N sulfuric acid. The purple color fades to a straw color when 0.169 mg of ethyl alcohol has been oxidized. The breath is then dried by passing it through magnesium perchlorate. The amount of breath required for the test is measured by the two means already discussed. With the alcohol/breath ratio established, the amount in the blood can be computed.

A recent variation in the Drunkometer employs exactly the same analytical procedure for alcohol, but uses air that has been rebreathed five times. This eliminates the need for the weighing of carbon dioxide in the breath and the answers can be obtained directly from the alcohol/breath volume ratio. This method eliminates the sampling and carbon dioxide variation problems.

The Drunkometer is as reliable as the training of the operator and the care in preparation and maintenance of the solutions. The apparatus is very simple. It is not influenced by acetone or breath odors.

THE *Drunkometer*

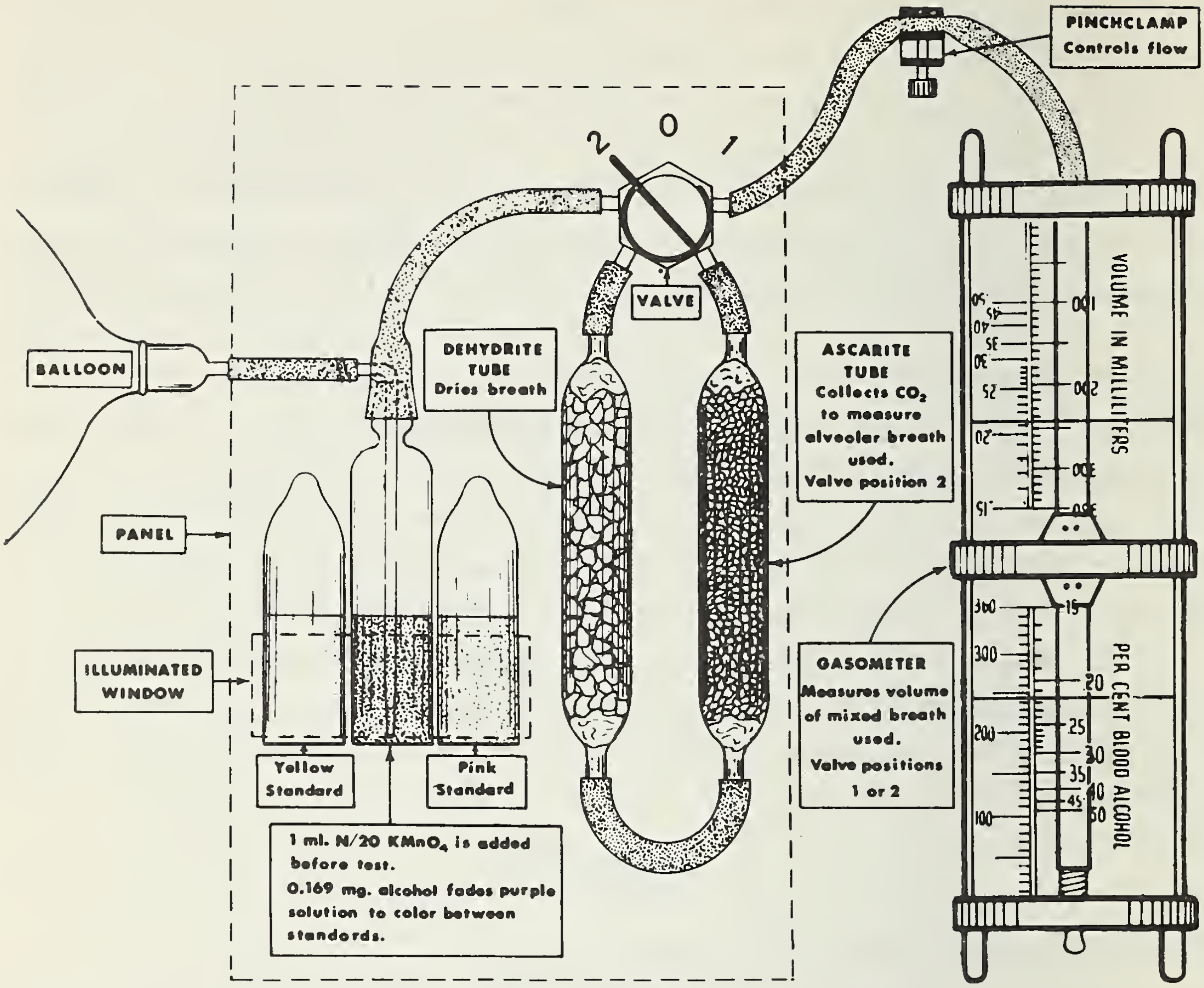

Figure 7

The Portable Intoximeter. The Portable Intoximeter follows exactly the same principles as the Drunkometer. A preliminary test is based on the time required to fade the purple color from a small amount of potassium permanganate-sulfuric acid reagent. The so-called "chemist's test" involves passing about 2 liters of breath from a balloon: first, through magnesium perchlorate to remove moisture and also to collect all the alcohol from the breath; and second, to absorb the carbon dioxide from the breath in an ascarite tube. This part of the test is sent to a laboratory where the amount of alcohol in the perchlorate is determined by conventional analytical methods, and the amount of alveolar breath used is found by reweighing the ascarite tube to determine the weight of carbon dioxide.

Thus a preliminary and a chemist's test are available. This method has the advantage that there is no capital investment and that it can be used at the scene of an accident or arrest. The police officer makes the preliminary test and collects the sample, but a chemist makes the analysis. It is as specific against interfering substances as the chemist's analytical procedure will permit it to be.

The preliminary part of the Portable Intoximeter test must be considered a guide only, since its indication of the blood alcohol level is only approximate. However, the chemist's test correlates satisfactorily with direct analysis of blood.

The Alcometer. The first instrumental method to make use of the principle of collecting the last breath to leave the mouth was the Alcometer. In this method a small amount of alveolar breath is trapped in a metal tube fitted with airtight solenoid valves at its ends. The subject blows into a tube leading into the instrument while the operator depresses a button that electrically opens the two valves. When the subject has reached the last (alveolar) phase of a forced exhalation, the operator

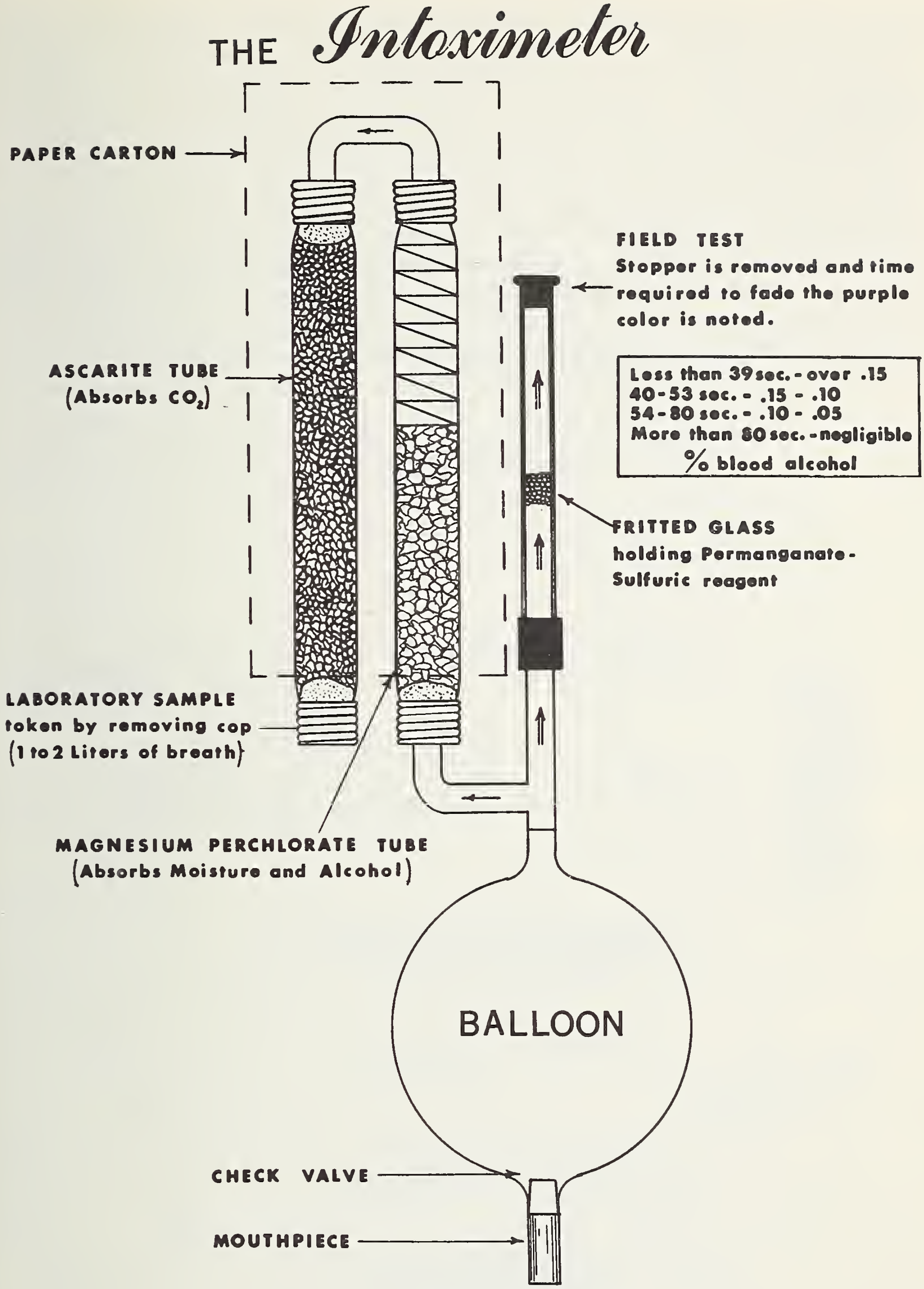

Figure 8

releases the button and the solenoid valves close, trapping 12 ml of breath. A stream of carefully cleaned room air is pumped through the sample chamber and forces the breath sample through a column of pumice granules coated with iodine pentoxide heated to a temperature of about 170° C. Any alcohol in the breath sample will be energetically and quantitatively oxidized by the iodine pentoxide, releasing free iodine in proportion to the amount of alcohol. This iodine vapor is pumped into a solution of starch and potassium iodide in which a blue color is developed in proportion to the amount of iodine released by the oxidation of alcohol in the breath sample.

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Light is then passed through the starch solution and falls on a self-generating photoelectric cell, measuring the blueness of the solution. This "blueness" is converted to percent blood alcohol on a direct-reading meter on the panel of the instrument. This whole process is controlled by an interlocked-cam-timing arrangement, making errors practically impossible in the sequence of operation.

The operator has only three things to do other than push buttons. First, he must replace the solution, furnished in sealed vials, for each test. Second, he must adjust the range of the instrument for "High" and "Low" before the test. Third, he must procure a proper sample from the subject. Other than this he has little control over the process. This is the most automatic of the breath methods. Like the other methods described, it is not affected by mouth odors produced by various foods, but it is sensitive to the ketones that may be present in the breath of diabetics.

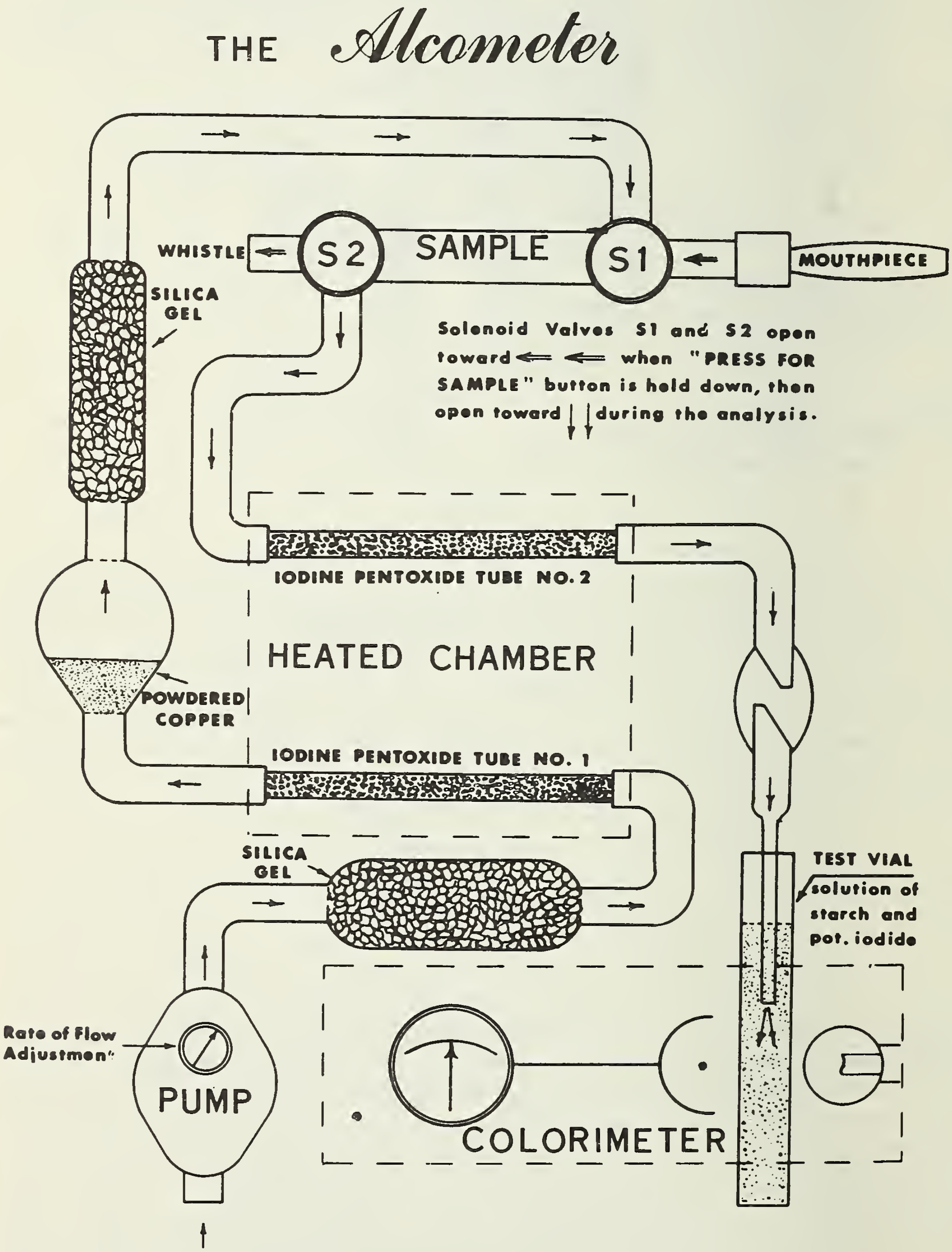

Figure 9

The Breathalyzer. The Breathalyzer is a photoelectric instrument employing the measurement of the change of blue-light transmittance in a solution of potassium dichromate caused by oxidation of the alcohol from a fixed volume of alveolar air. The method consists of three principal phases. In the first, the subject blows through a saliva-trap mouthpiece into a tube leading to the bottom of a metal cylinder. The force of the breath raises a piston to a point above vent holes. The first breath exhausts and 52.5 ml of the last (alveolar) air leaving the subject's mouth is trapped below the piston. In the second phase, a valve is reversed and the weight of the piston forces the fixed amount of alveolar air through a solution of potassium dichromate, sulfuric acid, and water. The oxidation of alcohol from the breath sample increases the blue-light transmittance of the solution. In the third phase, the color change in this solution is measured by a specially designed photoelectric photometer comprising two photovoltaic cells connected in opposition, one mounted back of the test ampoule and the other back of a similar ampoule used for comparison. The two photocells face each other. Before the test, a light on a movable track is adjusted back and forth between the two ampoules. There is one point at which the light reaching the photocells through the ampoules is equal and no current flows. A null meter connected across the circuit shows this balance point. Any change in the transmittance of the test solution caused by alcohol in the breath sample produces an imbalance in the circuit. The distance through which the light must be moved to restore the balance is indicated on a dial calibrated in percent blood alcohol. This photometer compensates for variation in strength of the test solution and for line voltage changes. The Breathalyzer may be used on alternating current or on direct current from an automobile battery.

Under the conditions of use of the sulfuric acid-potassium dichromate solution in this instrument, acetone that may be present in the breath of diabetics will not affect the test. There is no effect from odors on the breath caused by various foods.

The Photoelectric Intoximeter. The last instrumental method that has been announced is the Photoelectric Intoximeter. This instrument employs two sample chambers, similar to that used in the Breathalyzer, connected in series. One is of 105-ml and the other of 210-ml capacity. The subject fills both of them by blowing through a tube leading to the smaller of these sample chambers, the excess breath passing through a complex valve into the larger chamber. By reversing the valve, the two samples thus collected are passed into different solutions: (1) the 105-ml sample, into a solution of potassium dichromate, sulfuric acid, and water in an ampoule; and (2) the 210-ml sample, into a tube containing magnesium perchlorate. After heating the ampoule by placing it above a light bulb to complete the oxidation of the alcohol, the change in yellowness of the dichromate solution is measured in a modified Klett-Summerson colorimeter, a null-type instrument balancing the change in transmittance caused by the alcohol in breath by a variable resistance in one side of the circuit. The colorimeter is an integral part of the instrument. The variable resistance is calibrated to show the change in the output of the photocell behind the test ampoule. The calibration is in percent blood alcohol. The magnesium perchlorate tube containing the alcohol from the breath delivered by the second (210 ml) sample chamber can be retained for confirmatory analysis in a chemist's laboratory. Like the others, this instrument is not affected by the various food odors on the breath. The chemist's test is as specific as the analytical procedure will permit it to be.

The answers in both the Breathalyzer and the Photoelectric Intoximeter are based on the photoelectric measurement of the change in yellowness of a solution of potassium dichromate and sulfuric acid. The Breathalyzer employs a self-compensating photometer, geometrically designed to render the system independent of the dichromate strength of the solution, making possible duplicate tests in the same solution, and centering confidence in the stability of the instrumental test. The Photoelectric Intoximeter provides a second sample for later laboratory confirmation. These are two approaches intended to achieve the same thing—confidence.

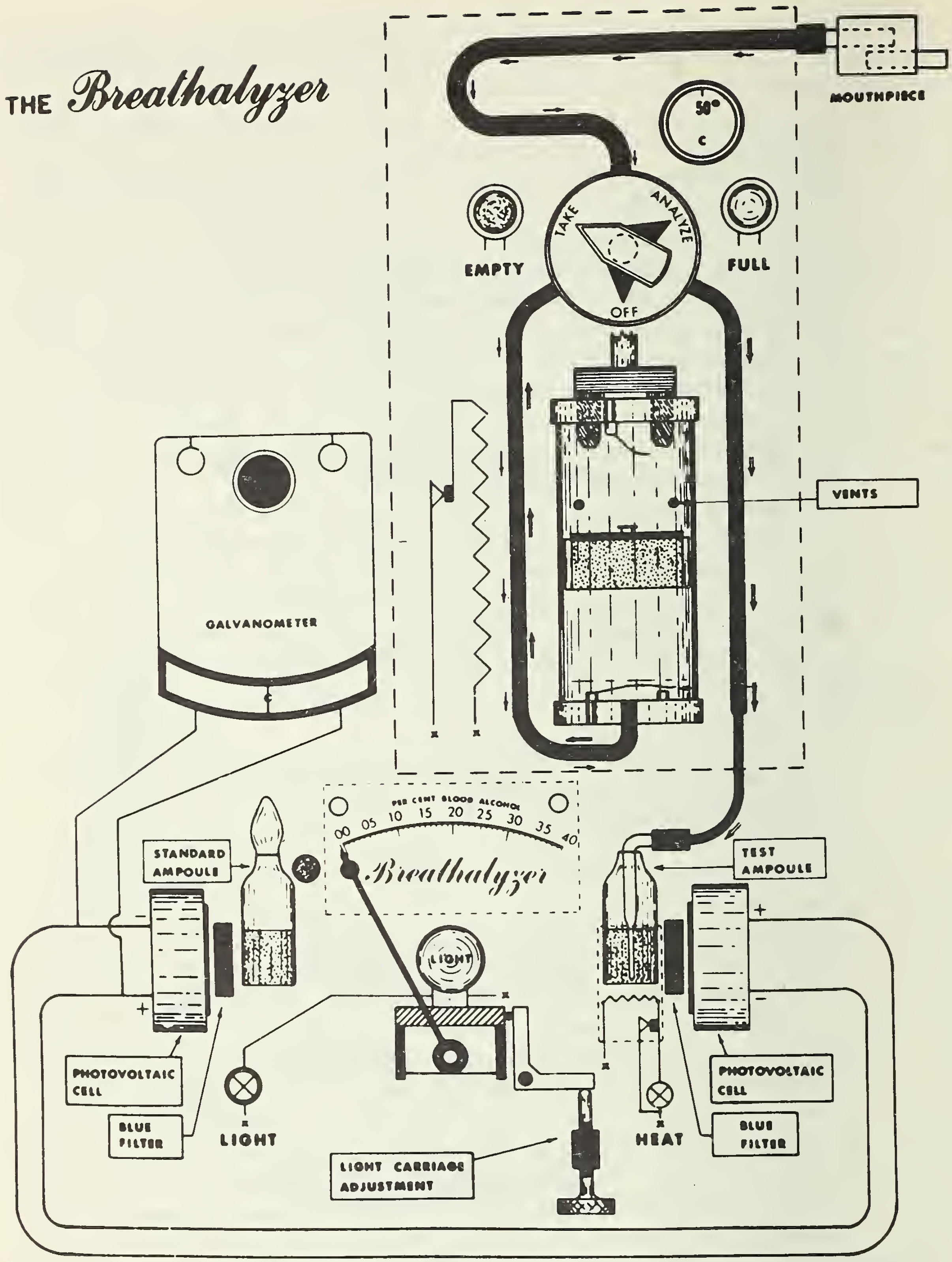
THE Breathalyzer
MOUTHPIECE
50°
C
TAKE
ANALYZE
OFF
EMPTY
FULL
VENTS
GALVANOMETER
PER CENT BLOOD ALCOHOL
00 05 10 15 20 25 30 35 40
Breathalyzer
STANDARD AMPOULE
TEST AMPOULE
LIGHT
PHOTOVOLTAIC CELL
BLUE FILTER
LIGHT
HEAT
LIGHT CARRIAGE ADJUSTMENT
PHOTOVOLTAIC CELL
BLUE FILTER

Figure 10

THE *Intoximeter* photoelectric

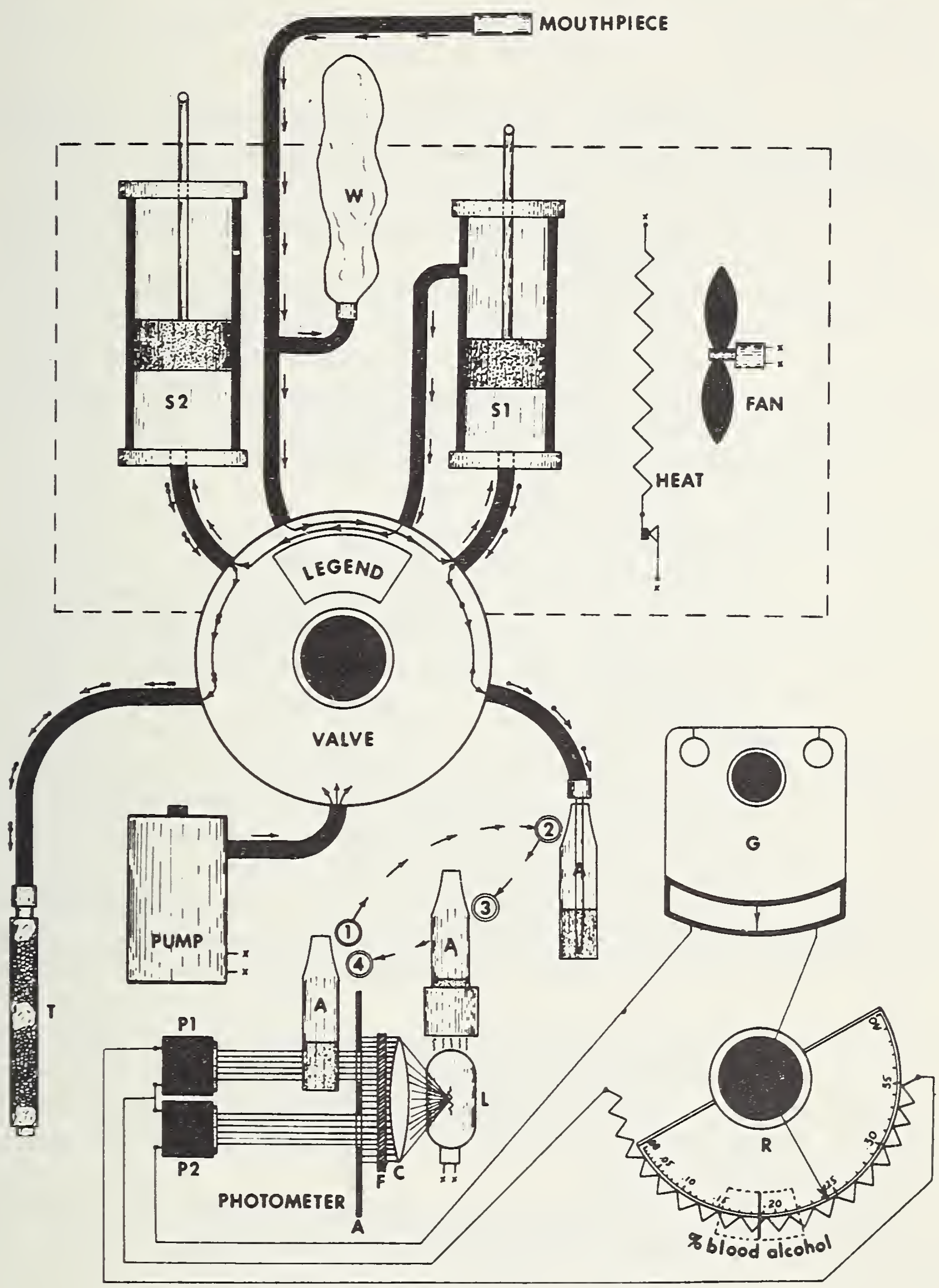

Figure 11

References

1. American Railway Association. Cited by E. H. Cherrington (Ed.), *Standard encyclopedia of the alcohol problem.* Vol. 6. Westerville, Ohio: Amer. Issue, 1930. P. 2661.
2. Anstie, F. E. Final experiments on the elimination of alcohol from the body. *Practitioner*, 1874, **13**, 15–28. (Used 0.66 percent $K_2Cr_2O_7$ in concentrated H_2SO_4 as ethanol reagent for analysis of body materials.)

