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PSYCHOPHYSICAL TESTS FOR DWI ARREST

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June 1977
Final Report**

PREPARED FOR:

**U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590**

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16. Abstract As part of DWI arrest procedures, tests of alcohol impairment may be used by police officers, either at roadside or in the station. Objectives of this study included evaluation of currently-used tests, development of more sensitive and reliable measures, and the standardization of test administration.

On the basis of preliminary investigations, six tests were chosen for an evaluation study. Ten officers administered the 6-test battery to 238 participants who were light, moderate and heavy drinkers. Placebo or alcohol treatments produced BACs in the range 0 - .15%. The police officers scored the performance of each test on a 1-10 scale, and on the basis of the entire battery judged whether the person should be arrested or released.

All of the 6 tests were found to be alcohol sensitive, and the officers made correct arrest/release decisions for 76% of the participants. Data analysis led to recommendations of a “best” reduced battery of tests which includes examination of balance (One-Leg Stand) and walking (Walk-and-Turn), as well as the jerking nystagmus movement of the eyes (Alcohol Gaze Nystagmus).

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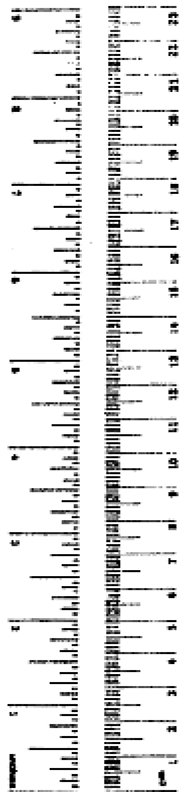
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
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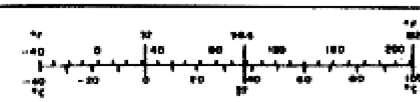
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

TECHNICAL SUMMARY

CONTRACTOR SOUTHERN CALIFORNIA RESEARCH INSTITUTE	CONTRACT NUMBER DOT-HS-5-01242
REPORT TITLE "Psychophysical Tests for DWI Arrest"	REPORT DATE January 1977
REPORT AUTHOR(S) Marcelline Burns, Ph.D. and Herbert Moskowitz, Ph.D.	

The objectives of "Psychophysical Tests for DWI Arrest" were:

(1) To evaluate currently used physical coordination tests to determine their relationship to intoxication and driving impairment,

(2) To develop more sensitive tests that would provide more reliable evidence of impairment, and

(3) To standardize the tests and observation.

Criteria for the selection of sobriety tests and an initial list of potential tests were derived from field observations, interviews with law enforcement officers and from a literature review. Administration and scoring procedures were standardized during laboratory pilot studies of the tests. On the basis of these preliminary investigations the following tests were chosen for an evaluation study: One-Leg Stand, Walk-and-Turn, Finger-to-Nose, Finger Count, Alcohol Gaze Nystagmus (AGN), Tracing, and alternate tests (Romberg body sway, Subtraction, Counting Backward, Letter Cancellation).

For the evaluation study ten officers (police, sheriff, and highway patrol) served as examiners, administering the tests of impairment to 238 participants who were Light, Moderate and Heavy drinkers. Placebo or alcohol treatments produced BAC's in the range 0-.15%. The officer scored an individual's performance of each test on a 1-10 scale, and after administering the entire battery recorded his decision as to whether the individual should be arrested or released if the testing were occurring at roadside, assuming a legal criterion of .10% BAC.

All of the tests were found to be alcohol sensitive. The arrest/release decisions were correct for 76% of the participants, but the officers' scoring indicated that they had adopted a lower level of impairment as a decision criterion for arrest than would typically be applied in the field. This resulted in a high rate of false-arrest decisions.
(Continue on additional pages)

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A second approach to an arrest/release classification of participants used a test-score criterion as determined by linear regression calculations. On the basis of this analysis a total score greater than the criterion of 28 caused the individual to be classified as at or above .10% BAC and thus subject to arrest. Eighty-three percent of the classifications were correct, and neither false arrest nor false release decisions were unduly high.

A reduced "best" test set was determined by stepwise discriminant analysis. It includes One-Leg Stand, Walk-and-Turn, and Alcohol Gaze Nystagmus. This final, recommended sobriety test battery can be administered without special equipment in most roadside environments, and it can be adapted to yield more precise measurement if administered in the station. The total test time in most cases will be no more than five minutes. More than 83% of the evaluation study participants can be correctly classified on the basis of just these three tests.

If balance and walking skills are examined, and the eyes are checked for the jerking nystagmus movement, the officer will have as much information about intoxication level as can be obtained at roadside. Alcohol gaze nystagmus is a particularly valuable measure, which is underutilized in law enforcement and which merits additional study and application.

The evaluation study data show that substantial impairment typically occurs at a BAC lower than .10%, the current arbitrarily defined level for DWI arrest. It is suggested that a more appropriate legal BAC limit would be .08%.