3. Atkinson, S. B. Medico-legal relations of alcoholism. In T. N. Kelynack (Ed)., *The drink problem in its medico-sociological aspects.* New York: Dutton, 1907. Pp. 108–121.
4. Bjerver, K., Bonnichsen, R. K., Goldberg, L., and Theorell, H. Determination of ethyl alcohol by crystallized alcohol dehydrogenase. In *Proceedings of First International Conference on Alcohol and Road Traffic.* Stockholm: Kugelbergs Boktryckeri, 1951. Pp. 124–127.
5. Bjerver, K., and Goldberg, L. Effect of alcohol ingestion on driving ability. Results of practical road tests and laboratory experiments. *Quart. J. Stud. Alc.,* 1950, **11,** 1–30.
6. Bogen, E. Drunkenness. A quantitative study of acute alcoholic intoxication. *J. Amer. med. Ass.,* 1927, **89,** 1508–1510.
7. Bogen, E. Tolerance to alcohol: its mechanism and significance. *Calif. West. Med.,* 1936, **44,** 262–270.
8. Bonnichsen, R. K., and Theorell, H. An enzymatic method for the micro-determination of ethanol. *Scand. J. clin. Lab. Invest.,* 1951, **3,** 58–62. (Proposed a specific quantitative enzymne-microdetermination method for alcohol employing yeast-derived ADH at pH 8.6–pH 9.2.)
9. Borkenstein, R. F. Unpublished data, 1958.
10. Borkenstein, R. F. Unpublished data.
11. *Breihaupt* v. *Abram,* 352 U.S. 432, 77 S. Ct. 408 (1957).
12. Bücher, T., and Redetzki, H. Eine spezifische photometrische Bestimmung von Äthylalkohol auf fermentativem Wege. (A specific photometric determination of ethanol using fermentation techniques.) *Klin. Wschr.,* 1951, **29,** 615–616. (Derived ADH at pH 8.6.)
13. California Highway Patrol. *The drinking driver* (Enforcement Guide). Sacramento, Calif.
14. Carlson, A. J., Kleitman, N., Muehlberger, C. W., McLean, F. C., Gulickson, H., and Carlson, R. B. *Studies on the possible intoxicating action of 3.2 percent beer.* Chicago: Univ. of Chicago Press, 1934.
15. Chastain, J. D., Strauss, H. J., and Maupin, C. W. *A correlation study of blood alcohol levels as determined by Alcometer, Breathalyzer and direct blood analysis including blood-urine alcohol ratio.* Austin: Tex., Department of Public Safety, 1957.
16. Coldwell, B. B. (Ed.) *Report on impaired driving tests.* Ottawa: Crime Detection Laboratory, Royal Canadian Mounted Police; Queen's Printer, 1957.
17. Connecticut Motor Vehicle Commission. Cited by E. H. Cherrington (Ed.), *Standard encyclopedia of the alcohol problem.* Vol. 6. Westerville, Ohio: Amer. Issue, 1930. P. 2663.
18. Conrad, E. Push-button evidence. *Virginia Law Rev.,* 1955, **41,** 232–236.
19. Cushny, A. R. On the exhalation of drugs by the lungs. *J. Physiol.,* 1910, **40,** 17–27.
20. Data held vague in auto accidents. *New York Times,* Aug. 24, 1958. P. 119.
21. Drew, G. C., Colquhoun, W. P., and Long, Hazel A. Effect of small doses of alcohol on a skill resembling driving. *Traffic Safety Res. Rev.,* 1959, **3**(4), 4–11.
22. Eggleton, M. Grace. Psychological tests and blood alcohol levels. In *Proceedings of the Second International Conference on Alcohol and Road Traffic.* Toronto: Brewers' Warehousing Co., Ltd., 1955. Pp. 103–107.
23. Fitzgerald, Mabel P., and Haldane, J. S. The normal alveolar carbonic acid pressure in man. *J. Physiol.,* 1905, **32,** 486–494. (Noted the approximate constant carbon dioxide concentration of normal alveolar air as 5.5 percent of volume.)
24. Ford, H. Cited by E. H. Cherrington (Ed.), *Standard encyclopedia of the alcohol problem.* Vol. 6. Westerville, Ohio: Amer. Issue, 1930. P. 2664.

25. Forrester, G. C. *Photoelectric Intoximeter manual.* Niagara Falls, N.Y.: Intoximeter Association, 1958.
26. Forster, B. Elektronystagmographische Untersuchungen über den Drehbeschleunigungsnystagmus nach Alkoholgaben. (Electronystagmic investigation of rotational nystagmus after alcohol ingestion.) *Dtsch. Z. ges. gerichtl. Med.,* 1958, **47,** 282–288.
27. Friedemann, T. E. The direct determination of ethyl alcohol in saliva without distillation. *Proc. Soc. exp. Biol., N.Y.,* 1938, **37,** 686–689.
28. Goldberg, L. Quantitative studies on alcohol tolerance in man. The influence of ethyl alcohol on sensory, motor, and psychological functions referred to blood alcohol in normal and habituated individuals. *Acta physiol. scand.,* 1943, **5,** Suppl. 16.
29. Greenberg, L. A., and Keator, F. W. A portable automatic apparatus for the indirect determination of the concentration of alcohol in the blood. *Quart. J. Stud. Alc.,* 1941, **2,** 57–72.
30. Gréhant, N. Injection d'alcool éthylique dans le sang veineux. (Injection of ethyl alcohol into venous blood.) *C.R. Acad. Sci., Paris,* 1895, **120,** 1154–1155. (Demonstrated ethanol distribution to all organs following injection into the bloodstream.)
31. Grosskopf, K. Technische Untersuchung von Gasen und Flüssigkeiten durch chromometrische Gasanalyse. (Technical analysis of gases and liquids by chromometric gas analysis.) *Angew. Chem.,* 1951, **63,** 306–311.
32. Haddon, W., Jr., and Bradess, Victoria A. Alcohol in the single vehicle fatal accident. *Traffic Safety Res. Rev.,* 1959, **3** (3), 4–9.
33. Haggard, H. W., and Greenberg, L. A. Studies in the absorption, distribution, and elimination of ethyl alcohol. II. The excretion of alcohol in urine and expired air; and the distribution of alcohol between air and water, blood, and urine. *J. Pharmacol.,* 1934, **52,** 150–166.
34. Hall, J. *General principles of criminal law.* (2d ed.) Indianapolis: Bobbs-Merrill, 1961. (A careful reading of this scholarly work is recommended to all thoughtful persons.)
35. Harger, R. N. Paper read at meeting of Amer. Chem. Soc., Indianapolis, 1931. Reported in Science—Supplement (Science News), *Science,* Apr. 3, 1931, **73** (Whole No. 1892), p. 10.
36. Harger, R. N. A simple micromethod for the determination of alcohol in biologic material. *J. Lab. clin. Med.,* 1935, **20,** 746–751.
37. Harger, R. N., Forney, R. B., and Baker, R. S. Estimation of the level of blood alcohol from analysis of breath. II. Use of rebreathed air. *Quart. J. Stud. Alc.,* 1956, **17,** 1–18.
38. Harger, R. N., Lamb, E. B., and Hulpieu, H. R. Rapid chemical test for intoxication employing breath: a new reagent for alcohol and a procedure for estimating the concentration of alcohol in the body from the ratio of alcohol to carbon dioxide in the breath. *J. Amer. med. Ass.,* 1938, **110,** 779–785.
39. Harger, R. N., Raney, B. B., Bridwell, E. G., and Kitchel, Mary F. The partition ratio of alcohol between air and water, urine and blood; estimation and identification of alcohol in these liquids from analysis of air equilibrated with them. *J. biol. Chem.,* 1950, **183,** 197–213.
40. Heise, H. A. The specificity of the test for alcohol in body fluids. *Amer. J. clin. Path.,* 1934, **4,** 182–188.
41. Heise, H. A., and Halporn, B. Medicolegal aspects of drunkenness. *Penn. med. J.,* 1932, **36,** 190–195.
42. Holcomb, R. L. Alcohol in relation to traffic accidents. *J. Amer. med. Ass.,* 1938, **111,** 1076–1085.

43. Immermann, H. Ueber den Schwindel bei Erkrankungen der hinteren Schadelgrube und seine Abhängigkeit von reellen Schwankungen des Rumpfes. (On vertigo-producing illnesses of the posterior cranial fossa and their dependence on actual bodily sway.) *Dtsch. Arch. klin. Med.*, 1866, **1**, 595–615.
44. Indiana General Assembly, Acts of, 1939. Ch. 48, art. 5, sec. 54(2).
45. Jetter, W. W., Moore, M., and Forrester, G. C. Studies in alcohol. IV. A new method for determination of breath alcohol. Description and examination of the perchlorate method for breath alcohol determinations. *Amer. J. clin. Path., tech. Suppl.*, 1941, **5**, 75–89.
46. Kobayashi, Y. Gas analysis by means of detector tubes. VIII. Rapid method for the determination of ethyl alcohol and methanol in air. *J. chem. Soc. Japan* [Ind. Chem. Sect.], 1953, **56**, 526–527.
47. Larsen, G. New breath test method. *Traffic Dig. and Rev.*, 1954, **2**(11), 2–5.
48. Legislators join a liquor patrol. *New York Times*, Mar. 18, 1962. P. 68.
49. Liebig, J. Ueber die Producte der Oxydation des Alkohols. (On the oxidation products of alcohol.) *Liebigs Ann.*, 1835, **14**, 133–167. (Described oxidation of ethanol by acid dichromate.)
50. Liljestrand, G. Till frägan om läkarundersökning rörande alkoholpåverkan. (Concerning the question of medical examinations with regard to the influence of alcohol.) *Tirfing*, 1940, **34**, 97–105. Cited by L. Goldberg, Tolerance to alcohol in moderate and heavy drinkers and its significance to alcohol and traffic. In *Proceedings of First International Conference on Alcohol and Road Traffic.* Stockholm: Kugelbergs Boktryckeri, 1951. P. 88.
51. Liljestrand, G., and Linde, P. Über die Ausscheidung des Alkohols mit der Exspirationsluft. (On the identification of alcohol by expired air.) *Skand. Arch. Physiol.*, 1930, **60**, 273–298.
52. Liquor laws stiff in Sweden. *New York Times*, Apr. 5, 1959. P. 46.
53. Lloyd, J. T. *Lloyd's steamboat directory.* Cincinnati: J. T. Lloyd, 1856.
54. Loomis, T. A., and West, T. C. The influence of alcohol on automobile driving ability. An experimental study for the evaluation of certain medicological aspects. *Quart. J. Stud. Alc.*, 1958, **19**, 30–46.
55. Mason, M. (Dallas, Tex.) Report of Toxicology Section, American Academy of Forensic Sciences, February 1960.
56. McKenney, S. M. (LaMotte Chem. Prod. Co., Chestertown, Md.) Personal communication.
57. Michigan State Statutes; Rules for the Recorder's Court of the City of Detroit. Clerk's Office, Detroit, Mich., 1938.
58. Moore, L. S. (Police Department, Louisville, Ky.) Lecture given at Southern Police Institute, May 9, 1955.
59. Muehlberger, C. W. (Lansing, Mich.) Personal communication.
60. National Road Safety Organization, Sweden. The national campaign "No alcohol while driving." In *Proceedings of First International Conference on Alcohol and Road Traffic.* Stockholm: Kugelbergs Boktryckeri, 1951. Pp. 309–314.
61. National Safety Council, Committee on Alcohol and Drugs. October 1959 meeting.
62. National Safety Council, Committee on Tests for Intoxication. 1938 report.
63. Newman, H. Paper presented in Panel on Interpretation and Medical Aspects. In *Proceedings of the Symposium on Alcohol and Road Traffic.* Bloomington, Ind.: Department of Police Administration, Indiana University, 1959. Pp. 185–195.
64. New York Vehicle and Traffic Law of 1929, Sec. 71(a), as added by L. 1953, c. 854.

65. Nicloux, M. Dosage de l'alcool éthylique dans des solutions ou cet alcool dilué dans des proportions comprises entre 1/500 et 1/3000. (Dosage of ethyl alcohol in solutions or of such alcohol diluted in proportions between 1:500 and 1:3000.) *C.R. Soc., Biol., Paris,* 1896, 10th series, Book III, 841–843.
66. Order of Railroad Conductors et al. Reported by E. H. Cherrington (Ed.), *Standard encyclopedia of the alcohol problem.* Vol. 6. Westerville, Ohio: Amer. Issue, 1930. P. 2662.
67. Police Department, Tucson, Ariz. General Order, Dec. 28, 1957.
68. Purves-Stewart, J. Cited by E. H. Cherrington (Ed.), *Standard encyclopedia of the alcohol problem.* Vol. 6. Westerville, Ohio: Amer. Issue, 1930. P. 2664.
69. *Reitz* v. *Mealey,* 314 U.S. 33 (1941). "Any appropriate means adopted by the states to insure competence and care on the part of its licensees and to protect others using the highway is consonant with due process." See also: *Bailey* v. *Smith,* 40 F. 2d 958, 959 (1928), and *Hendrick* v. *Maryland,* 235 U.S. 610, 622 (1915).
70. Sheehe, G. H., Frost, J. K., and Nafus, R. *What are your chances?* E. Lansing: Michigan State University, School of Police Administration, 1955.
71. Shupe, L. M., and Dubowski, K. M. Ethyl alcohol in blood and urine; a simple photometric method for its forensic determination. *Amer. J. clin. Path.,* 1952, **22,** 901–910.
72. Smith, H. W., and Popham, R. E. Accident contribution of drivers as a function of their blood alcohol levels. In *Proceedings of First International Conference on Alcohol and Road Traffic.* Stockholm: Kugelbergs Boktryckeri, 1951. Pp. 150–151.
73. *Steffani* v. *State,* 45 Ariz. 210, 42 P. 2d 615 (1935).
74. Stevenson, G. Cited by E. H. Cherrington (Ed.), *Standard encylopedia of the alcohol problem.* Vol. 6. Westerville, Ohio: Amer. Issue, 1930. P. 2661.
75. *Stockton et al.* v. *Bishop,* 45 U.S. (4 How.) 155 (1846).
76. Subbotin, V. Ueber die physiologische Bedeutung des Alkohols für den thierischen Organismus. (On the physiological significance of alcohol for the animal organism.) *Z. Biol.,* 1871, **7,** 361–378. (Proposed the determination of ethanol by oxidation with chromic acid to acetic acid and titration of the acetic acid.)
77. Turner, R. F., Bennett, W. B., Cestaric, E. S., and Muehlberger, C. W. *Evaluating chemical tests for intoxication.* Chicago: Committee on Tests for Intoxication, National Safety Council, 1953.
78. Turner, R. F., Heise, H. A., and Muehlberger, C. W. Interpretation of tests for intoxication. In *Chemical tests for intoxication manual.* Committee on Medicolegal Problems, American Medical Association, 1959. Pp. 57–61.
79. Uniform Vehicle Code, Sec. 11–902. Washington, D.C.: National Committee on Uniform Traffic Laws and Ordinances, 1956.
80. Van Doorn, W. (Holland-American Line). Cited by E. H. Cherrington (Ed.), *Standard encyclopedia of the alcohol problem.* Vol. 6. Westerville, Ohio: Amer. Issue, 1930. P. 2663.
81. Vierordt, K. *Grundriss der Physiologie des Menschen.* (Fundamentals of the physiology of man.) Tübingen: H. Laupp'schen Buchhandlung, 1864.
82. Widmark, E. M. P. Om alkoholens öfvergång i urinen samt om en enkel, kliniskt användbar metod för diagnosticering af alkoholförekomst i kroppen. (On the role of alcohol in the urine and also about some clinically usable method for diagnosing the occurrence of alcohol in the body.) *Uppsala LäkFören. Förh.,* 1914, 19 N.F., 241–273.

83. Widmark, E. M. P. Über die Konzentration des genossenen Alkohols in Blut und Harn unter verschiedenen Umständen. (On the concentration of ingested alcohol in blood and urine under various conditions.) *Skand. Arch. Physiol.*, 1915, **33**, 85–96.
84. Widmark, E. M. P. Eine Mikromethode zur Bestimmung von Äthylalkohol im Blut. (A micromethod for determining ethyl alcohol in blood.) *Biochem. Z.*, 1922, **131**, 473–484.
85. Widmark, E. M. P. *Die theoretischen Grundlagen und die praktische Verwendbarkeit der gerichtlich-medizinischen Alkoholbestimmung.* (The theoretical fundamentals and the practical application of forensic-medical alcohol determination.) Berlin: Wien, Urban & Schwartzenberg, 1932.

CHAPTER VII

Motivational and Educational Aspects of Drinking-Driving

DONALD CAHALAN [1]

Introduction

The first requirement of any educational campaign is to define the problems to be solved and to describe the special characteristics of the potential audience. Thus our primary concern at this point is not with whether specific educational and motivational techniques do or do not work, but rather to set forth *principles* which may serve as guidelines to an effective long-term program to cope with drinking-driving.

Regarding the "drinking-driving problem," even a cursory investigation shows that it is really *two* problems—the drinking problem and the driving problem—which have deep roots in the modern American culture and are not lightly to be disposed of, even by some multibillion-dollar "drive" such as we have seen in public health or in commercial advertising. A review of the background of the problem is needed before prescribing remedies, both to know the size of the problem and to infer what types of approaches will help to reduce the seriousness of consequences of mixing alcohol and gasoline.

Drinking and Driving is a Sizable Problem, Though Statistics Are in Dispute

As regards *automobile* accidents in toto, the Public Health Service reports in recent years a total of about 2 million disabling injuries (*50*) and about 38,000 deaths (*51*) per annum, with not much change in the number of deaths during these years.

[1] While the author has had the full responsibility for the preparation of this paper, the contributions of the following participants in a preliminary U.S. Public Health Service conference Oct. 3–4, 1960, are gratefully acknowledged: David H. Barnes, San Francisco State College; Ira H. Cisin, George Washington University; John L. Finan, George Washington University; Raymond Fink, Health Insurance Plan of Greater New York; and Harold Mendelsohn, University of Denver.

As regards *drinking* in toto, Greenberg (*17*) says, "If education is to serve effectively in meeting a solution to the problem of drinking and driving, it must deal with the facts of reality. One fact of reality is that there are some 80 million adults in the United States who drink beverages containing alcohol, on a multitude of different occasions and in different degrees of moderation. Of these adults a very large proportion operate motor vehicles." A Gallup poll of May 1960 (*3*) reported that about 62 percent of Americans drink beer, wine, or liquor at least occasionally. A New York metropolitan area survey conducted by W. R. Simmons & Associates in 1958 (*44*) found that 71 percent of New York area households served alcoholic beverages "within the last month." And Patrick (*43*) cites statistics that indicate that about 60 percent of the men and one-third of the women said they used alcoholic beverages, or about 43.5 percent of those 15 to 60 years of age; and that of those who reported they drank, 80 percent said they used alcohol at least once a week.

As we will see, the proportion of drivers who drink is much in dispute; but growing official concern about the problem is evident in such statements as that of FBI Director J. Edgar Hoover (*20*): "Traffic regulations, as they should be, are the responsibilities of the various State and local governments. Indifference and the lack of positive action to reduce traffic fatalities, however, have brought on considerable talk of Federal intervention." This is a probable reference to his proposals for setting up a national clearinghouse for recording driver's license suspensions or revocations stemming from drunken and reckless driving. Mr. Hoover noted that in some States drunken driving is classed as a simple misdemeanor, involving a light penalty and no suspension of the driving privilege. He added, "It would appear just as logical to free a crazed man who had been firing a gun on a crowded street and return his weapon to him."

Certainly if one looks to the future of American traffic conditions, there would seem to be special need for greater control of use of alcohol among drivers. While it may be that in a maturing society there is less tendency for people to drink grossly to excess, there are mounting dangers inherent in the much faster speeds and the complexities of traffic tomorrow, just as there are more road hazards today than there were 20 years ago.[2] Consequently, any programs of education and of law enforcement need to take into account the future needs of the society, so as to cope with the problems of tomorrow through techniques which will be appropriate to these problems.

However, Experience Shows People Can Cooperate in Traffic Control

The prospects for ultimate effectiveness of programs of education and law enforcement to control the use of alcohol on the part of drivers are

[2] "Motor-vehicle registrations have more than doubled since 1945, and the forecast is for over two new vehicles on the road for every three additional Americans; by 1975 the United States will have over 100 million vehicles for a population of 220 million" (*8*, p. 41).

indeed bright, if we look at instances in the past. While it may seem that the cake of custom is indeed very hard when it comes to such basic "rights" as driving as one pleases, we must remember that people from abroad express amazement at the discipline we exhibit in traffic control. Further, at various times it has been said that the people of Memphis (Tenn.), Paris, and New York would never give up raucous hornblowing; yet in a relatively short time with local ordinances and a minimum of public education, loud hornblowing has almost ceased in these cities. While analogies can be dangerous, past experience with traffic control has shown that with the right kinds of enforcement and education working together, acceptable solutions to many traffic problems can be found.