I. INTRODUCTION

Nationwide traffic accident statistics show a high proportion of alcohol-related fatalities and injury accidents, reflecting the magnitude of the drinking-driver problem. Currently, the principal approach to the problem is deterrence by legal action, and the officer in the field is the first link in the chain of events aimed at the arrest and conviction of a drinking driver. Successful performance by the police officer of the detection and apprehension task, quite apart from any subsequent action directed toward the individual, also results in the immediate removal of an alcohol-impaired driver from the highway.

Data presented by Beitel, Sharp and Glauz (1975) reveal substantial deficiencies in the detection and arrest of DWIs, that is, drivers whose blood alcohol content (BAC) is at or above. 10%. They derived the distribution of drivers' BAC (from roadside survey findings) and also the BAC distribution of drivers arrested for DWI (from arrest records). Figure 1 graphs the two distributions.

As can be observed in the figure, a driver's BAC is almost three times as likely to be in the range. 10-.14% as to be .15-.19%. Yet the smaller number of drivers in the latter, high BAC group are much more likely to be arrested. The probability is .26 that an arrested driver's BAC is .10 to .14%, compared to a .43 probability that it is .15 to .19%.

The discrepancy between the two distributions reflects two major problem areas. First, the officer must detect the drinking driver by observing the vehicle and noting driving errors which may be subtle and ambiguous. The experienced drinker-driver may exceed the .10% level without obvious symptoms of impairment and with very obvious and observable impaired driving behavior occurring only at a quite high BAC. Understandably, the high BAC driver is most frequently spotted by police officers.

The second major problem centers on the arrest/don't arrest decision which must be made once a vehicle has been stopped. Roadside evaluation of a driver's alcohol-related impairment typically is performed under less than optimal conditions. Time is severely constrained; the individual must be arrested or released within a few minutes. The environmental conditions (lighting, noise, space, terrain) vary widely, and test procedures, which are part of the officer's assessment process, must be adapted accordingly. Individual differences in impairment at a given BAC are a function of such variables as drinking history, age, physical condition, illness, disability and fatigue. Also, intoxication may be confused with a variety of other causes of impaired behavior.

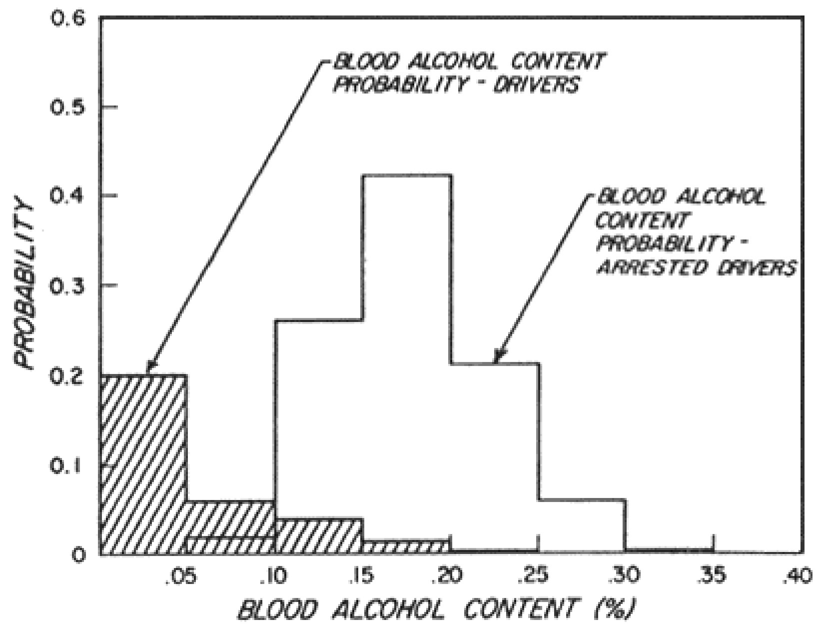

FIGURE 1: BAC Distributions of Two Groups:
Roadside-Survey Drivers and Arrested Drivers

As a rule, a police officer is reluctant to arrest a driver unless there is a high degree of certainty that the mandatory chemical test (breath, blood or urine) will yield a BAC reading of .10% or higher. Not only is it costly in officer time and effort to transport and test a driver who cannot be booked, it also leads to charges of harassment and generates bad community relations. These considerations certainly contribute to an over-representation among arrested drivers of those individuals whose BAC is quite high and for whom there is less uncertainty regarding impairment.

As an adjunct to observation and interrogation, the police officer in the field frequently uses behavioral tests to assist in the arrest/don't arrest decision process. Widely-used tests examine balance, coordination and speech, but the exact tests and procedures vary between locales, agencies and officers with no well-defined standards for performance or interpretation. This study was undertaken to develop an improved test battery which will facilitate the officer's identification of alcohol-impaired drivers and provide the required evidence for court proceedings.

II. EVALUATION STUDY

A. Test Selection

A search of the literature was undertaken to locate potentially suitable tests (Appendix 1). Also, observations were made of currently-used tests by riding with city and state police officers and sheriff's deputies in several locations (Appendix 2). The opportunities to observe the field conditions were of great value in developing criteria by which to evaluate potential tests. For example, it became apparent that it is not feasible to include tests which burden the officer with equipment, or which require his prolonged, concentrated attention. The officer must be alert to potential dangers and frequently this means surveillance of a strange environment and hostile bystanders. Realistically, he cannot be preoccupied with test devices nor be involved in any way that impedes access to weapons.