Much Research Needs To Be Done on the Actual Consequences of Mixing Alcohol and Gasoline Before We Can Have an Effective Enforcement and Educational Program

If the people who are most concerned with the problems of enforcement and education are so often in dispute as to what are the basic facts of the consequences of drinking and driving, or how the facts are to be interpreted, we scarcely can expect the general public to cooperate in any campaign with real enforcement teeth in it. Some of the areas of the problem on which all agree there needs to be more research—or at least more agreement on how the available facts should be interpreted—are as follows:

1. *There is disagreement on basic accident and death rates.* As one instance, Daniel P. Moynihan (*38*), a former chairman of the New York State Traffic Safety Policy Coordination Committee, says:

> By concentrating on deaths and the death rate, the Safety Council helps sustain an illusion of progress in the field of traffic safety, for it is quite true that the number of deaths per year has tended to decline slightly of late, and that the death *rate*—defined as the number of fatalities per hundred million miles of travel—has been declining steadily for thirty years. . . . But what brought about the decline? There is certainly no evidence that it was accomplished by any form of safety program—or even that the figures will be as low next year.
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> The most probable explanation of the declining death rate is that doctors are simply getting better at keeping people alive, so that fewer victims die of trauma whether on the battlefield or the highway. Furthermore, the Council's concentration on death distracts attention from the fact that automobile accidents maim their victims much more frequently than they kill them. For every death there are 125 injuries . . . . And both the number and the rate of injuries have been rising. . . .
>
> . . . the probable number of automobile injuries is at least three and a half times the figure published by the National Safety Council.

Further, before one can set up an effective program for controlling driving under the influence, the authorities need to make clearer their policies as to what standards of control are essential, and what are the costs of meeting those standards.

2. *There is disagreement on the proportion of drinking drivers and effects of drinking.* At the one extreme, perhaps, there is the implication that use of alcohol may be a relatively minor factor in accidents by citing Na-

tional Safety Council data for drivers who were violating some law at the time of a fatal accident. Licensed Beverage Industries, Inc., the association for the alcoholic beverage industry, in its pamphlet, "New Perspectives on Highway Safety" (*40*), says:

Here, compiled from National Safety Council data, are the principal violations, and the frequency of each violation per 100 drivers in fatal accidents in 1955:

Excessive speed	31
Failure to keep right of center line	9
Did not have right of way	7
Disregard of sign or signal	6
Under influence of alcohol	6
Improper passing	3
Other violations	9

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These figures place several facts in perspective.

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[Including] . . . that the driver who is "under the influence of alcohol"—that is, intoxicated in the legal sense—is not as great a factor in fatal accidents as he has sometimes been presumed to be.

The pamphlet goes on:

To say this is not to suggest that the driver who is found to be under the influence of alcohol is a negligible factor in accident causation. . . .

But at the same time, no purpose can be served by claiming—as some have done—that the number of persons who operate motor vehicles while under the influence of alcohol is greater than it actually is. To do so, in fact, is to draw a "red herring" across the path of accident investigation and prevention.

The National Safety Council (*2*) reports that for 1959 one out of every five drivers involved in a fatal motor-vehicle accident had been drinking, and that nearly one out of every three fatal accidents involved a drinking driver. Fragmentary reports from individual States indicated such a range of reported incidence of drinking drivers for 1959 and 1958—all the way from 30 percent to 67 percent—that it is self-evident the statistics from the various States are compiled on such different bases as to render any comparisons almost completely unreliable.

Not only are the available statistics questionable, but many experts appropriately quarrel with the implications of the statistics. The Licensed Beverage Industries, Inc., comments that statistics on the proportions of drivers who had been drinking prior to an accident—

. . . reveals almost nothing regarding accident causation—particularly since individual reactions to alcohol vary widely. But it points to the need for research to determine what motivates the individual under these circumstances, how he behaves, and whether the fact that he "has been drinking" plays any part in determining his behavior (*40*).

The same point of view is given by Greenberg (*17*):

The large amount of statistics . . . during recent years has dealt almost exclusively with the proportion of drivers involved in accidents who had been drinking and had various degrees of alcohol content in their blood. . . . In any estimation of the dimensions of the problem of the drinking driver, it is, indeed, essential to know to what extent various contents of alcohol in the blood cause accidents. . . . Is the proportion of drinking operators and at various levels of blood alcohol content significantly different in the accident population from that in the general driving population?

One approach to zeroing in on the contribution of alcohol to traffic accidents is that of Holcomb (*19*), whose random roadside tests utilizing a breath-measuring device found about 12 percent of drivers in general to have been drinking, in contrast to 47 percent of those involved in personal injury accidents. He found, "As the blood alcohol content increases, the number of drivers appearing in the personal injury accident group increases out of all proportion over that in the general driving population." Whereas it is not the mission of this chapter to dwell in detail upon the exact designs needed for research into effects of alcohol upon driving, it would appear that more work along the lines pioneered by Holcomb will help build the confidence of the laymen and the law enforcement agencies in research into the effects of alcohol and thus make educational campaigns more successful.

3. *Much is still unknown about the characteristics of the drinking driver, thus making it more difficult to prescribe remedial education.* To cite Greenberg (*17*) again:

> Approaches to the problem of the drinking driver have usually been made as if the offenders were all part of an homogeneous population with respect to such matters as how they drink, where they drink and why they drink. . . . Who are the offenders—are they young or old, are they typically of this or that economic, social, nationality origin, occupational, marital, educational or other status? Virtually no information on these matters has been sought or is known. If there is a definite patterning according to these or similar criteria (and it would be most surprising if there were not), it is clear that preventive techniques, especially in education, to be effective would have to be fitted to those one wished to reach. Programs which might be effective for middle-aged couples of lower-middle income brackets who went to a tavern in their own town are different from the "country club" set, different from the college boy on a spree. It is fairly obvious that whether enforcement or education is to be used, the same technique would hardly be effective in all instances.

The task of identifying the characteristics of the prime offenders can be simplified by application of experience with models of behavior of other kinds. It has been the writer's experience that on many behavior characteristics, about 10 to 15 percent of the population tend to account for from one-third to 40 percent of the behavior: For example, about 15 percent of the clothes buyers purchase more than 40 percent of the clothing; and about 20 percent of the drivers buy about 40 percent of the automobiles. It thus would appear most economical to try first to see whether it were possible to isolate some small fraction of the drivers who may be accounting for a disproportionately high share of the driving after drinking. Cisin has observed that *if* 20 percent of the people consumed 40 percent of the alcohol and if 20 percent of the people drove 40 percent of the miles covered, then even if drinking and driving were independent factors it would be likely to turn out that a certain proportion of the population would be doing much more than their share of the driving after drinking. Thus, looking for "repeaters" appears to be a promising approach, even though the absolute number of such cases might not be particularly large.

All of the foregoing underscores the relevance to educational efforts regarding drinking-driving of the statement by the House Subcommittee on Traffic Safety (*48*): "There is ample evidence . . . that improvements in driver licensing, driving training, enforcement, administration of traffic courts, and public education are greatly needed and can be developed through the support of research in these areas."

Agreement Upon the Criteria for Law Enforcement Regarding Drinking-Driving Needs To Be More Unanimous Before a Public Education Campaign Can Succeed

It will be shown that the experts are in fair agreement as to the *approximate* levels of blood alcohol which should constitute prima facie evidence of being under the influence, and that most are in favor of chemical rather than behavioral tests for drivers.[3] However, the position is here taken that there remains enough difference of opinion among experts as to details of law enforcement as to provide grounds for considerable confusion and noncooperation on the part of the lay public until such time as the authorities in the field themselves get together to present a united front.

The Symposium on Alcohol and Road Traffic, held at Indiana University in December 1958, resolved that it be considered established that a blood

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[3] From *Chemical Tests for Intoxication Manual,* prepared by the Committee on Medicolegal Problems, American Medical Association (*18*):

"The breath method of determining alcohol concentration in the blood was first used in 1927, and by 1938 a portable apparatus known as the Drunkometer had been developed. At least five other devices have since been developed to test the breath of individuals suspected of being intoxicated. They are the Breathalyzer, Intoximeter, Drunkotester, Alcotester, and the Alcometer.

* * * * * * *

"The use of chemical tests for determining intoxication is recommended by many national organizations including the following:

"1. American Medical Association.
"2. National Safety Council.
"3. International Association of Chiefs of Police.
"4. American Bar Association.
"5. American Association of Motor Vehicle Administrators.
"6. National Committee on Uniform Traffic Laws and Ordinances.
"7. The President's Highway Safety Conference.
"8. American Automobile Association.
"9. Federal Bureau of Investigation.
"10. Licensed Beverage Industries.

"Chemical tests for determining intoxication are known to be used in the following countries:

"Australia, Belgium, Canada, Czechoslovakia, Denmark, Finland, France, Germany, Greece, Iceland, Japan, the Netherlands (Holland), Norway, Sweden, Switzerland, and the United States."

alcohol concentration of 0.05 percent will definitely impair the driving ability of some individuals, and that at a level of 0.10 percent the driving ability of all individuals would be considered to be definitely impaired (*47*). The Insurance Institute for Highway Safety (*16*) cites the nationally recommended Uniform Vehicle Code which provides that 0.05 percent or less (by weight) of alcohol in the blood shall be presumptive evidence that the defendant is *not* under the influence of intoxicating liquor; that 0.05 percent to 0.15 percent should be considered along with other evidence as to being under the influence; and that 0.15 percent should be prima facie evidence that the defendant was under the influence. The same leaflet says that a number of States have "implied consent" laws for automatic suspension of the driving privilege (pending a hearing) for drivers who refuse to submit to a chemical test—but that thus far not one State had enacted mandatory legislation for such automatic suspension.

However, some authorities are pressing for a more stringent test of "under the influence" than 0.15 percent. One illustration is Horace E. Campbell, a member of the American Medical Association Committee on the Medical Aspects of Automobile Crash Deaths and Injuries, who reports the committee's conclusions as follows (*11*): "It is the opinion of this committee that it should be unlawful to drive a motor vehicle with an alcohol blood level of 0.05 percent or greater upon public roads." As reported by Greenberg, ". . . New York State has initiated a procedure that exerts some of the effects of a revised chemical test law. Although in New York State law 0.15 percent still stands as the minimum figure presumptive of alcoholic impairment and therefore criminal guilt of operating under the influence, the motor vehicle commission has been given the power to revoke the individual's privilege to operate with a finding of 0.10 percent alcohol in the blood" (*17*). And Brandaleone and Miller stated before the International Congress on Occupational Health that 0.15 percent is "way out of line"—that many automobile safety specialists would like to see the limit set at 0.05 percent, although they would probably have to settle for 0.10 percent (*9*).

The case for chemical tests and a relatively low level of alcohol as grounds for legal action is presented by Campbell (*11*), who says:

> The legal battles revolving around definitions of "under the influence" fill more than a five-foot shelf, and the numbers of those killed by drivers who had been drinking but were not "under the influence" has increased steadily.
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> * * * * * * *
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> Many police members have told me that they make no effort to get an alcohol conviction with a blood alcohol under 0.15 percent but switch to reckless driving, or some other charge, so deeply ingrained is the figure of 0.15 percent in the thinking of the courts. This will explain the low figures for "under the influence" and the high figures for "speeding" in many of the official tables. Every police officer that I have talked with would welcome legislation which would make it illegal to drive with a blood alcohol of 0.05 percent or above.

Cautions *against* lowering the criterion for blood levels of alcohol are stated by Greenberg (*17*):

Why . . . was the value of 0.15 selected . . . . At 0.05 percent a minimum proportion of individuals are impaired; this proportion increases until at 0.15 all are impaired. These were the facts; nor have they been changed. To place the punitive value at less than 0.15, therefore, would involve the questionable guilt of some. At concentrations close to 0.15 the proportion of these would be small; at concentrations close to 0.05 many would be punished for the susceptibility of the few. That solution to the problem of operating under the influence can be achieved in such a way is as unlikely as was the elimination of excessive drinking by prohibition.

Other criticisms of past psychophysiological research in effects of alcohol have been voiced on the grounds of a gross disregard for the finer points of experimentation, lack of proof that the higher thought processes are more readily affected before the lower processes (see ch. III), difficulty of controlling for the common phenomenon that the experienced drinker can "brace" himself when being subjected to performance tests (*47*), and that "compensation is the largest unknown quantity in evaluation of safe driving performance" (*27*).

Summary of Principles of Enforcement That Are Essential To Achieve Public Support

Again, the criteria for enforcement of legislation on drinking-driving are discussed in this chapter only to emphasize that to achieve public support, adherence to certain principles of motivation (including common-law traditions long held by the general public) will get better results:

1. Chemical tests, in principle, have the advantage with the general public (if appropriately publicized) of being unambiguous, being rather readily administered, and having potentially high reliability. The very impersonality and scientific nature of chemical tests are likely to make them better accepted than the subjective testimony of police officers or investigators.

2. If the blood alcohol levels established as prima facie evidence of being unfit to drive are established at a level low enough that quite a few highly publicized instances of "unjust punishment" result, public support of the law can be lost altogether.

3. Reasonable certainty of detection is considered by penologists as a prime deterrent. Therefore, to make sure that unfit driving is detected a high proportion of the time, there will need to be further research as to the times of night, days of the week, and points where there is likely to be maximum drinking-driving. Once these trouble spots are established, the use of well-publicized (but frequently moved) units to test a demonstrably fair sample of drivers could be tried to measure the effectiveness of such methods in reducing drinking-driving. It is likely that they would be most effective if administered by nonlocal police, to avoid imputations of favoritism. Provided that testing measures (such as breath measurements) were used which did not unduly impede traffic, and provided further that local newspapers and radio and television stations were cooperative in their news treatment of the testing program, much would be

learned about how to demonstrate the fair application of laws regarding unfit driving.

4. There would have to be "implied consent" legislation regarding such testing in most States, prior to its inauguration.

5. Application of the law, to be considered fair by the public, would require tailoring the punishment (or remedial action) to the methods which will be most effective with the individual offender. This may mean (instead of automatic revocation) some discretion of judicial authority in the use of parole systems, curfews, special training programs for offenders, supervised driving under the direction of a responsible adult, etc. No recommendation is here intended regarding any specific penalties; however, experts in such fields should consider at further length which penalties are most likely to advance the cause of public support of safe driving legislation.

6. Because the connotations of "drunken driving" and "under the influence" are unlikely to be accepted by the general public as having any relevance to situations where a person has "just a couple of highballs" or "a few beers," alternative terms—such as "unfit to drive"—should be considered for use in all references to legal definitions of excessive use of alcohol.

7. Law and persuasion must work together, especially when such commonly used (and abused) substances as alcohol and motor vehicles are concerned. There is abundant evidence that without public cooperation, laws are of little effect; and in fields where established practices and sentiments are one sided (as in areas where segregation has been firmly established), persuasion often is of little effect without the firm backing of law.

8. Ultimately, the effective combination of enforcement and education will be one which will precondition the individual to set absolute limits upon his own drinking-driving behavior *before* he takes the first drink, or to school those who are with a driver to be sufficiently aware of the potential penalties so that they will help to protect the driver (and themselves) against his drinking enough to become unfit to drive.

Cultural and Social Psychological Aspects of Drinking and Driving

Cultural Drawbacks to Public Support of Stringent Law Enforcement Are Many

As Patrick (*43,* p. 57) says, ". . . the evidence seems to indicate that all drinking, both moderate and excessive, is mainly a matter of the customs and traditions of groups and societies. The problem of understanding the use of alcoholic beverages is, then, essentially one of understanding human behavior, which is mainly learned behavior—cultural behavior." The same can be said about *driving* being a cultural phenomenon; *The American Psychologist,* in a recent issue (*6*), said:

Fritz Redl once called the automobile "a baby carriage with a motor"—and the remark showed up recently in an extensive article in the New York *Times* on the subject of what automobiles mean to teenagers.

A psychiatrist, Eugene Kaplan, of Great Neck, Long Island, has spent quite a bit of time thinking about this, and he thinks the day on which a youngster gets his learner's permit is our tribal ritual day of puberty. . . . And Kaplan says the aggression of a young driver "may also represent an unconscious desire to wreck the car, to get back at the person who owns it; i.e., Father."

A truism already cited is that "Driving has become a right rather than a privilege." So long as this concept holds, it will be difficult to raise the standards for competence in driving an automobile.

As Borkenstein et al. have pointed out (see ch. VI):

Since drinking of alcoholic beverages does not generally carry a serious social stigma, an unspoken "drinking partnership" was recognized to exist between a large segment of the public and the drinking-driver defendant. This affinity often results in less-than-energetic prosecution of this conduct that is dangerous from the traffic safety standpoint.

The American custom of trying (usually) desperately to live up to a strict timetable in our workaday lives probably serves to increase the amount of driving under the influence of alcohol more than would be the case (all things being equal) in a more leisurely culture. Not only do many of us have to work according to a rigid timetable, but there are also timetables as to when we must drink to excess (e.g., right after work, or on Saturday nights). We also have to maintain, at all costs, a timetable on when we take ourselves home via automobile, drunk or sober. We would rather take risks on the road than not to show up at home (or at the next drinking place) on time.

Behavior and Attitudes Relevant to Alcoholic Beverages Vary Considerably by Groups

Highly relevant to any program of motivation and education regarding drinking-driving is the fact that the amount and type of drinking varies according to ethnic groups, social classes, and age groups.

There are probably culturally related differences in law enforcement or —perhaps even more important in matters of public cooperation—at least there are *thought* to be such differences. Tracing of proportions of drinking-driving among various cultural groups would be difficult because, as is true of many delinquency statistics, the results would be affected by the well-to-do usually being more resourceful in not getting caught and in defending themselves when caught.

It can be hypothesized that since the police themselves tend to come from the less well-to-do homes, this might have an effect on their enforcement of drinking-driving laws, with the more upwardly mobile police being rather severe and other police being unduly permissive. Or the reverse may be true. In any event, hypotheses relating to the individual characteristics of enforcement officers as well as the social situations within which they work should be tested to determine whether they influence arrest rates differentially.

The Youthful Driver Is Probably Hard To Reach, and Finds It Hard To Reach Adults

It is hypothesized that in our culture at the present time there are special barriers to reaching the youngest drivers through campaigns designed for the average adult. In a pamphlet on "What Motorists Really Think About Traffic Safety," published jointly by the Pure Oil Co. and the American Trucking Industry (*53*), the statement is made that—

Teenagers feel they're being used as scapegoats by their elders, many of whom they feel are poor drivers. They resent it. They think they deserve to be treated as responsible individuals, even though adults surveyed agreed that, of all drivers, the most dangerous are teenagers. . . .

Who do the teenagers blame? Our cars mostly, or their designers. They talk a great deal about the need for mechanical changes . . . .

They're very enthusiastic about driver education—much more so than their elders. Teenagers agree with adults that high-school driver education does a lot of good. But the teenagers feel that present driver-training programs are neither as comprehensive nor as long-range as they should be.

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If there's one thing teenagers fear, they said, its being called a "square." A square is somebody who doesn't know the score. Maybe mass communications could be used to promote the idea that all teenagers who drive carelessly are squares.

While without further research and analysis one would not launch exactly the type of mass communications for teenagers suggested above, these illustrations do establish that no one single approach is likely to work equally well with all groups within the country.

Psychophysiological Aspects of Drinking and Driving

While psychophysiological phenomena are dealt with in greater detail in other chapters, some are mentioned here in the interest of inducing caution in adopting educational programs which may or may not be suitable to cope with the limitations of certain subgroups within the population. (While for convenience a distinction is made here between the cultural and social psychological, on the one hand, and the psychophysiological, on the other, in actuality all relevant human behavior should be assessed as a whole rather than being classified as purely "cultural" or purely "physiological.") The items described below probably interact with alcohol, but we know very little about the combined effects.

McFarland, a participant in the Panel on Medical Aspects of Crash Injuries at the 1956 annual meeting of the American Medical Association, has made observations which can serve as a useful summary of psychological problems involved in driving (*32*):

It is commonly believed that the attitudes and personal characteristics of drivers are the most important factors in accident causation. Only a few carefully controlled studies have been made, however, to test this assumption.

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In general, those persons having repeated accidents may be characterized as having a disrespect for organized authority, poor social adjustment, and evidence of permanent or transitory emotional instability. Just as delinquency may be a manifestation of the above-mentioned traits, so may repeated accidents reflect the type of adjustment or the mode of life.

Various hypotheses as to the psychopathology of unsafe driving have been advanced:

1. Some seem to imply that unsafe driving may be primarily a variable phenomenon among the "normal" population. Malfetti, executive officer of the Safety Education Project at Teachers College, Columbia University, makes these two points (*31*): that the subject of most concern in highway safety is the driver himself and that there is no such thing as a "safe" or "unsafe" driver, since each driver has a constantly fluctuating range of driving behavior going from safe to unsafe; and that ". . . most important is the understanding that for each driver, the unsafe end of the continuum can be reached. When sufficient negative forces are operative, no one is immune to unsafe driver behavior."

The evidence on whether drivers who are involved in accidents constitute a special group is somewhat equivocal, however. Malfetti's own research group, in a later report on 16- to 19-year-old traffic offenders (*7*), concludes that the juvenile drivers with two or more traffic violations *may* have the following special characteristics:

(*a*) . . . they do not give proper thought to the implications of their behavior for themselves and others; (*b*) they tend to be in disagreement or conflict with others . . .; (*c*) they are rebellious and selfish; (*d*) their hypersensitiveness, lack of self-confidence, and feeling of personal unworthiness may lead them to overcompensate with erratic and ill-considered action resulting in traffic violations; (*e*) their parents are relatively inactive in the community, indicating in the children a lessened sense of civic responsibility.

Although McFarland was earlier quoted as saying ". . . the attitudes and personal characteristics of drivers are the most important factors in accident causation," the same author is interpreted as concluding that the concept of the accident-prone person as one who has accidents because of fixed or absolute personality factors alone is a concept which does not hold up (*33*). While these opinions can be reconciled by viewing accident proneness as a short-term phenomenon, more research is needed before we can be sure whether accident proneness or drinking-driving are short-term or long-term phenomena; effective remedial programs obviously are dependent upon such background knowledge.

2. Others insist that many accidents are caused by the chronically and obviously unfit. One of the sources cited earlier (*40*) reports that a drivers' clinic in Detroit providing psychiatric examinations for repeated traffic offenders found over a period of several years that 20 percent of the "prob-

lem drivers" were mentally incompetent, with 850 out of 10,000 being found to be feebleminded and 100 insane, with another 1,000 being former patients in mental institutions; and that nearly half the drivers involved in fatal accidents who were referred to the clinic suffered from physical defects (such as poor vision, diabetes, and arteriosclerosis) which would preclude safe driving.[4] Such findings, if representative and reliable, would lend support to officials' asking for more stringent driver-licensing tests, in one instance asking a State psychological association ". . . to consider the advisability of physiopsychological tests in driver-licensing with particular reference to standards recommended by the State Medical Society and to recommend and assist the Traffic Epidemiology Section in research programing" (*5*).

3. Special psychological factors which may be highly relevant in drinking-driving, and which might well be studied intensively, in that context, are as follows:

a. "Frustration-intolerant" people[5] (following Rosenzweig's concept). It may well be that intolerance to frustration can be isolated as a special trait of many persons who break traffic laws; and it also may be that such intolerance to delays and frustrations of traffic may interact with drinking to make dangerous drivers of persons with high scores on the variable. (See, for example, McGuire (*34*).)

b. "Risk takers."[6] The hypothesis is that younger drivers are more likely to take risks, since the young have not as yet found that risk taking involves increasing disutilities. Research may show that risk taking may interact with drinking alcohol so that risk taking of the young may be accentuated while the older drinkers might actually tend to slow down after drinking. Research would be helpful in establishing whether the hypothesis is borne out. In any event, individual differences are to be expected in risk taking, with implications for screening and driver training programs.

c. Drinking-driving may be considered "manly" by the young, in the same way that early cigarette smoking is (*42,* p. 58). Consistent with this possibility is the preliminary finding, reported earlier, that a disproportionate number of accidents occur among those who are relatively young; i.e., 25 to 30.

d. The classical inadequacy of attention to their environment on the part of neurotics might well interact with drinking to account for many drinking-driving accidents among neurotics. This possibility seems worthy of further attention in driver testing and education programs.

e. The alcoholic, as mentioned earlier, contributes to an unknown degree

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[4] The report of the findings in this Detroit drivers' clinic did not provide sufficient information to permit evaluation of the reliability or representativeness of the study, particularly in view of the extremely selective character of the sample.