The most common practice is to test a DWI suspect at roadside, but it also is possible to delay all tests until the person has been transported to the station. There is considerable advantage to always giving tests in the same environment. Further, whatever test apparatus is useful can be made available in the station without risk or difficulty for the officer.

It is clear that tests which add a substantial amount of time to DWI procedures will not find wide acceptance. Drunk drivers are costly; the are time-consuming when the arrest is made and again when the officer is required to appear in court. At the same time, effective utilization of police manpower is an ongoing concern. At all levels, including the patrol unit, the officers are charged with achieving maximum law enforcement. From this perspective, a daily log with several DWI arrests may not "look good" in total number of contacts and arrests, so it is scarcely surprising that drunk-driver arrests sometimes are actively discouraged.

The test criteria which appear in Appendix 3 were developed to insure that the battery can be used in the field (or in the station), that the tests will be acceptable to the officers, and that they will provide evidence of impairment. The tests which are described below appeared to meet the criteria and were selected for a preliminary battery.

Alcohol Gaze Nystagmus (AGN)
The jerking movement of the eye, which is known as Alcohol Gaze Nystagmus, occurs upon lateral gaze when BAC exceeds a critical level (≈.06%). The eye jerks in the direction of gaze, independent of head position.
Person is asked to cover one eye and follow movement of a small light or object with other eye without changing head position. Light is moved slowly to points requiring 30° and 40° lateral deviation of the gaze. Test is then repeated with the other eye. Eye is observed for jerking movement.

Walk and Turn, Heel-Toe

Person is instructed to walk straight line, touching heel to toe each step for nine steps, then turn and return along same line in the same manner. Demonstration is given.

Romberg (Balance)

Person is instructed to stand with feet together, head tipped back, eyes closed, arms at side. Position is demonstrated. Observe anterior-posterior sway, 45 sec. trial.

Finger-to-Nose

Person stands erect with eyes closed, arms extended horizontally. Instructions are to touch nose with index finger, alternating right and left hands as instructed. Demonstration is given.

One-Leg Stand

Person is instructed to stand with one leg held straight, slightly elevated off floor, forward, for 30 sec. trial. Eyes remain open.

Finger Count

Person is instructed to touch and count each finger in succession, counting aloud. Demonstrate, “Watch what I do. 1-2-3-4-5-5-4-3-2-1.”

Tongue Twisters

Person is asked to repeat such words as “methodist, episcopal, sophisticated statistics.”

Subtraction, Addition, Count Backwards

Person is instructed to subtract 3, beginning for example at 102, continuing to some specified number (or add continuously). Same general instructions are given for counting backwards.

Tapping Rate

Person is instructed to tap a telegraph key as rapidly as possible. Number of taps are recorded by electronic counter during 10 sec. trial.

Letter Cancellation

Person is asked to cancel all of a given letter in a paragraph of text during 30 sec. trial.

Tracing

Person is asked to trace paper pathway (maze). Three 20 sec. trials are given.

Grip Strength

Person is instructed to squeeze as hard as possible a dynamometer of the type shaped like a pistol grip with grooves for each finger. This instrument measures force exerted in isometric contraction.

Coin Pick-Up

Three coins (or chips, matches) are placed on floor. Person is instructed to stand in one location and to pick up the coins one at a time, handing them to the examiner. Demonstration is given.

Two-Point Tactile Discrimination

Person is given 2-point tactile stimulation (forearm or back of hand, eyes closed) beginning with no separation of the two points, and is asked "How many places am I touching your arm?" Trials are repeated with increasing separation. Response measure is the first separation to which person responds "two."

Color Naming (Attention Diagnostic Method, modified)

Card presents number 10-59, in random order, in 4 colors by row. Person is instructed to find sequence of 10 numbers, beginning with some designated number, and to report the color of each. Verbal response, for example, might be, "Ten-blue, eleven-white, twelve-yellow, thirteen-red, etc. . ." Response measure is the time to report the colors of ten numbers.

Serial Performance

The device for this test consists of a small box. Five toggle switches and a small bulb are mounted on the face of the box. The box is presented to the subject with all switches in the center position. Subject is told to move the switches and that when they are in the correct sequence of up-down positions, the red light will come on.

B. Pilot Studies

Tests of 19 participants at BACs 0-.10% identified certain tests from the original list as being unsuited to the conditions typically applying to alcohol impairment testing. Grip strength and two-point tactile discrimination show great variability between individuals and cannot be interpreted in the single case without baseline data. The attention diagnostic method (color naming) requires precise instruction and a standard test environment. The serial performance scores did not justify the cost and inconvenience of the apparatus.

After the first pilot study the following tests remained as candidates for the battery: Romberg (body sway), Finger-to-Nose, Alcohol Gaze Nystagmus, Tongue Twisters, Walk and Turn, Finger Count, One-Leg Stand, Subtraction, Tracing (paper maze), Letter Cancellation, and Tapping. The latter three tests would be difficult to use at roadside but were considered to have potential merit for van or station settings.

Thirty participants were examined with these tests, ten each at 0, .10%, and .15% BAC groups.

In addition to the calculation of mean scores for these groups, which appear in Table 1, scatter plots of individual scores were constructed for each test. Those which best discriminated BAC were chosen for the large-scale evaluation study. It also was considered essential for the battery to represent a variety of skills; some persons are unduly handicapped on certain kinds of tests due to age, physical impairment, or language and cultural barriers. The following include measures of balance, large muscle coordination, cognitive skills and oculomotor control:

One-Leg Stand
Walk and Turn, Heel-Toe
Finger-to-Nose
Finger Count
Alcohol Gaze Nystagmus (AGN)
Tracing

Alternate Tests:

Romberg (Body Sway)
Subtraction
Counting Backwards
Letter Cancellation

(These tests are to be used when some factor precludes using part of all of the regular battery.)

C. Experimental Evaluation

Evaluation of the test battery, as configured on the basis of the literature review and pilot studies, was performed during ten day-long sessions in the SCRI laboratories. Appendix 4 shows the layout of the laboratory for the study. Figure 2 displays the cells of the experimental plan. Participants were categorized as light,

Table 1
Pilot Experiment
Mean Test Scores by BAC Group

Group	n	BAC	Romberg(Body Sway)	Finger-to-Nose	Nystagmus	Tongue Twisters	Walk & Turn	Finger Count	1-Leg Stand
0	10	0	2.00	.80	.85	.40	1.25	.60	1.20
2	10	.10%	5.10	4.05	8.80	1.60	7.80	4.50	5.30
1	10	.14%	4.65	6.05	12.00	2.10	6.80	4.00	6.00

	Subtraction Time	Subtraction Errors	Tracing* (Maze)	Letter* Cancellation	Tapping #
0	16 sec	.4	17.16	22	26.02
2	30.5	2.7	12.80	17.30	25.92
1	49.6	2.1	8.33	16.30	25.63

*High Score = good performance

*Low score = poor performance

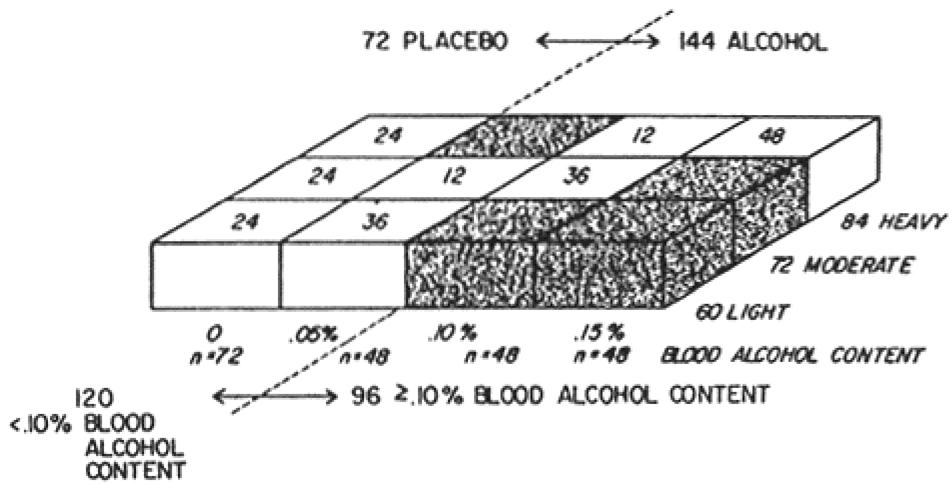

FIGURE 2: Experimental Plan for Participant Assignment by Q-F-V to Treatment Level

moderate or heavy drinkers by the Quantity-Frequency-Variability Index (Cahalan et al., 1969). They were assigned at random to 0, .05%, .10% or .15% BAC groups with the restrictions that only heavy drinkers were assigned to the .15% group, and light drinkers were assigned only to 0 or. 05% groups. The design permits examination of performance by individuals with widely differing alcohol-use practices at different BAC's.

1. Participants and Officers

The drinking subjects were recruited through the California State Employment Office and were paid $3.00 per hour for participation in one session.

Police officer-examiners were recruited from Los Angeles area agencies and were selected to represent a broad spectrum of experience with DWI testing. This ranged from relatively new officers with less than 200 DWI arrests to veteran officers with as many as 2000 arrests. Appendix 7 tables years of service and DWI arrest experience for the ten officers who participated in the evaluation study.

Each officer attended one training session where he was given intensive instruction in the test administration and scoring procedures developed by SCRI during the pilot studies. The officers practiced administering the test battery using immediate video-feedback. The practice continued until the officer indicated that he felt confident with the procedures and the Project Director judged the officer's level of competence acceptable. Each officer participated in two test days, testing 10-15 persons each day.