[5] The writer is indebted to Prof. Joseph Weitz of New York University for discussion on this point.

[6] Appreciation is expressed for a discussion on "risk taking" with Ira Cisin and Raymond Fink.

to the total auto accidents. One guess is that few advanced alcoholics could get their cars on the road often enough to cause many accidents (although no data are available), but that those with incipient alcoholic tendencies may contribute heavily to auto accidents—particularly because of the interrelationship between alcoholism and the personality problems mentioned above (lack of frustration tolerance, risk taking, inattention, and also aggressiveness). Again, research on the alcoholic participant in accidents is very much in order.

f. Fatigue as a factor in late-at-night and weekend accidents, when most drinking-driving accidents occur, is also worthy of research prior to instituting remedial training and educational measures. Fatigue is known to increase suggestibility; and consequently, late-at-night fatigue may lead to more "social" drinking as well as fatigue-induced driver errors.

g. Extraversion-introversion. H. Ward Smith, reporting on Drew's work (*47*), says:

> More light is thrown upon compensatory activity by a study of the individual differences in response to alcohol. These . . . appear to be related, at least in part, to personality characteristics, especially those of extraversion-introversion. In this experiment subjects classified as extraverts appear not to be bothered by the extra stress imposed by alcohol. They drive much the same speed as before but they make much more error. Those classified as introverts, on the other hand, appear to be striving to compensate for the alcohol effect, and to be anxious to demonstrate their efficiency.

These illustrations of psychophysiological factors which may be involved in drinking-driving should make it clear that a much more thorough understanding of "the psychology of the drinking driver" needs to be attained before a definitive program of public education can be effective.

Attitudes About Driving and Drinking

So very little research into public attitudes directly relevant to the issue is available that it seems appropriate to devote a special section to such attitude material to get the maximum of guidance out of it.

The Opinion Research Corp. Pilot Study

In 1958 a pilot study on the topic of automotive safety was conducted by the Opinion Research Corp. of Princeton, N.J. Part of the findings have been referred to earlier (*53*). Most of the findings are presented below. The pilot study involved four steps: a canvass of research on traffic safety, personal interviews with experts in accident prevention, group discussions with some 40 persons from various segments of the driving public, and a self-administered questionnaire (filled out by 246 teenagers and adults) to check the plausibility of the principal hypotheses which had emerged from the first three steps [7] (*12*).

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[7] Appreciation is here expressed to Joseph C. Bevis, chairman of the board, and Henry W. Wolpert, survey director of the Opinion Research Corp., for making this unpublished material available.

Almost all (about 9 in 10) considered themselves as better-than-average drivers. On this question, there was no difference in response between men and women, among people varying in the length of time they had driven, and between those who had been involved in moving-accident violations as against others. This would suggest that few, indeed, would accept the possibility that they are poorer-than-average drivers. If this finding holds up under more research, it shows the kind of difficulty driver education forces will have in getting people to face up to the possibility that they *might* not be the best drivers in the world.

About 8 in 10 agree that "it is just as wrong to break a traffic law as to steal or lie." However, the Opinion Research Corp.'s unpublished report says that ". . . many drivers look on infractions of traffic laws as sort of a game of 'cops and robbers.' "

Two-thirds favored giving warnings instead of tickets for "minor" traffic violations.

Ninety-six percent of the adults and 78 percent of the teenagers (division of the 246 interviews between adults and teenagers is unknown) *agreed* that "they should take the license away from people who get caught driving while drunk."

The report further observes that "people seem to have a very limited idea of what constituted violation of traffic laws: to them it is 'drunken driving' and exceeding the speed limit."

One conclusion in the unpublished report was:

> The foregoing suggests that "the good and law-abiding" driver is a powerful symbol for traffic safety communications. This is a symbol with which every driver can readily identify himself. Further research will have to button down the themes or appeals that play up to the "good driver" and yet are forceful enough to motivate people to become safer drivers.

New Jersey's Public Opinion Poll on Traffic Safety

In 1958 the Department of Law and Public Safety of New Jersey published a report of a survey in which Boy Scouts were used to distribute self-administered questionnaires (*39*). The auspices of the study were so obvious that the findings hardly warrant literal acceptance, even though the numbers of interviews on which the report is based is sizable (2,079 for most items), and professional consultation was obtained (from Opinion Research Corp.) on the sampling. Some of the findings were as follows:

Even though the survey materials emphasized the iniquity of drunken driving, a sizable proportion (34 percent) mentioned "driving in disregard of the rights and safety of others" as the most serious offense, while 56 percent selected "driving while under the influence of alcohol."

As "the most important cause of serious accidents," 36 percent mentioned "driving while under the influence of alcohol," 20 percent chose "lack of courtesy toward other drivers," and 17 percent chose "not paying enough attention to the road."

As "the best way of preventing accidents due to driving while under the influence of alcohol," almost equal numbers chose "police spot checks on the road every night stopping cars" (42 percent) and "an educational program on the dangers of drinking and driving" (41 percent). (Only 7 percent each chose "have all taverns close at midnight" or "have people warned against permitting guests to drive after drinking at parties.")

The leading type of penalty considered "most effective in preventing traffic violations" was "taking the license away for a period of time" (more than 50 percent).

Choice of "the best way of preventing accidents through safety education" included 49 percent choosing "TV program dramatizing accident causes," as against 21 percent choosing "newspaper stories of actual accident cases." The public educational method considered by a plurality as being the least effective was "use of 'horror' in presenting safety driving practices."

In summary, it is believed that even the fragmentary surveys of public attitudes cited above provide useful clues to the kinds of public reactions to be expected in more thoroughgoing studies. And, at minimum, these findings do indicate that intensive surveys of public attitudes and knowledge on traffic safety and drinking-driving ought to provide information of great usefulness in planning public educational campaigns.

Some Principles Regarding Effective Communication and Public Education

The following principles and observations have been gleaned from scattered professional communications literature, research findings, and personal impressions. As such, these observations need to be recombined into a more systematic and concise form at some later date for the purpose of maximum usefulness in planning campaigns of public education regarding alcohol and traffic control.

1. Any educational campaign must contain within it a promise of concrete rewards for appropriate behavior or attitudes. The prevailing approaches ("If you drink, don't drive" and "Drinking and driving don't mix") provide absolutely no reward to the observer, even in the form of humor. Such slogans sound as though they were concocted with an eye more to pleasing the sponsors of campaigns rather than to having a real effect on a real-life public. (It is not impossible that the writing of a commercial to please the client can apply as well within nonprofit quasi-public agencies as it too often appears to do in advertising circles.) The advantage of a positive approach in slogans obviously is that *only a positive approach can promise rewards.*

2. Among communications specialists there is a growing realization that *there is no such thing as a valid "mass motivation" program to achieve any communications goal.* The general public is made up of many sub-

cultures, each with its own special interests and vulnerabilities. An effective communications program utilizes a battery of appeals and media to reach all relevant groups.

3. The mass media—such as television, national magazines, newspapers, outdoor advertising, radio—are truly only "media" in that they do not magically convey conviction for every idea that is expressed over these channels. Conviction (if any) inheres in the message itself and the person or institution responsible for the message. Media can have a role in *reaching* audiences; but the message is "on its own" once the audience has been exposed.

4. The mere fact that a drive is "in the public interest" is no indication that it will be successful. Look at the failure of post-World War II civil defense (*36*). Perhaps we are too often beguiled by communication success stories such as the Kate Smith war bond drive (*37*) to realize that many such successful drives are the culmination of lengthy campaigns in which public attitudes, values, and interests all operate in the direction of wholehearted support of the public when it is appealed to. Such, it is suspected, is not as yet the case with any current action program regarding alcohol and traffic control.

5. "The people you may want most in your audience are often least likely to be there" (*1*, p. 54). It is common knowledge that Republicans tend to listen more to Republican speeches and Democrats to Democratic speeches, and that new-car owners will read advertisements for their own makes more than for other makes. It would be only reasonable to suppose, then, that most appeals directed toward control of drinking-driving will be attended to and acclaimed primarily by those who are least in need of reeducation.

Much the same conclusion is reached by Hyman and Sheatsley in their paper on "Some Reasons Why Information Campaigns Fail" (*24*). They draw attention to the "hard core of chronic 'know-nothings,' " the fact that interested people acquire the most information, that people seek information congenial to prior attitudes, that people interpret the same information differently, and that—

> Information does not necessarily change attitudes. . . . There is evidence . . . that individuals, once they are exposed to information, change their views *differentially*, each in the light of his own *prior* attitude. . . .
>
> The . . . findings indicate clearly that those responsible for information campaigns cannot rely simply on "increasing the flow" to spread their information effectively.
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> Psychological barriers to information campaigns are readily admitted by those who stop to consider the point, but they seem often to be overlooked in the general eagerness simply to distribute *more* information. (*24*)

6. The "sloganeering" approach in drinking-driving control has not been established as having paid handsome dividends. Two instances of this approach are:

a. Materials made available free through the Advertising Council to mass media.[8] There have been no resources available to assess the effectiveness of such drives. Some materials have drawn a protest from newspapers. As an illustration, when the council sent out materials with the slogan "When Traffic Laws are Enforced, Deaths Go Down," some newspapers voiced a fear that local law enforcement agencies might be offended; so the slogan was amended to read "When Traffic Laws Are Enforced *and Obeyed* . . . ."

b. The activities of local alcoholic beverage association members reporting to the Licensed Beverage Industries, Inc., appear to extend primarily to distribution of posters in bars and package stores, of tavern signs and table cards bearing such admonitions as "Drive Cautiously and Soberly" and "Drink Moderately! Drive Carefully!" and of ashtrays imprinted "Know Your Capacity—Keep Your Driver's License" (*30*).

7. Pseudoscientific approaches to self-testing of driver competence may elicit interest in the problem of drinking-driving, but might have serious consequences if taken literally. A prime example of this type of approach is an article in *Esquire,* "Eight Simple Tests for Self-Determination of When You Are Fit To Drive" (*35*), which gives a remarkable list of rather complex tests for self-administration—tests of peripheral vision, depth perception, pupillary reactions, memory for such things as the names of the last seven French premiers, handwriting tests, reaction time, maintaining balance with one's eyes closed, and walking the chalkline. The classic among the items described in these "tests" begins as follows: "A third test of vision requires a flashlight and two sober friends."

8. The use of "scare" pictures of accidents or "shock" headlines is almost always ineffectual. As noted in a recent survey (*53*), "A look at these scare appeals along highways, on posters or in print gives another clue as to why people seem to react to them in such peculiar fashion. Perhaps the trouble is that these displays scare people without telling them what to do." And, as Greenberg says, "Most of the efforts that have been made on the educational level have been on the basis of terror or shock psychology. The remaining educational efforts have been couched in terms of reduced reaction time, or the number of feet traveled before a car moving at a given speed will be brought to a halt. This sort of pedagogy appears to have limited appeal" (*17*). It is clear that "scare" techniques do not work. There is the further danger that they direct resentment against law enforcement agencies merely because such "scare" tactics stir up people without providing them with a constructive means of relieving their tensions.

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[8] The Advertising Council's annual report for 1958–59 states that free advertising mustered for various causes totaled about $170 million for that year. Typical recent campaigns: Aid to Higher Education; Better Schools; Confidence in a Growing America; Crusade for Freedom (for Radio Free Europe); Forest Fire Prevention (Smokey the Bear); mental health; NATO; Red Cross; Register, Vote and Contribute; Religion in American Life; and others.

9. Most people fail to see anything very reprehensible about driving after a few drinks—the term "under the influence" is not seen as fitting them. It appears so many people have driven after drinking without having become involved in an accident that they may fail to take the official "under the influence" alcohol levels seriously.

Some, such as Greenberg (*17*), contend that if only people were taught the correct answers as to relatively safe drinking-driving tolerances—

> Most of them would, I believe, be receptive to factual information that would provide guidance toward sober driving without demanding total abstinence. The admonishing slogan "if you drink, don't drive" affords no such guidance; when should one not drive after drinking what? If a certain quantity has been consumed, how long must one wait before driving? Scientific knowledge on this matter is now abundant. Why not apply this knowledge in a meaningful and constructive educational way?

However, only further experience with more specific education regarding appropriate drinking-driving tolerances will establish whether most people *really* want to learn the facts about what is unsafe drinking-driving behavior, or whether they prefer to avoid learning the correct facts.

10. Strong threats must be used with caution, for they may boomerang. The limited available evidence indicates that *if* strong threats are used, they must be accompanied soon after by some device to reduce tension, or the threat may backfire against the threatener. Dollard and Miller (*15*) propose that "When fear is learned as a response to a new situation, it serves as a drive to motivate trial-and-error behavior. A reduction in the strength of the fear reinforces the learning of any new response that accompanies it." Continuing this thinking, Hovland, Janis, and Kelley (*22*) say, "Thus it is assumed that a threat appeal is most likely to induce an audience to accept the communicator's conclusion if (*a*) the emotional tension aroused during the communication is sufficiently intense to constitute a drive state; and (*b*) silent rehearsal of the recommended belief or attitude is immediately followed by reduction of tension." Thus, if the driver is threatened (say, through posters) with being jailed if he becomes "legally unfit to drive" because of alcohol, to make the threat effective he should be given *a solution* (such as exact instructions on how to keep his drinking within permissive yet safe limits by taking not more than one drink per hour).[9]

An empirical illustration of the boomerang effect of strong threats is provided in the now classic study of Janis and Feshbach (*25*). In brief, matched groups of students were exposed to three strengths of threat in lectures about what can happen if children do not brush their teeth (the "strong threat" group was exposed to dramatic pictures of tooth decay, etc.). It was found that while the group exposed to the most threatening materials worried more than others immediately after exposure, the groups

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[9] John L. Finan provides this conclusion with a learning-theory rationale: that when one inhibits behavior by having the subject avoid punishment, one does not usually reinforce the learning of the desired behavior as effectively as when one provides ***positive*** goals and rewards.

exposed to more moderate information showed *more* compliance with the desired goal (more toothbrushing); and differences in behavior among the three groups persisted for a full year. The major sources of interference which can work against the public's acceptance of recommendations when a strong threat is used include: inattentiveness to the communication, aggression toward the communicator (such as toward the law enforcement agencies), and defensive avoidance of the issue through various psychological strategems (*22*, pp. 84–89). It has been suggested that it is a good thing, in promoting safe driving habits, to do something to sustain a moderate level of anxiety about the consequences of disregarding the rules of safe driving. Only further experimentation can establish exactly what level of anxiety is most effective in reinforcing safe driving behavior.

11. People tend to ignore risks until there are clear signs of *really* imminent dangers. Most often this seems to be associated with a feeling of being personally exempt from the potential danger (*22*, p. 67). It looks as though the danger has little reality unless it can be linked to the real-life experience of the individual. Thus, green troops are probably more likely not fully to realize the danger of bullets and grenades until they have seen with their own eyes what grenades and bullets will do. However, one should *not* conclude that gory pictures or posters of the results of drinking-driving will be effective, for the reasons given above. Any effective communications on the dangers of drinking-driving must thread a narrow course between being too mild on the one hand and too threatening on the other.

12. The role of the group in reinforcing good driving practices should be utilized in effecting education and training about alcohol and traffic:

a. One should work with organized groups in imparting the message:

> . . . experience in leadership training, in changing of food habits, work production, criminality, alcoholism, prejudices—all seem to indicate that it is usually easier to change individuals formed into a group than to change any one of them separately.[10] As long as group values are unchanged the individual will resist changes more strongly the further he is to depart from group standards. If the group standard itself is changed, the resistance which is due to the relation between individual and group standard is eliminated (*29*, p. 228).

b. "A person's opinions and attitudes are strongly influenced by the groups to which he belongs and wants to belong" (*1*, p. 20). Abelson cites a study which is particularly appropriate to our inquiry, "Status Factors

[10] The need for more emphasis upon *group* behavior in drinking-driving research and action programs should be underscored. Mendelsohn, in addition to emphasizing that drinking-driving usually is *social* rather than individual behavior, points to a recent (unpublished) study of beer consumption in five cities scattered across the country, in which he found marked differences in the rate of consumption, correlated to the local social acceptability of beer drinking. The writer can cite his current research on life insurance (which indicates that one reason that so many men are "underinsured" is that the life insurance industry has failed to provide the layman with "norms") as indicating the importance of changing the social norms when one is attempting to change the behavior of individuals.

in Pedestrian Violation of Traffic Signals" (*28*). In this experiment, a "planted" bellwether part of the time played the part of a high-status person (with good clothes, etc.) and part of the time took the role of a low-status person (dirty workingman). This "planted" confederate part of the time violated a "wait" signal at a traffic light and part of the time obeyed the "wait" traffic light. Nearly all (99 percent) of the surrounding pedestrians obeyed the signal when the confederate obeyed the signal; but slightly more of them (4 percent) disobeyed the light when the confederate in low-status garb disobeyed the light, while a considerably higher proportion (14 percent) followed the confederate's lead in disobeying the traffic light when the confederate was in high-status clothes. The clear implication is that in driver education about alcohol control, the actual or symbolic persons used as examples of approved temperate behavior should be people with whom the individuals in target groups (e.g., teenagers) can identify in a favorable way.

c. Personal participation in driver education programs can be an effective means of bringing about the desired conduct. There are several related reasons why this is so: role playing tends to augment the effectiveness of a persuasive communication by inducing an inner acceptance (*22*, p. 228); even when only superficial conformity occurs, "opinions which people make known to others are harder to change than opinions which people hold privately" (*1*, p. 31). That public discussion induces people to conform to their own expressed values as well as to the values of others is well established in the effectiveness of group therapy, such as Alcoholics Anonymous, group driver education in high schools, and (perhaps) in properly run classes held for traffic violators.

d. "People who are most attached to a group are probably least influenced by communications which conflict with group norms" (*1*, p. 28). Thus if teenagers as a group are so very group dependent as they appear to be, the more imperative it is that the motivation for good driver conduct come from within the teenage group itself.

13. "There will be more opinion change in the desired direction if the communicator has high credibility . . . ." (*1*, p. 72). Studies have shown that presentation of communications which are identical but are represented as coming from sources varying in credibility have been judged as trustworthy by a high majority of the subjects when the source was given as a highly reputable one, and as trustworthy by very few when the source was given as an unpopular one (*23*). "It is cognitively inconsistent for us to think of people we dislike and distrust making honest . . . moves, behaving as human beings ought to behave, and assuming noble postures" (*41*). Therefore, probably posters or other materials would be most effective when they depict or quote sources highly acceptable to the average driver, which might not be blue-coated officers of the law or others bearing negative connotations.

14. A related point is the evident sincerity and altruism of the communicator. For example, Kate Smith's war bond drive was considered to have been so effective in major part because ". . . the public felt that in carrying out the bond drive she was interested only in the national welfare . . . ." (*22,* pp. 23–24). Thus, the evils of mixing alcohol and gasoline no doubt would be more effectively presented by an earnest amateur who is a member of our own peer group, rather than by a professional policeman or one who is merely carrying out the duties he is being paid for.

15. Certain psychopathological or negative personality traits in some individuals make them amenable only to specially intensive training. Among those who resist or ignore socializing influences and education are the persistently aggressive, the socially withdrawn, those with acute psychosomatic complaints, those of lower intelligence (*22*), as well as the highly prejudiced (*13*). Ultimately, driver-testing programs (as discussed below) may keep more of such persons off the road. Certainly, however, such persons will, it is hypothesized, continue to account for an undue proportion of auto accidents of all types. When detected—too often, unfortunately, only after they have caused serious accidents—intensive retraining and psychiatric counseling (or simple detention) rather than regular education will be needed to cope with such misfits in society.

16. Education on drinking-driving should be as definite, direct, and clear-cut as is possible without exaggeration. As Abelson says, "There will probably be more opinion change in the direction you want if you explicitly state your conclusions than if you let the audience draw their own" (*1,* p. 10). As one illustration, the *amount* of liquor that is safe to drink within an hour prior to driving a car should be spelled out as clearly as possible; and presumably (although no research tests have been conducted on the point) this kind of graphic information should be widely distributed through all available media, including roadside billboards. Much of the information that has been distributed on safe tolerance levels is ill adapted to driving home the facts to a public which at best is likely to be much confused on such issues and not too willing to face the scientific facts anyway. One promising approach which appears deserving of wider application is a "Driver WAIT Meter" (*45*), which shows the length of time one should wait after drinking a specified number of cocktails, highballs, or steins of beer.

17. For effectiveness, all media should be utilized in education programs on drinking-driving. As in any other long-term behavioral problem so closely tied to rather enduring tendencies in our culture, use of various media of communication should be made *continually:* unlike various fund-raising drives, drinking-driving is not going to be affected materially by any single onslaught of publicity.

Some rather obvious uses and limitations of the various media of communication are listed below.

a. Magazines (including Sunday newspaper supplements) probably are best adapted to a factual, scientific approach. Apparently, self-administered "information quiz" approaches to driving home facts about drinking-driving—following up a factual article with a "quiz" which tests the reader's retention of the material—should be popular. Limitations: magazine articles on drinking-driving may be read by members of leadership groups; but traffic offenders are less likely to read nonfiction articles in magazines at all, much less articles which appear to "preach" to them.

b. Television is an excellent medium for spot announcements (such as to warn people during the holiday season to get others to drive them home if they have had more than a couple of drinks within an hour), and television can be used in a great variety of featured ways.

c. Radio is excellent for spot announcements about drinking-driving, particularly since so much radio listening is either in autos or among the growing transistor-radio-carrying youthful audience.

d. Outdoor posters represent a high potential, both getting across graphic messages (such as safe drinking limits) and in creating the impression of the omnipresence of law enforcement officials. Continuity of characters in such posters (e.g., Smokey the Bear) both sustain interest and reinforce the message. The "Burma Shave" type of serial poster is worth investigating—e.g., Connecticut has a series of experimental signs which read approximately as follows:

"Don't stick your arm
Out too far
Or it may go home
In another car."

e. Newspaper copy regarding drinking-driving generally is in the form of medium-sized display advertising format, with pictures. Pictures of scenes of serious accidents probably are ineffectual, in the light of the reasons discussed earlier: very strong threats are not well received.

Law Enforcement and Driver License Control

It is a truism that effective laws depend absolutely upon the consent of the governed; and it is also true that without effective law enforcement, no educational program can make much of a dent in the drinking-driving problem.

No doubt there exists in the United States a high proportion of people only too willing to think ill of traffic officers and traffic courts (*53*). A 1957 survey of motor vehicle commissioners and chief enforcement officers throughout the United States ". . . resulted in an expression by 30 of 43 State officials that existing legislation was insufficient to deal with the [drinking-driving] problem. Other reasons why difficulty is encountered in convicting the guilty, in order of frequency of mention by State officials, are as follows: (1) jury attitude of sympathy for violators, (2) penalty causes economic hardship on violator's family, (3) lenient judges, (4) vio-

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lators are often sober, upstanding citizens when they appear for trial . . . ." (*46*).

Apparently, most motor vehicle and chief enforcement officers feel that penalties are not severe enough. The 1957 survey (*46*) found most feeling that mandatory minimum penalties should be provided, with many favoring suspension of the driving privilege; and 18 of the 41 States reporting felt conviction of "driving under the influence" should warrant a mandatory jail sentence for the first offense. Yet the same survey finds only 1 State (in 1957) in which conviction is considered a felony under all circumstances; and in only 10 States is conviction of being "under the influence" *ever* considered a felony, regardless of number of convictions.

No recommendation is here made regarding the types of penalties to be applied: such matters are for law enforcement specialists and penologists. However, the gap between the present status of penalties and the opinions of high enforcement officials indicates that further efforts toward resolving the disparity would be in the interests of better public relations between motorists and law enforcement personnel.