2. Apparatus

For the Alcohol Gaze Nystagmus measure a simple device was developed by SCRI which utilizes the position of the small light to control the angle of eye deviation (Figure 3). The individual was asked to cover the left eye and to follow with the right eye the movement of the small light as the examiner moved to it to 30° and 40° positions on the right. He then was asked to cover the right eye, and the same procedure was followed for the left eye in the left visual field. Floor markings were provided for Walk-and-Turn and One-Leg Stand. In addition, vertical wall stripes were used to provide contrast to body movements on videotape. Each examiner was provided with a stopwatch for exact timing of trials. Blood alcohol levels were monitored with a breath sampling gas chromatograph. No other apparatus was required.

It was considered necessary in the context of evaluation to standardize test administration, but all of the tests can be used without special devices or setting. However, it is recommended that a watch be available to precisely time the test trials.

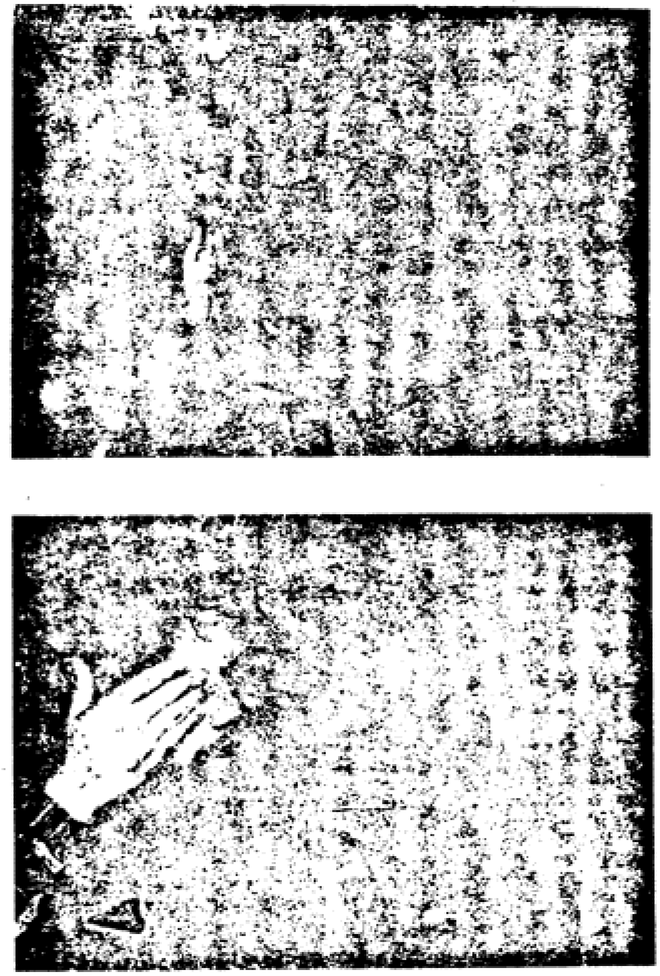

FIGURE 3: Alcohol Gaze Nystagmus (AGN) Apparatus

3. Alcohol Treatment

Alcohol was administered in the form of a beverage containing 60% orange juice and 40% eighty proof vodka. The total beverage was given as three drinks over a 1½ hour period. The drinking schedule was adopted as a best compromise between typical social drinking, which may extend over several hours, and the constraints of the experiment schedule. Alcohol doses were calculated by body weight to produce peak BAC's of 0, .05, .10, or .15%.

4. Procedures

Potential participants were interviewed and scheduled by telephone. They were instructed to take no food or stimulants for four hours preceding a session and to abstain from alcohol for 24 hours. These conditions were violated by a number of persons, some arriving with positive BAC's and several admitting to having eaten within the proscribed time. However, for the objectives of this study, these violations were not considered sufficient cause for dismissal, and they were allowed to remain.

The study was performed double-blind. Neither the participants, the police officers, nor the SCRI research assistants knew the alcohol content of the drinks, which were prepared by the Project Director. A small amount of alcohol was floated on the placebo drinks for the 0 BAC group to give the characteristic odor.

Police examiners and observers were separated from the drinking subjects, the treatment preparation area, and the gas chromatograph. Their interactions with the participants were restricted to the time when a research assistant took an individual to the test area. These conditions were very rigidly maintained since it was felt officers might be able to pick up clues about BAC level if permitted to observe participants outside the test area. The intent was that the officer's contact with the participants be closely similar to what would typically occur in the field.

Participants were scheduled to arrive at the SCRI laboratory beginning at 8:00 a.m., with two persons arriving every 15 minutes through 12 noon. Upon arrival the day's procedures were fully explained to the individual, the participant agreement was read and signed, and a breath reading was taken.

The first drink was given within 10-15 minutes of arrival. A 90-minute time period was allowed to complete the drinks, and an additional 30 minutes elapsed to allow further absorption. The second BAC reading was taken 2 hours after beginning to drink. The participant then was taken immediately to the officer-examiner for administration of the test battery. Participants were assigned in advance to groups. Half of each experimental cell on each day were designated Group 1, assigned to Officer 1; half were Group 2, assigned to Officer 2.