Chemical tests seem to be popular with traffic officials and the courts. The 1957 study found that "officials from 36 States and the District of Columbia feel that chemical tests are the best way to determine guilt or innocence . . . . Only 6 States of the 42 reporting answered 'no' to this question. And, with one exception, these six State officials feel that the use of chemical tests is invaluable, but point out that this evidence should be supported by observation of driver behavior or other clinical evidence" (*46*). As a matter of fact, adoption of chemical tests is growing; in 1960 there were 33 States with chemical test laws, 8 having adopted the "implied consent provision" that issuance of a driver's license carried the provision that the licensee thereby consents to having chemical tests taken upon demand (*52*).

Earlier in this chapter reference was made to the suitability of chemical tests from the standpoint of *potential public support* of convictions obtained through such tests (because they are less equivocal, more objective than other types of tests or unsupported evidence). However, were the issue to be raised of establishing a blood alcohol level *lower* than 0.15 as constituting prima facie evidence of unfitness for driving, the guess is hazarded that legislators would not be likely to support such a move until the medical authorities, the legal profession, and the general public were much more in favor than they seem to be at present regarding the need for such a tightening of the laws.

Probably a fertile field for public education would be a general upgrading of the status of the driver's license, both to eliminate some unfit drivers and to contribute toward better observation of *all* traffic laws, including those regarding drinking-driving. Such an upgrading might be achieved by some of these steps:

1. More intensive testing prior to licensing, involving a maximum amount

of applicant participation in educational activities—ultimately, possibly the requirement for a certificate from a "driver's course." The educational purposes of such testing can be furthered by feedback from test items, so that the person tested is given special review and drill on items missed in the test, even though he gets a passing mark.

2. Higher qualifications for new licenses, possibly with a "grandfather clause" permitting those with old-type licenses several years to qualify. Ultimately, there might be two grades of licenses, analogous to pilot's licenses (e.g., for "instrument conditions" such as the Los Angeles Freeway or crosstown Manhattan at peak traffic hours, and limited-service licenses). A differentiation would tend to breed respect for the license, especially among the susceptible teenage group where licenses seem to be most highly prized. Since the average turnpike speed these days is about the average speed of the early airplane, the "pilot's license" analogy may not be too hard to sell the general public.

The use of various grades of licenses as "rewards" for careful driving is consistent with other opinion on the concept of rewards in driver training: "The use of positive rewards in driver improvement would constitute a bold departure from traditional methods and could open up new avenues of control over dangerous drivers" (*10,* p. 259).

Insurance companies apparently would be glad to cooperate with law enforcement agencies and driver education programs, both in establishing differential rates depending upon driving records and in assisting in supporting information campaigns designed to promote better driving.

Continuing studies of driver education programs should be conducted to measure how the programs measure up to the felt needs both of the students and of the law enforcement agencies.[11] In view of the evidently high interest of high school students in such courses, this appears to be one of the most crucial points at which to begin to "upgrade" the status of the driver's license. Intensive, factual education regarding the specific dangers of drinking-driving could well be covered in these driver education programs along with other physical and psychological hazards of the road.

Personal participation in sane-driving programs is an effective means of teaching appropriate values regarding the privilege of driving. One device, utilized by a California community each year during the Christmas-New Year holiday season, is to publicize the availability of youthful but well-qualified drivers to take people home from parties after party goers have taken too many drinks to drive home safely. Young drivers proceed

[11] Pointers on future driver education research are contained in the National Education Association's 1957 publication (*14*). David Barnes of the NEA pointed out that the number of high school students getting driver education is increasing yearly; and that a new group within the NEA, the American Driver Education Association, already has 3,000 certificated teachers as members whose help could be enlisted in educational programs developed to cope with drinking-driving.

in pairs to the pickup point in answer to telephone calls; and one drives the celebrant's car home while the other follows in another car. This type of personal participation accomplishes the following purposes: (*a*) it drives home to the youngster the dangers of drinking-driving, (*b*) it can give him a feeling of pride in being a "Good Citizen," and (*c*) it gives him a rare opportunity to be "one up" on the adults he drives home.

Research on *group drinking* is needed in order to control the effects of such drinking on fitness to drive home. Again using a positive approach, we should study the successful drivers as well as the failures: let us find out just how the person who drives a lot and also drinks a fair amount, but does not drive after drinking, manages to organize his driving and his drinking so that they do not coincide. One could use the findings of such a study in a realistic educational campaign that does not ask people to give up either drinking or driving, but shows them how they can manage to keep from mixing drinking and driving.

For that matter, much more research on *social driving* and its safety implications is in order (*49,* pp. 190–192).

Special law enforcement and education efforts of the various States, Canada, and European countries should be given intensive study to turn up motivational steps which seem to help reduce drinking-driving. From scattered sources one gets the impression that various local governments and unofficial associations have used devices which might well be tried out elsewhere. As one illustration in the law enforcement field, former Governor of California, Goodwin J. Knight, in a *Saturday Evening Post* article (*26*), discusses how a combination of mandatory jail sentences for driving "under the influence" and use of late-hour roadblocks, coupled with a program of newspaper and other publicity, appeared to have cut the death rate from drinking drivers. Further inquiry should turn up many good local campaigns which deserve wider application.

The Role of Formal Education

Patrick ranks the school second only to the family among the agencies which should assume prime responsibility in educating society on the nature and effects of excessive use of alcohol (*43,* p. 153). His citation of the 1930 report of the joint committee of the American Medical Association and the National Education Association seems so appropriate in conjunction with controlling drinking-driving, and after over 30 years still so psychologically sound in the light of the more recent research on motivation cited earlier in this chapter, that several paragraphs of the AMA–NEA report are reprinted in full below:

> The instruction concerning alcohol, tobacco, and other narcotics should be, in the main, part of the general work in training to personal health habits and to promotion of community health and welfare. The keynote should be, "Teach by facts and illustration; not by exhortation."

> Ideally, the instruction should be positive and demonstrative. Practically, the persistence of erroneous traditional beliefs about these substances, especially about alcohol, makes necessary concrete knowledge of their nature and effect as reason for practicing sobriety.
>
> The choice of material, therefore, involves: (1) recognition of the individual and community advantages resulting from sobriety; (2) correction of current fallacies as to the nature and effects of these substances in which much of their use finds excuse; (3) definite knowledge of modern scientific experiments and observations on this subject; (4) the application of this information to practical conditions of modern life in meeting individual and community problems. There are, for example, industrial and transportation conditions now which make the use of alcoholic liquors very much more dangerous in their results than was the case a century ago. The physiological lesson should be deftly interwoven with the concrete instruction.
>
> Facts taught should be graded to meet the interest and psychological development of pupils. Motivation may be given through the appeal to desire for fitness for sports, efficiency in play and work, vigorous health, safety, service of others, character qualities such as self-control, kindness, sportsmanship, self-reliance, duty, responsibility, truth, good workmanship, cooperation, loyalty (*4*).

In view of the evident keen interest of high school youth in driver education courses, thought should be given to having the course itself carry a goodly share of the responsibility for the general high school program of teaching the advantages of temperance in all of its aspects, of which the advantages of maintaining one's fitness for driving is one part.

Whatever formal educational program is adopted regarding good driving habits and the dangers of drinking-driving, professional educators would do well to avail themselves of facilities for testing the effectiveness of the methods used. As one case in point, controlled studies on the effectiveness (in terms of modifying smoking habits) of five different approaches to teaching the hazards of cigarette smoking established that, while all five approaches brought about improvements, one of the five was distinctly superior to the others (*21*). Methods of controlled testing of the relative effectiveness of various types of training and indoctrination techniques have been well worked out in the Armed Forces, in industry, in public health, and in education. In view of the potential gain in lives saved a generation hence, all well-designed studies of driver education should be encouraged in every way possible.

Summary

1. This paper takes the position that the "drinking-driving problem," being compounded of two major behaviors (drinking and driving) which are deeply embedded in our culture, will not yield to routine "educational" campaigns.

2. Much intensive research is needed on the real-life consequences of mixing gasoline and alcohol, and on the characteristics of accident-involved drinking drivers, before effective enforcement and educational programs can be developed which will result in a material reduction of drinking-driving accidents.

3. Agreement among authorities and leadership groups upon the criteria for law enforcement regarding drinking-driving needs to be achieved before a public education campaign can be very successful.

4. The public will be reluctant to accept hard-and-fast enforcement of drinking-driving laws unless the need for such enforcement is demonstrated in a more compelling way than heretofore.

5. Law and persuasion must work together. Without public cooperation, laws are of little effect; and persuasion regarding such a firmly established practice as drinking-driving is of little effect without the firm backing of laws which are applied with firmness and certainty.

6. Cultural and psychological impediments to public support of stringent law enforcement are many and complex, but research and action programs can be developed to overcome these impediments.

7. Among the communication principles discussed in this chapter as appropriate to preparing educational campaigns regarding drinking-driving are the following:

a. Any educational campaign must contain within it a promise of concrete rewards for appropriate behavior, rather than mere punishment for wrongdoing.

b. There being no such thing as a true "mass audience," a variety of appeals and specialized approaches are needed.

c. "Sloganeering" approaches, "shock" pictures or headlines, or other anxiety-producing communications on drinking-driving are likely to be ineffectual unless people are also given constructive guidance on exactly what is expected of them.

d. The role of the group in reinforcing good driving practices can be utilized especially effectively in combating drinking-driving.

8. Greater uniformity of laws and of enforcement in the various States and the uniform adoption of chemical tests as evidence on fitness to drive probably would help to raise the level of public cooperation.

9. A fertile field for public education appears to be a general upgrading of the status of the driver's license through such measures as: more intensive testing, higher qualifications and the use of various grades of licenses and insurance differentials as rewards for careful driving, and the intensification of high school driver education programs.

10. From a long-term preventive medicine standpoint, concentrating upon those of high school age appears to be one of the best ways of educating the public to the dangers of drinking-driving.

References

1. Abelson, H. I. *Persuasion. How opinions and attitudes are changed.* New York: Springer, 1959.
2. *Accident facts. 1960 edition.* Chicago: National Safety Council.
3. American Institute of Public Opinion (Princeton, N.J.). Gallup poll release of May 11, 1960.

4. American Medical Association and National Education Association report of joint committees, 1930. Quoted in C. H. Patrick, *Alcohol, culture, and society.* Durham, N.C.: Duke University Press, 1952. P. 155.
5. And what else is new? (Psychology in the States.) *Amer. Psychologist,* 1960, **15,** 237.
6. Automotivational research. (Psychology in the News.) *Amer. Psychologist,* 1960, **15,** 367.
7. Beamish, J. J., and Malfetti, J. L. A psychological comparison of violator and non-violator automobile drivers in the 16 to 19 year age group. *Traffic Safety Res. Rev.*, 1962, **23,** 12–15.
8. Bello, F. The city and the car. In *The exploding metropolis,* by the Editors of *Fortune.* Garden City, N.Y.: Doubleday (Anchor Books), 1958. Pp. 32–61.
9. Brandaleone, H., and Miller, E. Address before International Congress on Occupational Health. Reported in "Intoxication test held too lenient." *New York Times,* July 27, 1960. P. 31.
10. Campbell, B. J. (Institute of Government, University of North Carolina, Chapel Hill). *Driver improvement: the point system.* Published by the American Association of Motor Vehicle Administrators, 1958.
11. Campbell, H. E. Blood alcohol level and highway deaths. *Rocky Mtn med. J.*, 1958, **55**(1), 51–59.
12. Centering traffic safety around drivers' motivations. Unpublished pilot study conducted by the Opinion Research Corporation, Princeton, N.J., 1958.
13. Cooper, Eunice, and Jahoda, Marie. The evasion of propaganda: how prejudiced people respond to anti-prejudice propaganda. *J. Psychol.*, 1947, **23,** 15–25.
14. A critical analysis of driver education research. Washington, D.C.: National Education Association, 1957.
15. Dollard, J., and Miller, N. E. *Personality and psychotherapy.* New York: McGraw-Hill, 1950. Quoted in C. I. Hovland, I. L. Janis, and H. H. Kelley, *Communication and persuasion.* New Haven: Yale University Press, 1953. Pp. 61–62.
16. The drinking driver. Undated leaflet issued by the Insurance Institute for Highway Safety, Washington, D.C.
17. Greenberg, L. A. The problem of drinking and driving. Address before the National Conference of State Liquor Administrators, held at New Orleans, La., May 9, 1960 (mimeographed).
18. Hill, R. C. Acceptance and endorsement of chemical tests. In *Chemical tests for intoxication manual.* Committee on Medicolegal Problems, American Medical Association, 1959. Pp. 4–5.
19. Holcomb, R. L. Alcohol in relation to traffic accidents. *J. Amer. med. Ass.,* 1938, **111,** 1076–1085.
20. Hoover, J. Edgar. Letter to all law enforcement officials, reprinted from the *FBI Law Enforcement Bull.,* Sept. 1960.
21. Horn, D. Cancer facts cut teen-age smoking. *Senior Scholastic* (*Scholastic Teacher* ed.), 1960, **76**(12), 6–T—7–T.
22. Hovland, C. I., Janis, I. L., and Kelley, H. H. *Communication and persuasion.* New Haven: Yale University Press, 1953.
23. Hovland, C. I., and Weiss, W. The influence of source credibility on communication effectiveness. *Publ. Opin. Quart.*, 1951, **15,** 635–650.
24. Hyman, H. H., and Sheatsley, P. B. Some reasons why information campaigns fail. *Publ. Opin. Quart.*, 1947, **11,** 412–423.
25. Janis, I. L., and Feshbach, S. Effects of fear-arousing communications. *J. abnorm. soc. Psychol.*, 1953, **48,** 78–92.

26. Knight, G. J. We jail drunken drivers in California. *The Saturday Evening Post*, Apr. 26, 1958.
27. Lauer, A. R. Basic factors of safe automobile driving. *Police*, 1960, 4(4), 60–61.
28. Lefkowitz, M., Blake, R. R., and Mouton, J. S. Status factors in pedestrian violation of traffic signals. *J. abnorm. soc. Psychol.*, 1955, **51**, 704–706. Cited by H. I. Abelson, *Persuasion. How opinions and attitudes are changed.* New York: Springer, 1959. Pp. 20–21.
29. Lewin, K. *Field theory in social science* (edited by D. Cartwright). New York: Harper, 1951.
30. Licensed Beverage Industries, Inc., leaflet (untitled) reporting activities of local members and associations, October 1958.
31. Malfetti, J. L. Traffic safety, the driver and electronics. *Teachers College Record* (Columbia University), 1959, **61**, 99–111.
32. McFarland, R. A. Address at the 1956 annual meeting of the American Medical Association, on the Panel on Medical Aspects of Crash Injuries. Cited in "New perspectives on highway safety." Undated pamphlet issued in 1957 by Licensed Beverage Industries, Inc., New York, N.Y.
33. McFarland, R. A., Moore, R. C., and Warren, A. B. *Human variables in motor vehicle accidents.* Boston: Harvard School of Public Health, 1955. Cited in "A critical analysis of driver education research." Washington, D.C.: National Education Association, 1957. P. 12.
34. McGuire, F. L. Rosenzweig picture frustration study for selecting safe drivers. *U.S. Armed Forces med. J.*, 1956, **7**, 200–207.
35. Meehan, T. Eight simple tests for self-determination of when you are fit to drive. *Esquire*, October 1959.
36. Meisler, S. Charade of civil defense. *The Nation*, June 11, 1960, pp. 507–510.
37. Merton, R. K. *Mass persuasion: the social psychology of a war bond drive.* New York: Harper, 1946.
38. Moynihan, D. P. Epidemic on the highways. *The Reporter*, Apr. 30, 1959, **20**, 16–23.
39. New Jersey's public opinion poll on traffic safety. Department of Law and Public Safety, Division of Motor Vehicles, Bureau of Traffic Safety, Trenton, 1958.
40. New perspectives on highway safety. Undated pamphlet issued in 1957 by Licensed Beverage Industries, Inc., N.Y.
41. Osgood, C. E. Cognitive dynamics in the conduct of human affairs. *Publ. Opin. Quart.*, 1940, **24**, 341–365.
42. Packard, V. *The hidden persuaders.* New York: Longmans, Green, 1957.
43. Patrick, C. H. *Alcohol, culture, and society.* Durham, N.C.: Duke University Press, 1952.
44. Profile of the millions. (2d ed.) Report issued by the *New York News*, 1958.
45. A real menace demands a realistic attitude. *The Courant Magazine,* June 26, 1960.
46. Seales, T. A. The drinking driver. *Traffic Safety Res. Rev.*, 1957, **1**, 80–93.
47. Smith, H. W. Drinking and driving. The Attorney-General's Laboratory, Province of Ontario, Toronto, 1960.
48. U.S. Congress. House of Representatives Committee on Interstate and Foreign Commerce. Report of Special Subcommittee on Traffic Safety. Quoted in "New perspectives on highway safety." Undated pamphlet issued in 1957 by Licensed Beverage Industries, Inc., N.Y. P. 12.
49. U.S. Department of Commerce. The federal role in highway safety. House Document No. 93 of the 86th Cong., 1st sess. Washington, D.C.: Government Printing Office, 1959.

50. U.S. National Health Survey. Health Statistics, Series B, No. 37. Washington: U.S. Department of Health, Education, and Welfare, 1962.
51. U.S. Public Health Service, National Office of Vital Statistics. *Vital statistics of the United States*. Washington, D.C.: Government Printing Office. Published annually (see 1956–61).
52. Uses of chemical tests for intoxication. Report of the Committee on Alcohol and Drugs, National Safety Council, Chicago, Ill., 1959.
53. What motorists really think about traffic safety. A report on a study conducted by the Opinion Research Corp. Published jointly by the Pure Oil Co. and the American Trucking Association Foundation, 1958.

CHAPTER VIII

Some Miscellaneous Assessments in the Drinking-Driving Problem[1]

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In this chapter an attempt will be made to examine some aspects of the problem of drinking and driving. There are four central ideas, all relevant to several of the other chapters. The first subject has to do with the details of behavior in the process of driving, including, of course, the accident itself. The second topic, the idea of probability, is common to almost all phases of the problem of drinking and driving, and is related here to legal questions, risk taking, and habit. The third subject is a question relating to values: what are some criteria for success of a chemical testing program? Finally, some ideas will be mentioned on the question of the ultimate criterion in research on effects of alcohol on driving.

Effect of Alcohol in the Driving Situation

I would like to extend Carpenter's and Dubowski's thinking a bit by exploring the behavior making up the driving act and relating it to the effect of alcohol, particularly in a critical situation. Most of the discussion has dealt with drinking behavior and little with driving behavior. It would be proper to examine driving-drinking as well as drinking-driving.

Normal Driving Behavior

We are in the rather awkward position of not knowing very well what is involved in normal driving itself, to say nothing about what is involved in emergency driving. Take, for instance, a sampling of the actual behaviors we meet in the performance of driving. Platt has listed many of the elements of the driver's performance (*10*). I will edit his list a little. With the steering wheel the driver can do two things: maintain course; or make a turn, which involves turning the wheel and returning it to a central position. With the brake he can do two things: press or not press, which result

[1] Part of this paper was presented at the National Conference on Alcohol and Traffic Safety, Pittsburgh, 1961, under the title "Perspective."

in three events. By not pressing, he can maintain speed or allow it to decline slowly; by pressing some, he can slow down; and by pressing hard he can stop. With the accelerator he can either press or not press, which results in increased speed, maintained speed, or reduced speed. If he has a clutch and gear shift he can shift gears and engage or disengage the gear system. In addition, he can do many things not involving a direct effect on the car's motion, like signaling, switching on lights, turning on the windshield wipers, shifting his gaze within the driving scene, lighting a cigarette, talking, turning his head to look at his vis-à-vis in conversation, etc. These acts or some combination are present during the performance of driving.

Theoretically, we can look at driving in two ways. It can be regarded as proper behavior from which a greater or lesser departure takes place continuously. For instance, there is an optimum area of road position, in each driver's opinion, from which he occasionally deviates. This deviation requires a slight wheel adjustment in most cases. Sometimes it requires a more sudden and more severe adjustment, because the departure from the optimum is greater. Other optimums can be described such as closeness to the car ahead, or speed. But we can look at this in a second way. We can say that driving consists of a series of near misses, moderate misses, and far misses. In the far misses we have good control, danger is not close, and a possible mishap is seen well in advance and long anticipated in action or preparedness. The number of occasions requiring minor adjustments or adjustments well in advance of the potential danger is not too well known, but Platt has given us an approximation to it for some driving cases, and to boot, derived the data experimentally for a few—a rare thing in this field (*11*). The number of moderate misses, which require quicker adjustment and have a greater element of surprise or unexpectedness, is much less well known, since they occur less frequently, and one can only make good guesses based on a very little bit of information. The near misses are rare, and we can only say that they probably exceed the hits or accidents in number. By how much, we don't know. Their types as reported by drivers in retrospect have been described by Forbes (*7*). For some situations and some purposes, the idea of departure from optimum behavior is better; for others, that of closeness of approach to a hit is better. Let us use the latter in this case.

Now, in every situation in which an adjustment is made because the driver predicts that a hit might take place if the adjustment were not made, we need two things. We need the circumstance, such as an unexpected maneuver by a car ahead, or a child making a sudden move, or a parked car's exhaust starting up; and secondly, we need the perception by the driver that in fact a *potential* accident circumstance has arisen which would become an accident if he made no correction. For every successful correction made, we need two additional things. We need the driver's adequate judgment as to what would happen as a result of the particular correction he *wants* to make; and his adequate execution of the correction.

Let us take each of these in turn. The necessary circumstance can arise a shorter or longer time in advance of the car reaching the spot or of the driver being able to perceive it. For example, the child can run into the street 100 yards ahead of the car or 100 feet. This feature of the accident is less subject to control by the driver than other features may be, but in one way, its interaction with him is very much under his control. He can anticipate that unexpected events will happen, and do something in advance to allow himself greater time between the unexpected event and his car's involvement in it. This increased time and this anticipation form the crux of much accident prevention theory. Which is more important I don't know. To prevent an accident, the driver can reduce speed, he can allow a greater distance to the car in front of him, and so forth. From another point of view, he can *increase* likelihood of a circumstance involving danger by being a road jockey himself—that is, seeking out and creating hazardous situations. In these cases he decreases available perception and reaction time not only for himself, but for the other drivers. Some examples are deliberate weaving, hugging the center of the road, racing, going at high speed, etc. The negatives of all these, of course, tend to accident avoidance. Finally, the driver's characteristics and behavior can affect the type of circumstance.

The second consideration requires the driver to perceive that an emergency or potential emergency exists. Whenever anything interferes with such perception or heightens it, we have a changed accident potential, assuming for the moment an unchanged willingness to risk an accident. Several things can affect this. Experience is very important. Intent to search for emergency is important. Opportunity to observe circumstances is important. For example, a person who smokes often, or a person who must face someone to talk to him decreases his attention to the road by a small amount. Anything which constricts the field of attention is important, such as the rims of eyeglasses under some conditions. Some drugs act as if they do this. Personally, I believe that they do something else, however. I believe that they reduce the responsiveness of the person to the intrusion of other stimuli in part of the visual field, usually the periphery. That is, peripheral objects would be less able to capture or divert attention from its current object to themselves. This should be tested. Whether the field which is attended to is also smaller, I cannot say. Sensory deficit of most kinds also reduces capacity to perceive. Intellectual deficit will do so. (This stems from the definition of "perception," which is the receiving of a stimulus *and the attachment of meaning to it.*) And of course, anything which prevents or reduces the number of circumstances which can *be* stimuli reduces perception. For example, if a person's ability to maintain shifting attention is hampered or reduced, he will perceive less; or if his ability to maintain vigilance at a high level is reduced, so will the amount he perceives be reduced.

For the case of the driver who does make an adjustment, he does so because he made a judgment of impending danger, and also, of the best maneuver to prevent or avoid the danger. His correctness in predicting the probable result of his proposed maneuver can be affected by experience, intellectual deficit, knowledge of his capacity to react, and correctness of perceptual impressions such as distance, speed, estimated collision course, and position relationships.

The last requirement is actual ability to execute the correcting maneuver. The execution of an adjustment can be influenced by experience, characteristics of the car, ability to coordinate motor skill and perception, normal reaction time, drugs, fatigue, sleepiness, and the like.

Unfortunately, it would take too much time to apply the same analysis to the many driving situations which have been described by Platt, Forbes, and others.

Driving Behavior After Drinking

The question now, after describing the classes of events relating to the driver involved in potential and actual accidents, is what effect alcohol might have on these events, processes, or behaviors; how much effect; and what the likely consequence might be as regards the near, moderate, or far miss—to say nothing of the hit.

General performance. To begin with, let us look at general driving performance, without regard to its components. What driving and other behaviors do we *know* are changed with alcohol, and to what extent? Can we draw a conclusion from this knowledge?

The literature relevant to Carpenter's presentation has shown that alcohol in small doses does not cause major changes in the average speed of driving, but does cause increase in the variability of speed. (Abele (*1, 2*) and others in Germany have examined this question.) This means that some people drive slower and some faster; further, it means that some individual drivers drive with a greater spread of speed than their more consistent normal speed range. This was found in one study (*13*) to be particularly true of skilled drivers, perhaps because their original variability was so small. It has been shown that steering movements in driving become more variable with small and moderate doses of alcohol in the samples tested. We can only conclude that this implies less control, since the test runs were relatively smooth.

Other driving data from the laboratory, such as the work of Goldberg, Drew, Loomis, and Coldwell (see references in chap. III), show more or less the same thing about increased variability among drivers. Those of Drew's subjects who acquired greater consistency usually ended up driving either considerably faster or slower than their control runs.

In any case, what is the probable effect on the likelihood of an accident? Except for those who changed little, the actual car performance probably produced a net increase in danger. Those who varied their steering and speed behavior excessively were on the face of it more dangerous, although one should hasten to add that this should be proved. Those who reduced speed were less likely to have an accident (except for those who crept) unless they were forced into an external pace faster than their own controlling pace. Since this unexpected demand on reaction is almost always present in emergencies, it is likely that they too increased the danger of accident. For those whose speed increased, their likelihood of increased accident would be dependent on circumstances. For the particular ones described, I am inclined to think that it would be increased. All in all, a greater accident likelihood can be inferred. Please note that this is strictly a theoretical deduction, but it is empirically supported by the findings of Holcomb et al., Lucas et al., Haddon and Bradess, Smith and Popham, Vamosi, and others mentioned by Schmidt and Smart in chap. II. Again, inferentially, but with even less hard data as support because high dosage levels are not easily obtainable experimentally on the road, we might draw the conclusion that higher doses would result in even greater variability than lower, creating greater danger. Certainly the laboratory studies of actual or simulated driving support this contention.

We already have some statement of the amount of depressed function which is found with the ingestion of alcohol of various amounts for several tasks. Generally the picture is that deterioration begins at a low level, but slightly and only for some functions. It grows gradually until at moderate levels practically everyone is affected, but not necessarily to any great degree. For some functions there is a question as to whether deterioration exists or enhancement of ability exists. Particularly, Carpenter's study (*4*) may be cited. Carpenter et al. reported that performance on tasks involving higher logic and memory processes could be improved by small amounts of alcohol, although it degraded with larger amounts. In a sense this finding is contradictory to some of the most basic physiological dogma to which we have all been exposed; namely, that the higher processes are more quickly affected in the early stages of drinking than the lower. This study, even though it shows improvement with small doses, does not directly refute the findings of the others, since it dealt with highly complex logical processes. This is true in spite of the large number of studies in the literature which suffer from major deficiencies of design, as pointed out in chapter III. The reason that it does not refute them is that there still remains a large enough number of such studies which do not uniformly suffer from such deficiencies, so that we can come to a conclusion that a fair number of functions are in fact depressed by small to medium amounts of alcohol.

Components of the Driving Task After Drinking

A. *The Circumstance Permitting an Accident*

Now we come to an examination of the considerations that were mentioned above in the driving scene. A circumstance which leads to an accident or a potential accident must be present. Behavior which would either increase or decrease the likelihood of such a circumstance occurring or of the circumstance being close upon the driver influences this likelihood of accident. The factors here are not merely ones of vigilance or even anticipation, but they also involve an attitude of continuing assumption about the traffic situation. Most drivers act as if the current traffic situation will continue unless there are obvious evidences to the contrary. There are no data on the matter, but one might hypothesize that under the influence of alcohol an individual will be more likely to make such an assumption of inertia of circumstances than one who is not under the influence of alcohol. This assumption might be attributed to deficiencies other than alcohol induced, but at least it could be well described in these operational terms.

We would anticipate that when an individual varies his speed unpredictably, he is probably more likely to cause an accident by his own car becoming a circumstance of the nature we have spoken of. This condition is aside from deliberate acts such as weaving or hugging the center of the road. It is hard to come to a conclusion here because of the lack of data. However, on the face of it, it would seem likely that potentially dangerous circumstances would arise more often in the case of the alcoholized person than in the case of the sober person. Again, this is strictly inferential.

The second consideration spoken about requires the driver to perceive that an emergency or potential emergency exists. Does alcohol interfere with such perception? It need not necessarily remove the perception, but it might lengthen the time that it takes to realize the existence of an emergency situation.

B. *The Reaction Process*

This brings up the problem of what reaction time is. Most studies up to this time have examined reaction time on a continuum from fairly complex decision making to the most simple and straightforward reaction time possible. One component is almost always present. The stimulus to be reacted to is clearly available for inspection and perception. Various differences have existed in these situations, but it has never been pointed out with any great emphasis to the researcher on the effect of alcohol on reaction time that it is made up of several kinds of components.

The first of these is sensing the stimulus which might lead an individual to react or not react. It has been shown that some sensory capacities of the retina, for example, are slightly depressed by alcohol, depending upon what the functions are, and some are considerably depressed.

The second stage of a reaction is the structuring of patterns residing in what has been sensed. This structuring is probably almost automatic, but may in many cases mislead one in the next phase or even alter completely the correctness of the next phase.

The third phase is the attachment of meaning to the structured patterns. These two functions combined, I believe (structuring and attachment of meaning), are considerably more depressed by alcohol than one might discover from standard reaction time experiments, probably contributing much to lengthened reaction time. The hypothesis can and should be tested.

A fourth component of reaction time is the decision to react or not to react upon the completion of the perceptual act. There is a question as to whether this suffers as a result of small or moderate amounts of alcohol. It is difficult to determine.

The next component of reaction time is the decision as to what reaction to make. This is an interesting component, perhaps almost as important in the driving task as the duration of the perception time. It is here, where decisions of a critical nature must be made, that one might find much greater deterioration as a result of stress *plus* a depressant in the brain than appears from straightforward reaction time measurements.

The last component is the performance of the reaction itself. This type of behavior has received a great deal of attention and we probably know more about it than about any other, since it forms the backbone of the simple and sometimes the moderately complex reaction time experiment. Deterioration of this component due to alcohol seems to be somewhat less than the deterioration of the higher level elements of reaction time involving decisions and attachment of meaning. Still, execution may be poor if the action required is complicated.

In all accuracy it must be pointed out, however, that there is a large class of behavior in the automobile resulting from certain emergency situations which, in the hands of an experienced driver, becomes an almost automatic sequence. Cases where the requirement for fast braking is immediately obvious and almost automatic are almost identical to classical laboratory "simple reaction time" experiments, rather than different, as is proposed above. In cases where a decision is required as to whether to go or stop for a red or green light, this is again almost a classical "complex reaction time" test. Here the reaction time process is not particularly complicated and can be presumed to follow the findings in the literature.

There are a fair number of circumstances, however, in which one might find a decision process difficult to make. Certainly the process of defining a scene in terms of components meaningful for the likelihood or unlikelihood of accidents occurs many times during the driving situation. If this scene is misinterpreted, or if it takes a long time for the relevant features of the scene to be perceived as important for questions of safety, then we can see an important consideration in the accident picture. From this point of view one might question how many of the relevant stimuli for safety considerations have actually been tested in the laboratory experiments we have been told about. Surely some of them have, but in view of the way in which the world exposes itself to the driver we may have run into a fundamental lacuna in our experimental attack on the problem. I propose that this possible emptiness in our experimental structure be examined with great care.

C. *Interferences With Attention and Perception*

Let us look at some interferences with perception. Removing the circumstance which may be important from the field of attention reduces the ability to perceive. Thus, when socializing increases in a car, there is probably greater likelihood that certain emergency situations may fail to be seen.

We have already noted that the person under the influence of alcohol is less able to maintain attention, at least in a sensory way, than he is without alcohol. Tests of vigilance seem to be directly transferable to the road situation when one analyzes the performance and behavior and function involved. On this basis one might predict that less would be perceived on the road itself, including a number of circumstances that could lead to accidents, and therefore predict a greater probability of accidents.

D. *Adjustment to an Emergency: Judgment*

I mentioned that when an adjustment is made, two acts are involved. One is a judgmental act and the other is a performance act. The judgmental act itself is made up of two parts: that of judging that danger impends and that of deciding upon what maneuver to make. Of the items which have been mentioned as having an effect upon such a judgment, only certain ones are presumed to be subject to effect of alcohol: momentary intellectual capacity; knowledge of one's own capacity for reaction; and correctness of perceptual impressions, such as distance, speed, estimated collision course, and position relationships. Of these, only higher order intellectual performance has been subject to question. Carpenter's results show that with small amounts of alcohol, certain pure intellectual capacities may be improved. Other measures which he has spoken about seem to have deteriorated.

The person under the influence of alcohol has often been said to suffer a marked reduction in his understanding of his own capacities. We are not sure if it is universally true. But if so, this may, in fact, be a very important factor in the kinds of behavior encountered on the road among drinking drivers which might lead to increased accidents.

Tests have shown with a fair degree of consistency that judgments of estimated collision course and position relationships either do not change much or become worse.

Thus, all in all, correctness of perceptual impressions may be somewhat or markedly affected, depending on existing conditions. By whatever degree they are affected, they increase the probability of a circumstance of dangerous nature being unrecognized.

We must have care in interpreting such a conclusion and applying it, however. There is a curious forcing situation here which has not been recognized to any major extent in this field. Over a number of occasions, errors made in judgment of distance, speed, or estimated collision course are distributed around a mean. Some errors say there is a greater distance than really exists. Some say there is a smaller distance than really exists. For the driver, it is important to note that these two judgments do not balance out to a neutral situation. Rather, all those errors which lead to greater safety—that is, all those judgments which are conservative with respect to the man's danger—are in the same domain as those which are correct. This means that he either increases his functional safety with respect to the dangerous situation (due to that kind of error), or it remains the same, for cases where he makes no error. But when his error is not conservative, his danger is increased. Therefore, even though the sum of the errors may be a central value close to no error, the very existence of errors of judgment concerning distance, speed, and estimated collision course as part of the distribution will inevitably produce an increased likelihood of accident. However, this increase will occur only in about 50 percent of the cases in which an error in judgment has been made, provided that the distribution is anywhere close to being symmetrical, since only those errors which increase danger can be cited as contributing to accidents, and not those which decrease danger.

In summary, we may then say that a certain small portion of the general features which influence correctness of an adjustment produces either no change in danger or a slight improvement in safety when a person drives with a small amount of alcohol. This portion is intellectual performance. Other portions of the features which affect a judgment of danger and of a proper maneuver are detrimental to safety and include several items. Who is to say the relative balance of these combined contributions? If I had to make a judgment and my life depended on it, I would say that the greater weight of evidence points to a deterioration of such judgment. Again, of course, it is a deductive position.

E. *Adjustment to an Emergency: Action*

The execution of a maneuver is influenced by motor skill, perception, reaction time, and fatigue, among other things. Alcohol can decrease motor skill and perception, prolong reaction time, and increase sleepiness. One might feel it very important to ask the degree to which alcohol consumption contributes to increased sleepiness on the road when a person is alone or drives in such a situation that sleepiness tends to be induced in the normal driver. Here again the data, such as they are, support the contention that alcohol influences execution of adjustments in a negative way.

Some years ago analysis was made of a phenomenon of interest to the present case (*12, 14*). If a person made a decision to act, and entered into the action stage, it would go on for a certain length of time irrespective of any decision to change. This "ballistic motion" was preprogramed into the action and was carried out without continuous supervision of every phase of the action by the brain. In order for it to change in midstream, it had to take long enough in the first place for the previously mentioned decision process to take effect by inactivating active muscles and at the same time activating opposing muscles. A shorter ballistic movement went to completion irrespective of decision to change in midstream because the process of stopping occupied a definite time which took longer than the motion itself. It would be of some interest to see how alcohol affects the duration of ballistic movement which is reversed in midstream.

Up to this time I have neglected to mention the contribution of personal characteristics to behavior while under the influence of alcohol, or even to ask whether personality has a great deal to do with the fact of drinking alcohol. This belongs in a somewhat different area of discourse from the one in the above discussion, and will be taken up below.

All the above discussion is very relevant to the pedestrian as well as to the driver, and so will be the following discussion.

Some Inferences

In terms of strict psychophysical and performance characteristics of the driver, I believe that somewhat of a case has been built up for the logical picture that alcohol in amounts above a certain hazy range on the order of 0.05 percent is a cause of increased accidents and injuries on the road. It is a persuasive logical case, but even if a perfect case were made logically, we would still need hard data about driving behavior on the road, of the kind that people do in real life. The object of such data is to convince those who may still have doubts and who bring up certain exceptions. The object is also to point out the probable relationship between laboratory findings and on-the-road findings in order to indicate how relevant past and future laboratory studies might be. At the moment we are reluctant to place the greatest amount of faith in the laboratory studies, although we place some faith in them, as being relevant to road behavior. If it were established that certain kinds of laboratory studies could be direct measures of road behavior and road performance, it would be very important because a direct call upon a multitude of such studies could then be made. (Due respect is given here to the questions which Carpenter brought up about the confidence which one should place in such laboratory findings, even if relevance were to be established. I speak mainly of those in which the careful observer can have such confidence.)

Probability and Risk

The problem of variation is one which is continuously with us, not only in our relations with others and in our habitual behavior but also in our unusual and infrequent behaviors. Time and again, change, unexpectedness, or departure from normality has been the basis for both correct and false judgments. More often, expected continuance of circumstances forms the basis for persistent behavior on the road.

In this field we are concerned with a number of kinds of events. There are several which seem to have great importance. One is variation in blood alcohol determination. Another is variation in driving performance in the same person from occasion to occasion. A third is variation of behavior in different people. A fourth is a difference of opinion about driving in a given population. A fifth is the difference in the composition of driving populations as to exposure and experience. A sixth is variation of task demands. Many others can be named.

The Statistical Implications of Certain Laws and Ordinances

Let us take the case of alcohol effect and examine it with some care. We know that from one occasion to another, alcohol effect will differ in the same person. He will have a lowest level of effect for a given amount of alcohol, with a certain greater effect in the worst case, and an average effect over all occasions for this amount of alcohol. In addition, we know that different people differ in their response to alcohol, assuming a given blood level. When we assign an average for a given situation to a given population, the individual cases will sometimes give higher and sometimes lower values with respect to the average. If we were to take two similar groups and compare one measure in the two groups—for example, reaction time under alcohol in one group and reaction time with no alcohol in the other group—we would come out with a difference between the two groups. In view of what we know of alcohol effect, such a difference would include a fairly large amount of overlap, assuming that the averages truly differ by a hypothetical amount like 10 percent (I am not sure what the difference actually is for any alcohol level). This means that some people would have poor reaction time with no alcohol, and others would have good reaction time with alcohol. It means that some people would have good reaction time with no alcohol, and others would have poor reaction time with alcohol. The problem is: How many have prolonged reaction time in the alcohol group as compared to the nonalcohol group; or perhaps one might ask: To what degree is there a general shift in the whole experimental group as a result of its drinking alcohol?

The implications of the question pose basic problems in many legal areas, particularly chemical testing. We know that some people are already poor drivers, and others are good drivers. If certain drivers are reduced in skill in some degree, they may still be better than the poor drivers who do not have alcohol. This problem has been faced in other situations. In many areas of law it has been solved by specifying a particular behavior or a particular measure which may not be exceeded, because on the average a certain important proportion of the public is endangered by such and such a condition, even though some members of the group with this condition would not endanger others or themselves. This philosophy pervades a very large number of regulations regarding our daily living. For example, why is it forbidden that joists in a house be separated by more than a certain amount? Why is it required in certain geographical areas that the foundations of a house extend so and so deep? Why is it required that automobiles park so and so far away from a corner? Why is it required that gas furnaces require certain kinds of draft controls? Why are there speeding laws?

In all of these cases there is a presumption that some or even many of the population at risk—which is to say those who fall within the effective realm of the regulation—will be quite safe. That is, circumstances may never arise during which their behavior or objects in their environment will lead to danger to themselves or others, even if the regulation is broken. But there is the more important presumption that a sufficient proportion of the population at risk *will* suffer damage and injury as a result of failure to conform to safe practice. It is this presumption that has forced the regulations into existence. When the public is aroused to the need for the regulations, and when the public observes them, then the regulations, having been created for a purpose, are fulfilling their purpose. When such regulations are passed as a logical requirement and are not enforced, there may be many possible reasons. It might be that the public is either not enough concerned or informed about them; it might be that the legislators and public representatives are not enough concerned or informed about them (which in turn may go back to the public itself).

In any case, there is no question that the law recognizes the statistical quality of danger and therefore sets what has been decided is a proper limit for preservation of safety at a probability level which is satisfactory to the public and to the legislature. Sometimes this level is intuitively derived. Other times it is based on engineering specifications. In almost all cases a decision has been made as to the amount of danger tolerable in the face of cost, injury, manpower, etc. Whether implied or explicit, this decision underlies creation of the law.

When we consider behavior on the road in the same context, we find that there is great overlap between performance with and without alcohol. The major question here may be: Is the separation of performance in the two conditions so great that performance with certain levels of alcohol will lead to unacceptable danger to the public? The laws mentioned in chapters I, V, VI, and VII have been created with this presumption in mind. It may be important to note that there is a curious separation between what the law says and what the public thinks is important, as several writers have already pointed out.

To recapitulate: (1) Variation in general terms exists within the same person and between people. (2) There is overlap in performance among people who have and have not drunk alcohol. This leads to a basic problem of legal philosophy. (3) Many regulatory laws have been passed on the theory that the danger to a few on a few occasions justifies rules applying to many occasions which prevent injury or danger on those few occasions. Some are based on engineering and some on intuitive grounds. All such rules imply someone's decision process as to a balance between greatest permissible danger (or least permissible safety requirement) and such things as cost, ease of enforcement, public acceptance, and the like. (4) The same situation exists in the case of drinking and driving, or speeding.

From the above development, it is relatively easy to make the next jump. If this is the case with speeding, for example, why should it not be so with alcohol level? In both cases, some people did not endanger lives because their skill in driving was greater than the skill of the group that did. Should this lead to a definition of the illegal act as drinking to a certain blood level, followed by driving? Should this alone be the illegal act, rather than intoxication or alcohol influence leading to degraded performance, based on the statistics cited in chapter II?

This question has been asked by others, but was based, perhaps, on different considerations. I submit that the statistical nature of some regulations and ordinances should be added to the points already considered by others.

Risk and Hazard [2]

The problem of risk and hazard has often been suggested as an important one in the driving field. It would be worth looking at it more closely. I suggest, opposed to the definitions of Cohen et al. (5), that "hazard" be the term for objective danger and "risk" the term for perceived hazard. Thus a person cannot take risk of a certain degree unless he also makes some estimate of the hazard of the situation. For if a person perceives no hazard, he takes no risk, so far as he is concerned. In many cases hazard is correctly estimated, and risk is therefore a measure of the person's willingness to gamble with certain true odds. In other cases, this is not true; that is, the person gauges hazard incorrectly.

In accident theory much has been made of conscious risk taking (used in the present sense) as a cause of accidents. The present thesis questions the extreme prevalence of risk taking of high degree. The position that many accidents are due to high risk taking also implies that our general educational efforts should be directed toward reducing conscious risk taking. I question this as an area of major need.

First, however, it should be said that risk can only be taken with respect to events not under control of the actor. When he gauges the likelihood that he will meet a speeding car at an intersection, an estimate of hazard is made, a hazard which he can control only by manipulating his own behavior, not that of the world around him.

If the actor makes no conscious estimate of hazard at all, we can equate this to an estimate of zero hazard; hence the person in such a case takes no risk. This is the kind of event which is found when a mother leaves a medicine bottle lying on a table. She acts as if no child will find it. If the question were asked of her, she might say that it is possible that the child would find it, and thus assign a positive hazard to the situation. Often,

[2] The material on risk and hazard, and the next section on reinforcement and the driving act, were presented at a Public Health Service regional seminar in 1958.

if this happens—and it is equivalent to the question of possibility of hazard occurring to the mother when there is no one present to ask the question—she will decide that the hazard is too great, and will remove the bottle. Sometimes she balances other values against the hazard, like the urgency of other tasks, and decides that the hazard is too small to worry about. She then leaves the bottle. The point, however, is that the latter case differs fundamentally from the case where the question of danger did not even occur to the mother. In such a situation, risk must arbitrarily be defined as zero, and we can no longer argue about the risk-taking tendencies of people in such a state leading to accidents. The case is of overriding importance.

The second case of a person taking no risk occurs when he does not know of a hazard. This case is of great importance, and the analysis is fairly clear.

The last case of zero risk is that where the person correctly judges absence of hazard.

The whole analysis can be applied to the driver. If any of his assumptions, ignorances, inferences, and judgments about hazard are altered by alcohol one way or another, so will his probability of having an accident. I do not assume the risk to go down. It might go up, if the driver realizes that he is less efficient as a driver after drinking. Assuming no change in willingness to undergo hazard, increased risk usually results in more careful driving, and therefore smaller hazard. Risk might go down, in which case his hazard would probably go up, since he would probably relax vigilance and care. The question of measuring hazard itself, and therefore, to some extent risk, is another problem, which can be resolved only by a fairly searching analysis, since there is interaction. If his driving behavior did not change, no hazard change would be involved. But change of risk usually involves change of driving behavior, and therefore change of hazard. Thus there is reciprocal effect over the long run: quickly, in an effect of changed risk on hazard, and slowly, in an effect of hazard on risk by long-term experience.

Reinforcement of the Drinking-Driving Act

I should like to emphasize a factor which probably leads to the continuance of drinking and driving. Learning theory says that when an act is positively reinforced, it tends to be repeated in the same way, usually with some unassigned variation, when occasion arises to repeat it. If a variation occurs and the variation is reinforced, it joins the first act as a member of a class of reinforced, permissible—sometimes desirable—behavior, and the generalization extends to other variations. When a number of variations are reinforced, generalization of very broad scope occurs, and almost any variation is permissible. If one or two negative reinforcements occur, the process is very complex, and must be evaluated separately for each individual case, depending on strength of punishment, strength of reinforcement, etc.

As an example, consider a boy crossing a loose rug. How many successful steps must be taken without thought for safety; how many gaits must be used without thought for safety; how many places must be trod without thought for safety; how many near falls must occur without thought of safety—before a single hurtful, to say nothing of a seriously injurious, fall is experienced? Each time a success is achieved, a complex of behavior involving a characteristic step, a certain gait, a particular place for crossing—and others like them, all without thought for safety—is made more easy the next time. A hundred or thousand successful crossings without thought for safety lead to almost any attitudinal behavior except a heedful one. A fall will tend to lead to care, but the care is ordinarily quickly extinguished because of renewed positive reinforcement of heedless behavior. This will tend to happen unless (1) more falls occur; (2) a fall results in such severe negative reinforcement as to create a heedful attitude strong enough to compete successfully with other attitudinal habits; or (3) planned education or unplanned training creates a heedful habit.