As a police officer administered the test battery, one of two SCRI research assistants observed and independently scored the performance of the participants, by the following schedule. Each pair of officers examined participants on 2 successive test days.

	Participants Scored By:
Test Day 1	Officer 1 and Observer 1 or Officer 2 and Observer 2
Test Day 2	Officer 1 and Observer 2 or Officer 2 and Observer 1

The two research assistants who functioned as observers were involved with the development and pilot testing of the battery and are well trained in administration and scoring. The observer procedure was necessary in order to determine whether incorrect arrest/don't arrest decisions by the officers arose from administration/scoring errors or alternately were due to difficulties in discriminating on the basis of a given individual's performance.

Appendix 5 presents the test protocol which examiners followed and the score sheet which was completed for each participant by one officer and one observer. Each test was scored on a 1-10 scale. Examiners and observers also: 1) estimated BAC, 2) indicated whether the person appeared to be alcohol-impaired, and 3) made an arrest/don't arrest decision. A confidence rating was given for each of these judgments on a scale of 1-5, very uncertain to very confident.

A random sample of participants on each test day were video-taped during testing. Also, as discussed in a separate section, a subset of participants were tested with an analogue of the driving task, utilizing the SCRI Stimulus Programming System (SPS).

A participant was released when his BAC declined to .03%.

III. RESULTS AND DISCUSSION

The alcohol impairment test battery was evaluated with 238 drinking participants, 168 men and 70 women. Ages ranged from 20 to 71 years, with a mean of 26 years 6 months and distribution as shown in Figure 4.

These participants were categorized by the Q-F-V index of drinking practices as 62 light drinkers, 86 moderate drinkers and 90 heavy drinkers. Figure 5 shows the Q-F-V distribution by treatment (dose level) group. Some changes from the original experimental plan, as displayed in Figure 2, are evident. These changes and an increase in total N were due principally to a 20% failure-to-appear rate of the scheduled participants. It was not possible to accurately offset the deficit by overscheduling since there was no way to predict which cells would be short of participants. Also, some individuals were either unwilling or unable to drink the amount of alcohol proffered, so their peak BACs fell below the targeted level.

The distribution of mean BACs by test day appears in Table Ia. There was a slight skewing over time, the result of the tendency for heavy drinkers to fail to keep appointments. Because it was repeatedly necessary to reschedule for heavy-drinker cells, more individuals of that classification were tested in the last sessions than during the earlier test days.

Each test was scored on a 0-10 scale where the score increases as a function of more errors/poor performance. The specific nature and number of performance errors associated with a given test score can be obtained from the test record sheet (Appendix 5).

A. Are the Tests Sensitive to Alcohol?

The quantitative data from the evaluation study are summarized in Table 2 and Table 3 and Figure 6 and Figure 7. It is apparent that the tests, as administered and scored by the officer-examiners, and by the observers, generated clearly separated curves for the different BAC levels. All of the tests are sensitive to alcohol, and there is a consistent increase in mean score with increase in mean BAC. Note, however, that these are mean test scores, averaged across participants and officers or observers by actual BAC group. It is necessary next to examine the utility of the tests for deciding individual cases.

B. Do the Tests Discriminate Impaired Drivers?

The officers' scoring of the tests correlated with BAC as follows:

One-Leg Stand	.484	Tracing	.439
Finger-to-Nose	.421	Total Nystagmus	.668
Walk and Turn	.547	Total Score	.669

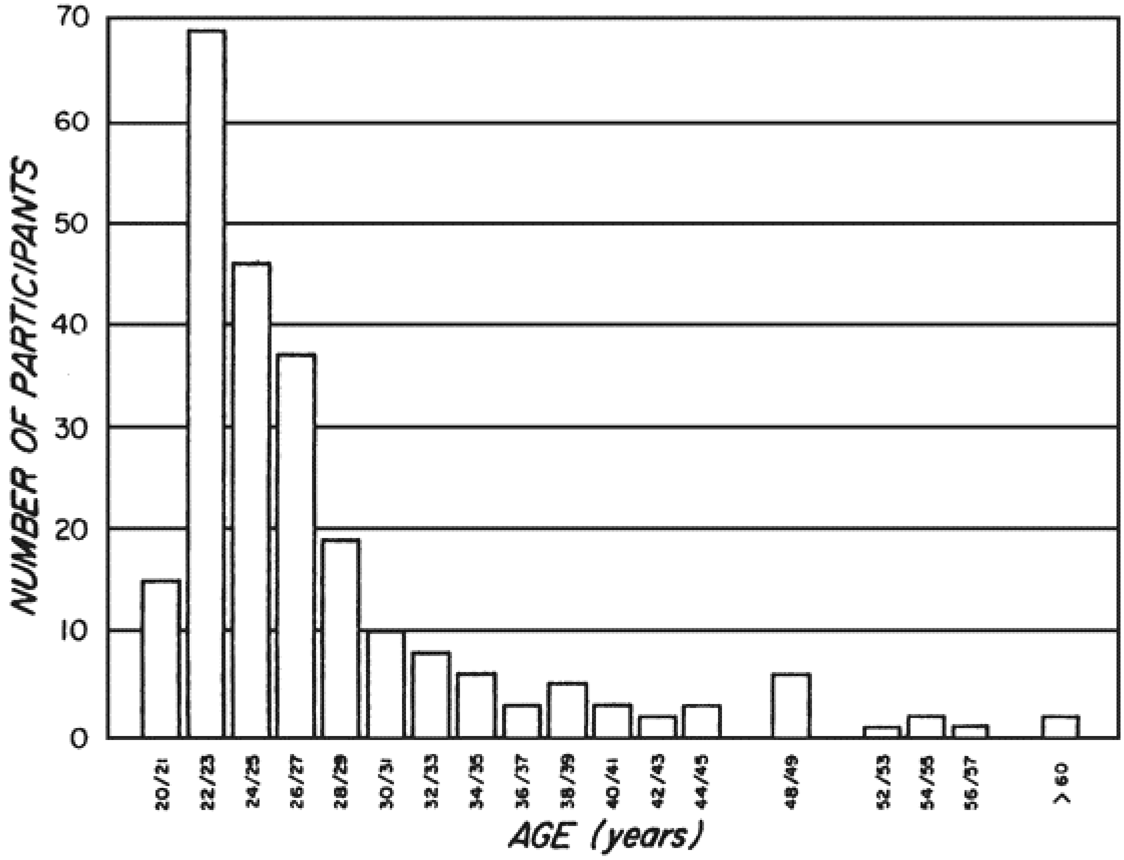

FIGURE 4: Age Distribution of Evaluation Study Participants

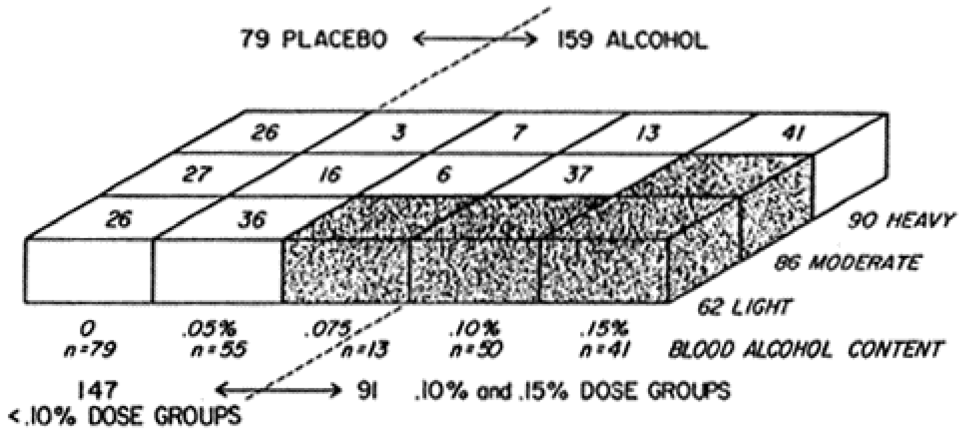

FIGURE 5: Evaluation Study Participants by Q-F-V and BAC

Table 1a
Gender, Age, Q-F-V and BAC
by Test Day and by Officer

			N			Q-F-V Classification, N			
Test Days	-	Officers	Men	Women	$\bar{x}$Age	Light	Moderate	Heavy	$\bar{x}$BAC
1 & 2	)	1	15	4	27.63	3	7	9	.058
	)	2	18	3	28.19	3	6	12	.074
3 & 4	)	3	20	4	26.42	2	14	8	.053
	)	4	14	7	30.95	5	9	7	.071
5 & 6	)	5	12	8	25.45	7	10	3	.067
	)	6	13	8	26.05	8	8	5	.051
7 & 8	)	7	20	9	28.55	7	10	12	.050
	)	8	16	9	26.36	11	7	7	.054
9 & 10	)	9	25	6	26.06	10	7	14	.073
	)	10	15	12	29.70	6	8	13	.060

Table 2
Officers' Scores and Observers' Scores by BAC (Actual) Groups

	Group 1 0 BAC N=79	Group 2 0<x<.05% N=20	Group 3 .05≤x<.10% N=75	Group 4 .10≤x<.15% N=48	Group 5 x≥.15% N=16
Mean BAC	0	.041%	.073%	.120%	.156%
TESTS:					
<u>10 Officers' Scores</u>					
One-Leg Stand	1.44	1.70	2.68	4.06	6.33
Finger-to-Nose	1.64	2.57	3.46	4.00	5.93
Finger Count	2.31	2.38	3.74	4.15	7.31
Walk and Turn	1.72	2.70	3.72	5.32	7.13
Tracing	2.73	2.62	3.80	5.04	5.75
Nystagmus					
Left	0.36	0.95	2.13	4.36	6.25
Right	0.29	1.05	1.93	4.53	6.06
Total	0.65	2.00	4.06	8.89	12.31
Total Score:	10.49	13.97	21.46	31.46	44.76
<u>2 Observers' Scores</u>					
One-Leg Stand	1.79	1.70	2.66	3.85	6.40
Finger-to-Nose	1.71	2.52	2.60	3.83	6.67
Finger Count	2.25	2.57	3.63	3.87	6.56
Walk and Turn	2.20	3.20	3.62	5.26	7.33
Tracing	2.73	2.62	3.74	5.04	5.88
Nystagmus					
Left	0.44	0.95	2.01	5.32	6.13
Right	0.31	1.24	2.06	4.81	6.31
Total	0.75	2.19	4.07	10.13	12.44
Total Score:	11.43	14.80	20.32	31.98	45.28