In some cases success must always be experienced, since failure leads to intolerable hazard or to death. The mountain climber, the worker with subcritical masses of atomic fuel, the carnival knife thrower must learn to succeed all the time. It would be instructive to ask why they are always successful. It seems likely that the major reason for their continued success is the interaction of high risk and high hazard which leads to lower hazard. The drinking driver does not fall at this extreme. But since he often does not perceive great hazard, his low risk taking is based on faulty estimate and he is in fact subject to greater hazard.

As an acceptable form of road behavior, if an individual drives, and time and time again after drinking he does not have an accident, then this reinforces any belief which he might have, even a slight one, that alcohol does not lead one toward greater danger on the road. Continued reinforcement is highly probable in most cases, because there is still only a small likelihood of an accident happening to the average alcoholized individual who drives even if, for example, it might be 10 times the probability of an accident happening to an unalcoholized person.

One is inevitably reminded of the cancer and smoking problem, where the hazard is very far away in time, where the probability of the smoker being a member of the suffering group is quite low at any moment, and where probably the notion of invulnerability also still pervades the thinking of most of those who smoke.

Some Speculations on the Distribution of Alcohol Effect

An interesting point might be raised in this context. Drew and his associates (*6*) found that under certain conditions some of the drivers, particularly a portion of those who tested as introverts in his group, tended to reduce their speed markedly after drinking and at the same time to reduce their errors in performance, because of the low speed at which they drove.

Now from one point of view such individuals are perhaps safer drivers than they might be if they drove at higher speeds, assuming only a moderate or slight reduction in other driving capacities, and no reduction in ability to deal with emergencies. But if this finding extends to the population, then a certain proportion of the population is on the face of it being unjustly accused by the law. (If the law were changed to forbid an alcohol level rather than a performance degradation, they would not be unjustly accused.) In order to condemn the unsafe deteriorated driver, prima facie law says that if a driver has acted unsafely, and has a certain amount of alcohol in his blood, by virtue of the alcohol he is a poorer accident risk than a person with less than this amount of alcohol in his blood. Whatever the merits of this point, the nearly errorless behavior of Drew's slow group only emphasizes the increased tendency of their brothers to accidents. This is so because the assumed total deterioration of safety in the population would result from adding up the records of the improved and the deteriorated drivers. The important point is that the deteriorated behavior, therefore, must be so bad that, in spite of the improvement of their better controlling brothers, the average hazard is presumed to go up. It is the movement of the average which some laws are concerned with, and not the change in any individual case.

If it were possible to identify those who improve their driving with alcohol because of one or another reason, then it might be valuable to separate such individuals out as being nonculpable in the case of the slowed drivers. If it *were* possible we would be interested to find out just what it is that makes such people better drivers. Is it their increased awareness of the potential danger? Is it that they are quickly affected in perceptible ways by alcohol and that therefore they think their total behavior is badly affected? Is it because their perception of their own driving progress is in fact so cloudy to them that they are not aware of reducing speed to this degree? An indication has been observed by Drew in the above-mentioned study that the last explanation may in fact be the case in some drivers. If so, we might question whether they are in fact safer drivers after all at the lower speed.

This discussion leads to some intriguing possibilities. It would be a most interesting study to find out whether some people are affected so much in sensation by alcohol that their own perception of its effect is false and that they think they are considerably more under the weather than actually is the case in terms of performance capacity. Such individuals would be expected, first of all, to be small consumers of alcohol. Secondly, they would be expected to drive far more cautiously than the actual levels of alcohol in their blood might dictate to other drivers who would be unaware of these effects. The other drivers would have greater psychic effects, which are presumably less self-perceptible as the result of alcohol. In a similar vein, if normal or greater than normal mood swing is brought about by alcohol, it may not be perceived as the result of the alcohol, but rather as a normal mood swing. In this case alcohol effect may not be recognized at all if sensations of a somatic type do not accompany this mood change. The attitude of such people would be expected to express greater confidence in good performance after drinking. Is there a personality relation as well?

Thus far nothing has been mentioned but pure performance. Two other factors may be involved here. One is the tendency to take risks, and the other is the tendency to pay attention to other things and thereby lose the opportunity for noting important circumstances. Cohen's data on risk taking (*5*) are subject to some question, but lean toward showing that drivers are incorrectly impressed by the magnitude of risks before them when under the influence of alcohol. There are no major studies directly examining the problem of distractibility, or whether one's behavior while behind the wheel when in the company of others tends to become more social than when alone, to the detriment of driving. The question of effect on driving, of course, is the most important one here.

Invulnerability. One reason why the public does not support the proper enforcement of laws on this matter is that many individuals who drink and drive cannot get a real picture of the probabilities involved. I believe that even if these probabilities were made known, the driver might be willing to take the chance of driving the way he does on the basis of a certain kind of belief of invulnerability, very similar to that which possessed the combat soldier during the war. The soldier was often very clear about his fear, but was willing to go into battle on the assumption that the bullet was not for him; that of all the people who would die, he would not be the selected one. This is a kind of denial of the laws of chance in that it is an expression of the greater likelihood of oneself being exempt from a probability than someone else when the same probability exists in fact for both. In essence, the person says, "Maybe the population at risk has a 0.1 percent chance of being killed, but I have negligible or zero chance, even though conceptually I am part of the population at risk." This kind of belief is very widespread. It is the point of view of the inveterate gambler; of the average driver, I would say; of the soldier on the field who denies his vulnerability; of the housewife who knowingly leaves a bottle of dangerous medicine within reach of a child; and of the man of the house who fails to fix a fault in the steps until next week. The list can be continued indefinitely. The point is that these people express an expectation in their behavior which is different from any intellectual expectation which they might have in terms of the odds on a theoretical level. So it is with the driver. How is it possible to convince him of his vulnerability, and thereby make him change his behavior to the point where he does not increase this vulnerability, but rather maintains it at as low a level as he can?

A community or State must evaluate many factors in deciding whether to have a chemical testing program. In each community the tradeoff values may be different.

On the one hand, the positive results must be adequate. Will drinking and driving be reduced? Will the program save people from being thrown in jail or fined when they were really ill? Will it reduce accidents? Will there be cases where blood determinations are impractical, but where breath tests are practical and may be taken? Will there be cases where innocence of a charge of drinking-driving may be proved by the chemical tests? Will there be cases where a doctor's or policeman's judgment is radically changed by the chemical testing?

On the other hand, in this community, will the police ignore drinking drivers because they cannot get convictions? Will the judge be so lenient that the drinking-driving charge is no worse than the standard speeding charge? Will the prosecution be so conditioned that a chemical test involving a level of less than 0.15 percent is ipso facto a basis for suggesting acquittal, or for failure to prosecute, or for lowering the charge because it is unlikely that conviction can result? In this community will the chemical testing program be regarded somewhat as a toy rather than as a serious tool for the prevention of drinking and driving, and the apprehension of those who do drink and drive? Will the officers be trained so poorly for the task that the defense attorney will find it fairly easy to upset the prosecutor's contentions? Will the chemical testing program follow an intensive training program, or will there be such a state of affairs that the amount of alcohol in the blood of accused persons may actually be misjudged in many cases because of faulty test procedures? Will the chemical testing program be so costly that it may be considered a burden by the police and community? Will the testing program be a subject of needling by the community if the police pursue drinking drivers assiduously?

The balance of weight of the answers to these questions for any community should decide whether a testing program is a feasible thing, a useful thing, and whether it should be undertaken. Costs are very important; response of the community is very important; feasibility is very important. A study of the community intent and of other community experiences would be a reasonable requirement.

I am reminded of an event which took place about 6 years ago on my first entering the field of accident prevention. At this time there happened to be a safety convention to which was invited a State senator. The senator was being subjected to a certain amount of pressure to approve State bills relating to traffic safety. Among other things he was asked about his opinion of chemical testing in his own county. His county happened to be a rural one, and he happened to be what one might call a politician's politician. He made a very important point, that if a blood testing program were to be initiated in his county, it would be a very difficult task to carry out practically. If the law required that a doctor withdraw blood and store it for later testing, it would mean taking the individual away from his car up to 20 or 30 miles to a doctor, waking the latter up in the middle of the night, and asking for a blood extraction. The continuation of this story and its ramifications are fairly obvious.

But what no one at the county conference asked the senator in public was why he did not consider the possibility of a breath-testing program in which the police would be trained to administer breath tests. He had been asked this question in private, and was of the opinion that breath testing did not, in fact, reflect actual blood alcohol, and if it did, his was too poor a county to finance a program. If this example is representative of our legislature's thinking—and I am not sure that it should be—then one might take a lesson from it. One might conclude that legislators are not scientists and have not kept up particularly with the concept of chemical testing, especially if their days of legal training took place a long time ago when such chemical testing was at a rather primitive level. Certainly there is little opportunity for legislators to become acquainted with such programs. It should be an important task to acquaint our lawmakers with their benefits and drawbacks.

One last point should be made. In private the senator also pointed out that the mode of life of his rural constituents absolutely forbade him, if he valued his political life, to try to reduce drinking-driving. He simply would not be reelected. There is no implication of good or bad in this story, or what should or should not be done. It was meant to point out one or two of the more difficult questions in this area.

The Problem of Research Validation

Both in the preliminary working conferences and in the final presentation at the Public Health Service National Conference on Alcohol and Traffic Safety, two points were stressed time and again. They are particularly emphasized by Carpenter, Schmidt and Smart, and the present writer, who are most directly concerned with the effect of alcohol on the driving act and its consequences. The points were that whatever alcohol effect is found in experimentation must be related to accidents and that whatever alcohol effect is found in experimentation must be related to actual driving behavior on the road. Little attempt was made to separate these concepts or to examine their implications. In fact, the two points are fundamentally different, the first probably being impossible to achieve properly. It is important to examine these ideas with a view to clarifying the objectives of future research in this field, which, as in the past, include accurate prediction as a major goal.

The series of predictive and criterion variables in this problem can be sensibly said to start with the drinking of alcohol, although from one point of view it might be considered to start earlier. These variables include laboratory responses and on-the-road responses in driving acts (propriety, latency, efficiency, etc.); the states of the person during driving (judgment, capacity, emotional upset, attitude, etc.); and occurrence of accidents.

In the main instance we would like to know what happens to the person when he drives, principally for the purpose of discovering things about accidents. For knowledge in a statistical sense we want to know whether accidents are increased if one drives after drinking; if so, how much; and further, if so, how much, depending upon the amount of drinking. If we are interested in the single person's behavior at the time of the accident, we would like to know what about his after-drinking behavior may differ from his behavior if he had not drunk, especially as any difference might exist in regard to accidents. The latter question is an improper question because it implies that there is a clear, separable set of events or characteristics which apply to the accident directly and another which apply to nonaccident situations. This is not true. There are many varieties of circumstance and condition which may bear upon the accident and yet may not necessarily be an immediate part of the accident. They may be distantly antecedent conditions which tend to increase the probability of accidents. In this case they cannot be discoverable at the time of the accident, except in an epidemiological sense by association with it. Thus, in considering certain behavior which might lead to an accident, it is difficult to separate external conditions which affect this behavior from internal ones. Accident antecedents which are intermediate in time are also hard to relate to accident and preaccident behavior, simply because they are considerably removed from the event. Training, sources of habit, type of knowledge—all these intermediate antecedents are difficult to relate to the influence of alcohol on accidents. Events immediately preceding an accident can also not be directly related to this influence, because no one can watch just before and during an accident.

It may be of interest, even if one establishes what the accident driver does, to find out why he does it. This can be considered as important an antecedent condition as behavior before the accident, and indeed falls into one of the categories listed above which may increase accident probability. For example, does the driver drive with greater hazard to himself because his perception of hazard is blunted or altered; doesn't he care about the hazard even though he perceives it; does his invulnerability illusion become strengthened; does his judgment about the inertia of circumstances alter; does he just think less about safety considerations; or what?

The central point is that the reality of the drinking circumstances and accident circumstances prevents us from examining adequately the drinker and the nondrinker at the time of the accident (at present). For this reason our interest must be refocused on an intermediate, an approachable, criterion: the deterioration of behavior with alcohol under nonaccident conditions. One is forced to the second point made at the national conference: we must relate alcohol effect to general driving behavior, rather than behavior just before or during an accident.

Because as an object of research the intermediate criterion is separated from the ultimate criterion, accidents, the behavior produced by experimental alcoholization must imply rather than describe the "natural" drinking-driving behavior. So we are interested in any such response patterns.

There are many ways in which alcohol can produce increased probability of accident. Note the inference that when the driver drinks, he has more accidents than he does when he does not drink.[3] The driver can have more accidents in several ways: by driving more than he does when not drinking, with an equal hazard; by more hazardous exposure (for example, driving in more dangerous places, such as near roadhouses, free access highways, etc.); by more hazardous driving practice with respect to other drivers (weaving, tailgating, not dimming lights, etc.); by more hazardous driving with respect to oneself (weaving, speeding, etc.); by reduced driving efficiency (sleepiness, slower reaction time, poorer perception, etc.); and by other means.

It is very difficult to tell what the driver does at the time of the accident. Certainly, even if one is able to examine the behavior of the person in the accident retrospectively, it would be very questionable whether one has a proper picture of accident-causing behavior. By and large, such examination has been attempted only in very selected cases (*3, 9*). Certainly one would not expect to get a good picture without a very, very extended effort. This seems hard to achieve on practical grounds.

The levels of prediction of the ultimate behavior at the time of or directly preceding the accident are concretely seen in experimental behavior which can be divided into classes. One logical grouping is the similarity to "natural" drinking-driving. There is probably a continuum of similarity with much overlap, but it is convenient to label salient categories. All involve controlled drinking.

1. Driving in real traffic.
2. Driving on a real road with restricted traffic.
3. Driving on a large test range with free driving behavior decisions.
4. Driving in a good unprogramed simulator with a visual driving environment.
5. Driving on a small test range with skill tests.

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[3] On the other hand, retrospective studies such as those mentioned in ch. II showed that if there is an accident, it is more likely that the driver was drunk than was the case if he had not had an accident. We infer the converse: that if the driver drank, then he was more likely to have an accident. It is probable that the inference is a correct one, but in order to have confidence in it one must examine the retrospective study very carefully, or do a prospective study to show directly that the inference is true. This can be done, but it might be subject to some biases, because of the particular nature of the study (for example, one must depend on the subject's statement as to how far he has driven or is going to drive, etc.). In any case, we do make the assumption that the inference is true.

6. Laboratory behavior ranging from a nonvisual driving simulator, through Link-trainer type of instruments, all the way to simple reaction time or single visual or other function test.

In almost all of the above, there exist at least two major problems which can disturb one's confidence in inferences from experiment to real life driving. These are knowledge that the task is a test; and knowledge by the subject that danger is lessened. We draw inferences about actual driving with less and less confidence as we move from 1 to 6. We are left essentially with three choices. First, let the subject drive on a real road with considerable danger, but considerable confidence (subject to the restriction of the problems just mentioned). Second, test on a simulator with fairly high fidelity, subject to the same problems. Third, do studies in the last two categories with little inferential or extrapolative power, but do many of them in various areas so that by sheer weight and breadth of evidence we may infer something of the population distribution of alcohol's effect.

None of these is completely satisfactory, but one can paint a fairly convincing picture with a broad program of work at all six levels, in conjunction with proper field studies. It is comforting to be told that after one-half hour in a simulator or on a long-drive track, one loses oneself almost completely and the problem of forced attention is lessened. Does one also ignore the absence of danger in a simulator, no matter how long one drives?

One consoling feature of the dilemma is that the two problems lead to opposed behavior. Knowledge of safety leads to laxity and decreased vigilance or attentiveness to danger; being "under the gun" in a test situation leads to increased attentiveness and vigilance and improved performance. Do they cancel? If so, at what point?

Perhaps many of these questions may be answered in a few years, when simulator research and alcohol research in general intensify, as they bid fair to do.

References

1. Abele, G. Die Gleichmässigkeitsleistung des Kraftfahrers unter Alkoholeinfluss. (The stability of performance of drivers under the influence of alcohol.) *Dtsch. Z. ges. gerichtl. Med.*, 1958, **47**, 462–471.
2. Abele, G. Die Geschwindigkeitsleistung des Kraftfahrers unter Alkoholeinfluss. (The speed performance of drivers under the influence of alcohol.) *Dtsch. Z. ges. gerichtl. Med.*, 1958, **47**, 447–461.
3. Baker, J. S. (Ed.) *Selected reports from case studies of traffic accidents.* Evanston, Ill.: Traffic Institute, Northwestern University, 1960.
4. Carpenter, J. A., Moore, O. K., Snyder, C. R., and Lisansky, Edith S. Alcohol and higher-order problem solving. *Quart. J. Stud. Alc.*, 1961, **22**, 183–222.
5. Cohen, J., Dearnaley, E. J., and Hansel, C. E. M. The risk taken in driving under the influence of alcohol. *Brit. med. J.*, 1958, **i**, 1438–1442.

6. Drew, G. C., Colquhoun, W. P., and Long, Hazel A. *Effect of small doses of alcohol on a skill resembling driving.* Med. Res. Council Memorandum 38. London: Her Majesty's Stationery Office, 1959.
7. Forbes, T. W. Analysis of "near accident" reports. In *Driver characteristics.* Highway Res. Bd. Bull. 152 (National Academy of Sciences-National Research Council Publication 487). Washington, D.C., 1957. Pp. 23–37.
8. Goldberg, M., Hehir, R., and Hurowitz, M. Intravenous tri-iodothyronine in acute alcoholic intoxication. Preliminary report. *New Engl. J. Med.*, 1960, **263,** 1336–1339.
9. Moseley, A. L. (Ed.) *Research on fatal highway collisions. Papers, 1961–1962.* Cambridge: Harvard Medical School, 1963.
10. Platt, F. N. Operations analysis of traffic safety. [Part I.] A classification of traffic situations. *Traffic Safety Res. Rev.*, 1958, **2**(4), 17–24.
11. Platt, F. N. A unique method of measuring road, traffic, vehicle and driver characteristics. Paper read at the Fourth World Meeting of the International Road Federation, Madrid, Oct. 14–20, 1962.
12. Searle, L. V., and Taylor, F. V. Studies of tracking behavior. I. Rate and time characteristics of simple corrective movements. *J. exp. Psychol.*, 1948, **38,** 615–631.
13. Shaw, W. J. Objective measurement of driving skill. *Internat. Road Safety and Traffic Rev.*, 1955, **3,** 21–30.
14. Taylor, F. V., and Birmingham, H. P. Studies of tracking behavior. II. Acceleration pattern of quick manual corrective responses. *J. exp. Psychol.,* 1948, **38,** 783–795.

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CHAPTER IX

Drinking-Driving—A Public Health Concern

James H. Fox, Ph. D.

Introduction

The Public Health Service's interest in the problem of drinking-driving stems from its concern for all those things which affect the health of the people in our Nation. Included among its interests are the acute and chronic physical diseases and illnesses, mental illness, and accidents, whether they occur at home, work, or on the highway. The gross mortality and morbidity statistics justify the attention which accidents in general, and highway accidents in particular, are receiving. Accidents were responsible for 92,249 deaths in 1961; of this number, 38,091 were motor vehicle accidents (*16*). While this loss of human life and human suffering is regrettable, it should be noted that in general the American highways are relatively safe. For example, the accident rate based on 100 million vehicle-miles has been declining since 1934 (*1*). However, commendable though this record is, the fact remains that motor vehicle accidents were the seventh leading cause of death in the United States in 1961 (*16*).

Public Health Service Concerns

The goals of the Public Health Service are to eradicate or control the environmental influences, both internal and external, which are injurious to the physical and mental well-being of man. Efforts at water and air pollution control would be examples of attempts to curtail external environmental influences, while early detection techniques for cancer and tuberculosis are examples of the efforts to control internal environmental factors. The terms "eradicate" and "control" are used here in their technical sense: "Control" is the purposeful reduction of specific disease prevalence to low levels in a given area, but the disease is not permanently eliminated; "eradication" implies the continued absence of transmission of the disease within the specified area (*2*).

Prevention is the key mechanism which is used to achieve the Service's goals. There are, however, three levels of prevention: primary, secondary, and tertiary. In primary prevention, the emphasis is placed on preventing the occurrence of an illness. Secondary prevention is concerned with improving the people's health by definitive treatment of identified cases. And, in tertiary prevention the attempt is made to curtail the disabling effects of an illness (*8*).

Prevention, at whatever level, must be based on knowledge, and knowledge is derived from research, whether in the laboratory or in the field. This is not to say that the etiology and course of a disease or illness must be known before preventive measures can be employed, but it does suggest that reliable knowledge about the condition must be available before an effective program can be initiated. In traditional public health work with the communicable diseases, a great deal of effort and research were directed toward isolating the primary organism, vectors, and hosts which were responsible for the initiation and spreading of a particular infection. When these were determined, control could then be established through mass vaccination. Smallpox is one classic example; and of more recent vintage, the use of polio vaccine to control poliomyelitis. This is a relatively direct approach to control, and the underlying reasoning is relatively simple—find the infectious agent and then develop an appropriate vaccine.

In addition to the direct approaches to the control of diseases and illnesses, there are indirect approaches. One example is the preventive measures used to control hookworm. In this case, rather than the administration of mass vaccinations, a change in behavior is required. Efforts are being made to persuade the inhabitants of the rural areas of southern United States to wear shoes and build privies, and thus prevent the invasion of *Necator americanus.* In this instance, as in the prevention of dental caries, the underlying reasoning is more complex. Prevention is achieved only through modifying the behavior of the population at risk. Control rather than eradication is the goal.

Underlying reasoning of even greater complexity is required when the aim is the prevention of abnormal or aberrant forms of behavior for which there is no readily identifiable pathological organism or condition. Such reasoning is necessary when there is a confluence of physical, psychological, social, and environmental factors which produce a condition which is perceived as being injurious to the self or others. Suicide, accidents, and alcoholism are examples of such conditions. At the present time, primary etiological factors have not been isolated for these conditions. One exception may be the presence of the psychological state of depression in the case of suicide, yet depression itself is exceedingly complex and is apparently neither necessary nor sufficient for suicidal behavior to occur. Parenthetically, it should be noted that indirect approaches are available for the control of alcoholism and conceivably suicide. Antabuse, if taken, will keep the alcoholic from drinking alcohol. Of course, the alcoholic will still have his problems, but he will be sober. The difficulty arises because few alcoholics are willing to modify their behavior and take antabuse. It is conceivable that some of the newer antidepressants may forestall some suicidal behavior, but as yet there is little evidence that this is so.

Accident Prevention

In the field of accident prevention there are also indirect approaches, notably engineering improvements in the vehicle and highway, especially the limited-access road system. The efficacy of these and other measures seems to be reflected in the generally decreasing accident rate per 100 million miles driven. However, their insufficiency is reflected in the relatively high absolute number of deaths and injuries.

An important variable in prevention is the epidemiological concept of "population at risk." In the field of suicide, older white males have the highest rate of actual suicides, while younger white females have the highest rate of suicide attempts. In alcoholism, males rather than females, and the Irish rather than the Jews or Italians comprise the population at risk. In a like manner, the data in table I will permit a rough designation of the populations at risk as far as motor vehicle accidents are concerned. It should be noted that in addition to drivers, pedestrians and passengers are included in the table.

TABLE I. *Motor vehicle death rates, specific for age, color, and sex—1960*
[Rates are per 100,000 population]

Sex and color	Age						
	Under 15	15–19	20–24	25–44	45–64	65 and over	Total
Male	10.6	51.7	73.2	34.9	33.3	52.1	31.8
White	10.5	54.0	73.5	33.4	31.7	52.1	31.5
Nonwhite	11.2	34.8	71.0	47.5	48.4	51.9	34.4
Female	6.4	16.0	14.0	9.2	13.1	20.3	11.0
White	6.3	16.8	14.3	9.0	13.1	20.8	11.2
Nonwhite	7.1	10.7	11.8	10.7	13.5	13.9	10.1
Total	8.5	33.9	42.9	21.7	23.0	34.7	21.3
White	8.4	35.5	43.3	21.0	22.2	34.9	21.2
Nonwhite	9.1	22.6	39.7	27.9	30.6	31.9	21.9

Sources: *Statistical Abstract of the United States, 1961*, table 19; and Advanced Report, Vital Statistics of the United States, 1960, table 5–11.

It can be seen in table I that the motor vehicle death rate for males is much higher than it is for females. This relationship holds true regardless of age or color. Is this higher death rate the result of "exposure to risk"; i.e., males drive more than females? Is it associated with the expectation that males should exhibit more aggressive behavior than females? Do men drink and then drive more frequently than women?

Table I also reflects age variations in the motor vehicle death rates. The younger age groups have the higher rates, especially the 20–24 age group. Is this too an exposure-to-risk phenomenon? Are individuals in this age group more likely to own older, and perhaps less safe, automobiles? Is there an overriding sense of omnipotence, coupled with a fatalistic feeling, among members of the 20–24-age group? What contribution does the ingestion of alcohol make to this high rate?

In general, the rates of the white and nonwhite populations are remarkably similar. There are two interesting differences, however. In the 15–19-age group, the nonwhite rate is considerably lower than the white rate; this holds true for both sexes. These lower rates may well be the result of less exposure to risk. There may be fewer automobiles available to the nonwhite population in this age group. The other difference is to be found in the 25–44- and 45–64-age groups. The motor vehicle death rate of the nonwhite population exceeds the white. Is this the result of an economic factor; i.e., are the cars used by the nonwhite population relatively old and unsafe? Once again it is not known whether the use of alcohol contributes significantly to these variations.

These types of data are extremely useful in designating the population at risk and can lead to effective preventive measures. Yet, they do not provide answers to the questions raised. Special studies are required, in much the same manner as special studies were and are needed for all the components of the driving situation; i.e., the driver, the automobile, and the highway. For example, highway engineering studies can lessen harmful influences in the physical environment, automotive crash studies can lessen the injurious effects of automobile design, and driver-attitude studies can determine the contribution which the driver makes to the accident toll.

Drinking-Driving

This rough sketch of the motor vehicle accident problem is presented to show its difficult nature, and to indicate that while tremendous progress has been made, its complexity precludes a simple solution based on determining a primary etiological factor. However, complex though the motor vehicle accident problem is, it becomes even more so when one facet is singled out for intensive investigation. This is especially true, as the preceding chapters have shown, when an assessment of the effects of the drug—alcohol—is being made. Recognition of the difficulty does not preclude either effective analysis or effective action. What it does demand, however, is a cautious approach founded on the best available evidence.

The preceding chapters reflect the current level of knowledge pertaining to the effects of alcohol on driving behavior. In varying detail they set forth what is known about the effects of alcohol on the physiological and psychological processes, as well as the social and enforcement problems engendered by its use. It would, perhaps, be well to summarize some of the more salient facts which can be related to an effective prevention program. In order to do this it will be necessary to define a few of the terms which must be used in discussing the relationships between alcohol usage and driving behavior.

The first term is "blood alcohol level," which means simply the percentage concentration of alcohol in the blood. Typically, blood alcohol levels range from 0 percent to 0.2 percent W/V. While it is true that after an especially heavy drinking event blood alcohol levels may exceed 0.2 percent, for most individuals in their normal drinking behavior, the range 0 to 0.2 percent is applicable. To give some meaning to blood alcohol percentages, it should be noted that in many States a blood alcohol level of 0.15 percent is taken as prima facie evidence of being under the influence of alcohol. Blood alcohol levels in the range of 0.05 to 0.15 percent are taken as presumptive evidence of being under the influence of alcohol, but additional confirming evidence is required. Ordinarily, blood alcohol levels below 0.05 percent are taken as evidence of not being under the influence of alcohol.

While there are some hazards involved, it would be helpful to equate roughly "number of drinks" with the blood alcohol levels. If an average person has two highballs or cocktails, his blood alcohol level will begin to approach 0.05 percent. If he has four highballs, his blood alcohol level will be at approximately the 0.10-percent level. If he has had six highballs or cocktails, or roughly one-half pint of whisky, his blood alcohol level will have reached the 0.15-percent level. These equivalents are not exact; such things as amount of food in the stomach, length of time during which the alcohol is consumed, the weight of the individual (the above "equivalents" are based on the traditional 150-pound male), and other variables intervene.

The second important term is the "blood alcohol curve." Typically, the blood alcohol curve rises sharply after drinking has been initiated, peaks, and then begins a slow descent. The height of the curve (i.e., the blood alcohol level reached) and the length of time it takes the body to eliminate the alcohol are functions of the amount of alcohol consumed and the length of time during which drinking is continued.

Four questions, basic to the relationship between alcohol usage and driving behavior, must be answered before a systematic prevention effort can be initiated. These questions are: (*a*) Is the ingestion of alcohol prior to driving a factor in traffic accidents? That is, can it be demonstrated that drinking prior to driving increases the likelihood of being involved in a traffic accident? (*b*) If so, how does the drug—alcohol—affect driving behavior so as to increase the chances of an accident occurring? That is, is there evidence to indicate that driving behavior deteriorates under the effect of the drug, and at what dosage? (*c*) What are the cultural patternings and social psychological factors which predispose toward drinking-driving? That is, are there social forces which channelize human behavior so as to create the situation in which drinking and driving occur in close temporal proximity? And finally, (*d*) if it is determined that the use of alcohol is a significant factor in traffic accidents, the question arises, what, if anything, can be done about it?

The material in chapter II clearly indicates that there is a strong association between the ingestion of alcohol and traffic accidents. The nature of this association is such that as the blood alcohol level rises, the likelihood of being involved in an accident also increases. While it has not yet been determined that the alcohol is *the causative* factor, its contribution to causation is beyond doubt. In this problem area, as in some other public health problems, such determination is not essential for an effective preventive program to be developed. It may be possible to change the total motor vehicle accident rate by modifying the behavior associated with one of the contributing factors; in this case, alcohol consumption prior to driving.

Accepting the position that alcohol is associated with motor vehicle accidents, the question arises as to its specific effects on driving behavior. As set forth in chapters III, IV, and V, alcohol clearly affects the psychological and physiological functioning of an individual. While individuals with certain personality characteristics, e.g., high anxiety level, may improve performance on some tasks when small doses of alcohol are consumed, the more general effect is to cause deterioration of motor and intellectual skills. The ingestion of alcohol also apparently increases risk-taking behavior. And further, these effects are progressively heightened as the amount of alcohol consumed is increased.

Except for the alcoholic's drinking, a problem which is discussed later in this chapter, most drinking occurs in a social setting. Of major concern, therefore, is the more general problem of determining the social situational factors which are conducive to drinking-driving. It is pointed out in chapter I that between 66 and 75 percent of the adult population in the United States use alcoholic beverages, and that about one-half of the drinking occurs in places other than the person's home. Presumably. therefore, many who drink and drive do so in order to change their location.

Three of the questions have been answered. Drinking *is* a factor in traffic accidents; the use of alcohol *does* have a negative affect on driving behavior; and there *are* social and cultural factors which predispose toward drinking-driving. Before turning to the "What can be done about it?" question, it would be well to consider some of the controversies in the field, for they bear directly on the question.

Areas of Controversy

The magnitude of the problem is one of the areas of controversy. The inadequacies of the official reports and special studies have been pointed out. The basic questions to be answered are: (*a*) How many individuals are driving under the influence of alcohol at any point in time and at varying points in time? (*b*) What is their expected contribution to the total motor vehicle accident picture, and do they exceed this?

It is not known how many individuals are drinking and driving at any point in time. There are some estimates, however. The California data (see ch. I) indicate that the proportion may be quite small. If supporting data from elsewhere were to confirm this finding, then surely the conclusion that drinking-driving contributes disproportionately to the motor vehicle accident total would be justified. Other data reported in chapter II, however, suggest that drinking-driving is much more prevalent. In any of these investigations in which the normal flow of traffic is impeded, it is not known whether drivers, those who have been drinking and those who have not, attempt to avoid the roadblock or whatever method is used to encourage participation in the investigation. It is possible to design a study which through the use of appropriate sampling procedures could provide information on the magnitude of the problem. However, the cumulative evidence of the several studies does not appear to justify such an effort. The weight of these data is such that they command the attention of those who are concerned with prevention.

Another controversial area pertains to the blood alcohol level which should be considered as prima facie evidence of driving under the influence of alcohol. As has been pointed out, many States use the 0.15-percent level. However, several concerned groups, e.g., the Committee on Medicolegal Problems of the American Medical Association (*14*) and the National Committee on Uniform Traffic Laws and Ordinances (*15*), have suggested that the level be lowered to 0.10 percent. Since the driving ability of many individuals will be seriously impaired when this level is reached, the suggestion has merit. There are several difficulties, however. As the blood alcohol level is lowered, more individuals will be subject to arrest. Yet, not all will be sufficiently impaired at the lower level to justify prosecution. More importantly, however, there is the problem of successful prosecution. If as is presented in chapter VI, enforcement and other responsible officials have difficulties in securing convictions at the higher level, then this problem will be increased many times if they are required to prosecute at the lower levels. Certainly there will be fewer obvious clinical signs of intoxication. Automatic revocation of his driver's license if the individual has a blood alcohol level of 0.10 percent or more is one way around this problem. However, this would eliminate trial by jury and judge, and as such may be considered by many to be too great a cost to pay.

The Haddon and Bradess single-vehicle, fatal-accident study referred to in chapters II and VI is also a source of controversy (*9*). The presence of very high blood alcohol levels in the fatalities is clearly demonstrated. It has been suggested that the high blood alcohol levels can be taken as a manifestation of alcoholism, and that these drivers were probably alcoholics. Another possibility is that the drivers were inexperienced drinkers and as a result drank too much. Or, it is possible the behavior of the drivers was truly suicidal. The authors appropriately did not go beyond their data in assigning motivation; however, as will be indicated later such determination in future studies will be invaluable.

Additional Knowledge Needed

In addition to the resolutions of the controversies just discussed, other knowledge would be exceedingly useful in the effort to prevent drinking-driving accidents. Surprisingly, the kind of information which would be most valuable to a prevention program is not available. It is not known where those involved in traffic accidents, drinking and nondrinking, were coming from or going to. As a matter of fact, not too much is known about how the automobile is used in our society. It can be assumed that, with the possible exception of the Sunday-afternoon drive, driving behavior is purposive and not random behavior. That is, individuals drive to and from places rather than simply wandering around the streets aimlessly. If driving behavior is purposive, then it is patterned. If it is patterned, it is subject to study and analysis which, in turn, may provide the necessary information for successful intervention in those patterns which are perceived as being harmful to the individual and others. For example, do most drinking-driving accidents occur while the individuals are going to or coming from the center of the town or city? Are the drivers on their way home or to another drinking place? Is there another qualified driver in the vehicle who had not been drinking? Is the suburban country club or the downtown bar more likely to contribute to the drinking-driving accident population?

The need for baseline information on driving behavior has been set forth in chapters I and III. Certainly if the effect of alcohol on driving behavior is to be determined, such baseline information is essential. There is no disagreement with this need. However, it was pointed out in the working conference on the Social Psychological Factors in Drinking-Driving that an individual has more than one driving pattern. For example, he drives one way to work, and quite a different way if he believes he will be late for a train or plane. What is needed then is not simply a description of an individual's driving behavior, but a description of the range of driving behaviors.

For other purposes, similar information was needed about drinking patterns and range of drinking behaviors. Some of these data are now available (*5, 6, 10*), and could be used in conjunction with the information secured about driving behavior.

One of the barriers to progress in curtailing drinking-driving behavior is the ambiguity which permeates many facets of the problem. This ambiguity, in turn, is based apparently on a rather general ambivalence with which much drinking behavior is viewed (*7*). Among the various aspects of the problem in which the ambiguity is present are the following: the self, the enforcement officer, the juror, the schoolteacher, and the host.

For the individual, the ambiguity manifests itself immediately when he has to decide whether to take a drink or not, if he will have to drive afterward. He has been told if you drink, don't drive; he has been told if he drinks and drives, he will lose his license; and he is being told that there are important groups who feel that if his blood alcohol level reaches a point lower than a point previously used, then he should be considered under the influence of alcohol on the basis of prima facie evidence. Yet, if he is one of the approximately 65 million adults who do drink and if he has a valid driver's license, then the chances are very good that he has had experience with some driving after drinking, most likely without being involved in an accident. Thus, on the one hand, he is being told not to drink and drive, or if he does drink to use some less convenient or more costly method of transportation than his own car. On the other hand, his own experience, up to this time, has shown him that he can drink something and still drive—thus, the ambiguity.

The uncertain situation in which the enforcement officer finds himself when confronted with a driver who has been drinking has been commented on in chapter VI. The officer is more likely to charge the driver with reckless driving than with driving under the influence, or not charge him at all. This action is not based on compassion for the driver, but rather it is based on the greater assurance of a conviction for a reckless driving charge. The inherent difficulties in this situation are set forth in detail in chapter VI. Here it is important to note that the enforcement officer is placed in the ambiguous position of having to enforce the laws against drinking-driving, and at the same time having such difficulty in doing so that other charges must be used.

The individual juror is also in an ambiguous position. He apparently identifies with the defendant. He probably finds it difficult to imagine that the defendant before him could have behaved in the inebriated manner that is described by the police officer. He, too, may have had only "two beers" and then driven his car, and he knows *he wasn't* drunk. Therefore the defendant couldn't have been *that* drunk. And, yet there are the results of the chemical test . . . . The juror is thus being asked to pass judgment on another person in a situation in which he identifies with and feels sympathetic toward the defendant, and in which scientific tests show that the individual was driving under the influence of alcohol.

The ambiguous position of the host is quite apparent. He wants his guests to have a good time and frequently provides alcoholic beverages; yet if one of his guests gets too drunk, the host becomes concerned about how his guest will get home. He wants his guests to feel free to drink as much as they want, but not so much that they are likely to have an accident on the way home. How much is *this much* defines the ambiguity in the situation.

Finally, the schoolteacher, especially the driver education teacher, is in an extremely ambiguous position. He is charged with the task of preparing youngsters for their adult responsibilities as operators of automobiles. In fulfilling this charge, he has been appropriately concerned not only with the skillful handling of the automobile, but also with the development of positive attitudes toward its use. However, it is well to note that at this point the ambiguity of the teacher's role becomes manifest. On the one hand, as a teacher he is concerned with the dissemination of knowledge; on the other, as a teacher of high school students he must also be concerned with the moral framework within which that knowledge is transmitted. For example, it is abundantly clear that the admonition, "If you drink, don't drive," is of little value in curtailing drinking-driving behavior. The question of how the teacher handles the information about drinking-driving becomes an important one. It would seem that there are three ways in which this might be done: (*a*) ignore it—that is, do not include any reference to the drinking-driving problem in course presentation; (*b*) emphasize the "don't"—that is, reinforce the slogan; and (*c*) provide information about tolerance limits. Of course, the teacher does not decide on his own in which of these directions he will proceed. The community, the principal, his fellow teachers, and his professional associations all influence his decision. However, it is quite likely that the moral judgments may run counter to scientific knowledge, thus establishing the ambiguity.

Others also experience ambiguity concerning the drinking-driving problem. Judges, public health officers, prosecutors, legislators, editors, and journalists are included. To dispel such uncertainty and ambiguity, it is essential to provide clear and accurate knowledge and information. For example, a speed-limit sign which simply said "Speed Limit Strictly Enforced" without telling what the speed limit is would lead to uncertainty and ambiguity, and, perhaps even worse from a traffic accident point of view, would lead to each driver's determining his own speed limit (*13*).

While it is always hazardous to reason by analogy, it may be possible to see some similarities between the speeding situation and drinking-driving. Speed-limit signs indicate the maximum speed permitted, and on certain high-speed highways minimum speed, thus the driver knows exactly what is expected of him. Some jurisdictions have a similar approach to drinking-driving. That is, if a driver's blood alcohol level exceeds, let us say, 0.15 percent, then he has exceeded the "alcohol limit" and is subject to arrest and prosecution. However, there is this significant difference: by use of his speedometer the driver can tell whether he is exceeding the speed limit. The driver has no such reference point or gauge for determining whether he is approaching or has exceeded his "alcohol limit." One way to overcome this difficulty is to provide the general public with information pertaining to how long one should wait after a given number of drinks before attempting to drive. It has been suggested that after one drink (1.5 ounces of whisky, 3 ounces of wine, or 12-ounce bottle of beer), no wait is necessary; after two, one should wait 2 hours; after three drinks, the wait should be 4 hours; after four drinks, wait 6 hours; and after five drinks, one should wait 8 hours (*11*). These hours of waiting apply if the drinking occurs within 1 or 2 hours. Since the body oxidizes alcohol at the approximate rate of three-fourths of an ounce of whisky each hour, if the drinking occurs over a period longer than 2 hours the waiting period could be shorter.

Whether such information should be made available is a question which each jurisdiction will have to decide for itself. However, it would make explicit what is implied in the notion that when blood alcohol levels are below 0.05 percent, individuals are not considered as being under the influence of alcohol.

It should be noted that, like all analogies, there is a major difficulty in comparing "alcohol limits" with speed limits. Alcohol, as a drug, affects the individual who is consuming it so that the more he drinks the less likely he is to make sound judgments about his driving ability, or any other ability for that matter. Speeding is not likely to have this effect.

If an individual is a poor driver, or what has been termed a "pathological driver," then the speed-limit sign by itself may have little, if any, effect on his driving behavior. In much the same manner, the pathological drinker, i.e., the alcoholic, is not going to be governed by the recommended number of drinks and suggested waiting period; he is going to drink a great deal and if necessary drive immediately after. The alcoholic is thus a very definite part of the drinking-driving problem.

Since it is not known how many drivers on the road are under the influence of alcohol, it cannot be determined how many of these are alcoholics. There are some estimates, however, based on clinic populations (*12*). The difficulty here is that many alcoholics in a given area are not known to the local clinics. In general, however, it is estimated that 20 to 40 percent of those who drive under the influence are alcoholics. This in turn means that 80 to 60 percent are not alcoholics. Additional information comes from Pennsylvania, which is requiring a physical examination of all motorists. In 1961, physical examinations were requested of 169,000 accident-involved drivers; of these, 10 were turned down for chronic alcoholism (*3*). Thus, there is conflicting information, and additional research is needed.

With the widespread use of the automobile, it may be that a useful alcoholism casefinding mechanism is readily available. Instead of fining or jailing an individual who has been arrested and convicted twice of driving under the influence of alcohol, it may be desirable to refer the driver to the local alcoholism clinic for an evaluation of his drinking behavior. If it is found that he is in the early stages of alcoholism, then earlier intervention becomes possible.

Overview

The weight of the evidence contained in the preceding chapters attests to the seriousness of the drinking-driving problem. While there is much to be learned about the various facets of the problem, there exists enough information to permit the development of a control program which should include both primary and secondary prevention techniques.

The goal of such a program should be control rather than eradication. It is likely that eradication could be achieved only through the elimination of the automobile or alcohol or both. This suggests that since these cannot be eliminated, some irreducible minimum of drinking-driving may have to be accepted. In much the same manner, it is possible to eliminate all drownings, but the cost, economic and recreational, may be considered too great. Therefore, control rather than eradication becomes the aim of a program. This control is achieved through education and enforcement.

The nature of the control program will vary from community to community. But certainly the prevention aspect must include both education and enforcement, emphasis being placed on education, for there are apparently few things which Americans do about which they know so little. The educational effort will probably not touch either the pathological driver or the alcoholic; however, if it is presented in an attractive factual way, chances are good that it will reach the social drinker. Information about enforcement procedures should be included. If a Breathalyzer, or some similar device, is used for determining the blood alcohol levels of drivers in the community, the way in which it functions should be explained.

In the area of intervention a device such as those discussed in chapter VI is invaluable, for it permits the identification of cases. Elevated blood alcohol levels are detected and the individual is then subject to the laws of the State. However, as has been pointed out, case identification of this type may also provide for earlier detection of the alcoholic, which, in turn, may aid in getting the alcoholic into treatment sooner.

Ideally, such a program, to be effective, should include some research effort so that our knowledge may be increased. The "Where are you going and where were you coming from?" question, for example, might be asked. Psychological autopsies, such as those being conducted in the

Los Angeles Suicide Prevention Center (*4*), might be used in the cases of single-vehicle fatal accidents.

Finally, while enforcement is a major part of this problem, the public health officer can't ignore drinking-driving, and probably should be actively involved in any program designed to combat it. He is in a unique position to coordinate many efforts in the community; and with the shifting nature of public health problems, accident prevention in general, and drinking-driving accidents in particular, must be of increasing concern to him.

Within the Public Health Service, the Division of Accident Prevention has been assigned major responsibility for the Service's program in the accident field. It provides support for research, consultation, and other services to the several States and other governmental and private agencies.

The task is undoubtedly difficult, for the goal must be the modification of human behavior. There is no single pathological agent which is solely responsible for drinking-driving accidents, and there are few readily accessible avenues of intervention. Drinking-driving accident prevention can be viewed, therefore, as an example of the types of public health problems with which the country will become increasingly concerned.

References

1. *Accident facts. 1960 edition.* Chicago: National Safety Council.
2. Andrews, J. M., and Langmuir, A. D. The philosophy of disease eradication. *Amer. J. publ. Hlth*, 1963, **53**, 1–6.
3. Driver fitness in spotlight. *The Washington Post*, March 24, 1963. Sec. B, p. 5.
4. Farberow, N. L., and Shneidman, E. S. (Eds.) *The cry for help.* New York: McGraw-Hill, 1961.
5. Fink, R. Factors related to alcoholic beverage choice. *California drinking practices study. Report No. 4.* Berkeley: California State Department of Public Health, Division of Alcoholic Rehabilitation, October 1961.
6. Fink, R. Parental drinking and its impact on adult drinkers. *California drinking practices study. Report No. 5.* Berkeley: California State Department of Public Health, Division of Alcoholic Rehabilitation, March 1962.
7. Fox, J. H. An overview of alcoholism research. *Publ. Hlth Rep., Wash.*, 1961, **76**, 223–230.
8. Gruenberg, E. M. Application of control methods to mental illness. *Amer. J. publ. Hlth*, 1957, **47**, 944–952.
9. Haddon, W., Jr., and Bradess, Victoria A. Alcohol in the single vehicle fatal accident. Experience of Westchester County, N.Y. *J. Amer. med. Ass.*, 1959, **169**, 1587–1593.
10. Knupfer, Genevieve. Characteristics of abstainers. A comparison of drinkers and non-drinkers in a large California city. *California drinking practices study. Report No. 3 (rev.).* Berkeley: California State Department of Public Health, Division of Alcoholic Rehabilitation, November 1961.
11. Robinson, R. R. Implications of research for alcohol education. Alcohol, culture, and youth. In *Alcohol education and its implications for the youthful driver.* Proceedings of a workshop, Newport, R.I., Nov. 20–22, 1961, sponsored

by the Division of Alcoholism of the Rhode Island Department of Social Welfare. Pp. 8–28.

12. Schmidt, W., Smart, R. G., and Popham, R. E. The role of alcoholism in motor vehicle accidents. *Traffic Safety Res. Rev.*, 1962, 6(4), 21–27.
13. Sherif, M. Group influences upon the formation of norms and attitudes. In G. E. Swanson, T. M. Newcomb and E. L. Hartley (Eds.), *Readings in social psychology.* (Rev. ed.) New York: Henry Holt, 1952. Pp. 249–262.
14. *Supplement, Chemical tests for intoxication manual,* Committee on Medicolegal Problems, American Medical Association, Chicago, Ill., 1959. Cited by W. Haddon, Jr., Alcohol and highway accidents. Paper read at the Third International Conference on Alcohol and Road Traffic, London, Sept. 4–7, 1962.
15. *Uniform vehicle code,* Sec. 11–902(b), 1962 rev. Washington, D.C.: National Committee on Uniform Traffic Laws and Ordinances.
16. U.S. Public Health Service, National Vital Statistics Division. *Vital statistics of the United States, 1961.* (Advance report.) Final natality and mortality statistics. Table 4. Washington, D.C.: U.S. Department of Health, Education, and Welfare, November 1962.

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