Table 3
Data Summary: <.10% BAC, ≥.10% BAC
and Total Sample

	<.10% BAC		≥.10%BAC		Total Sample	
	mean	σ	mean	σ	mean	σ
10 Officers' Scoring						
Test:						
One-Leg Stand	2.01	2.36	4.61	3.20	2.69	2.84
Finger-to-Nose	2.54	2.38	4.47	2.73	3.04	2.61
Finger Count	2.94	3.54	4.95	3.96	3.47	3.76
Walk & Turn, Heel-Toe	2.71	2.75	5.75	3.22	3.51	3.17
Tracing	3.18	1.91	5.21	2.49	3.72	2.27
Nystagmus - Left	1.20	2.01	4.84	3.07	2.16	2.83
- Right	1.10	1.89	4.92	3.16	2.11	2.85
- Total	2.30	3.71	9.76	6.00	4.27	5.52
Total Test Battery Score:	15.68	11.09	34.76	13.85	20.70	14.56
2 Observers' Scoring						
Test:						
One-Leg Stand	2.14	1.98	4.47	2.85	2.78	2.47
Finger-to-Nose	2.19	1.74	4.52	2.53	2.82	2.23
Finger Count	2.87	3.50	4.55	3.98	3.33	3.71
Walk & Turn, Heel-Toe	2.92	2.34	5.75	2.95	3.69	2.82
Tracing	3.14	1.93	5.25	2.48	3.72	2.29
Nystagmus - Left	1.68	2.05	5.52	3.14	2.36	3.08
- Right	1.16	2.01	5.19	3.26	2.27	3.01
- Total	2.34	3.75	10.71	5.77	4.63	5.77
Total Test Battery Score:	15.60	9.39	35.25	13.10	20.97	13.67

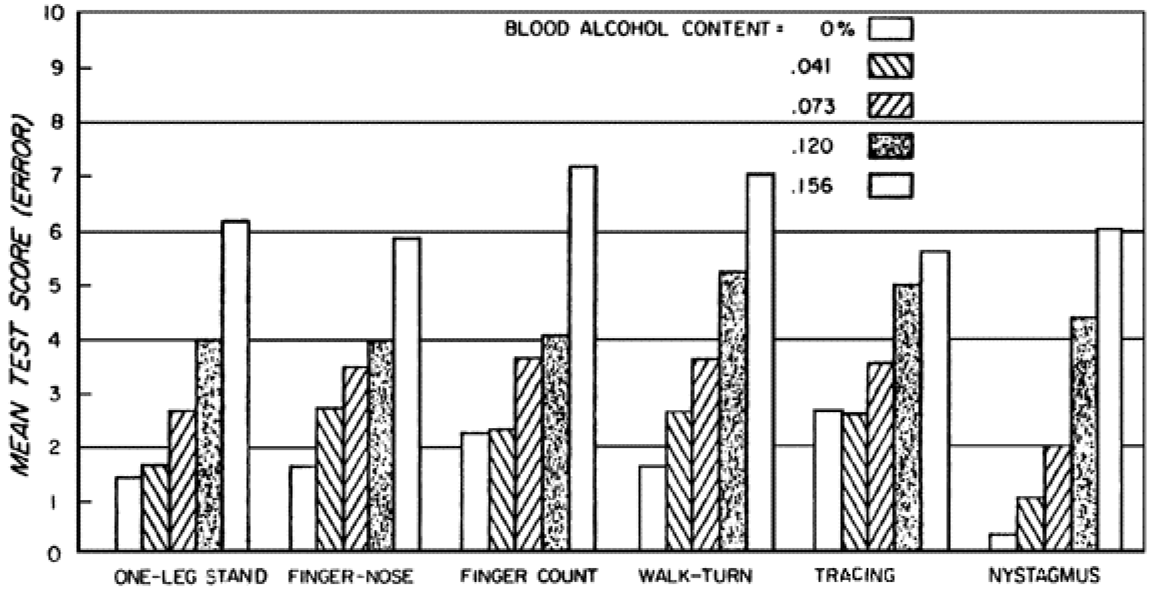
BLOOD ALCOHOL CONTENT = 0%
.041
.073
.120
.156
MEAN TEST SCORE (ERROR)
0
1
2
3
4
5
6
7
8
9
10
ONE-LEG STAND
FINGER-NOSE
FINGER COUNT
WALK-TURN
TRACING
NYSTAGMUS

FIGURE 6: Mean Test Scores by BAC Group

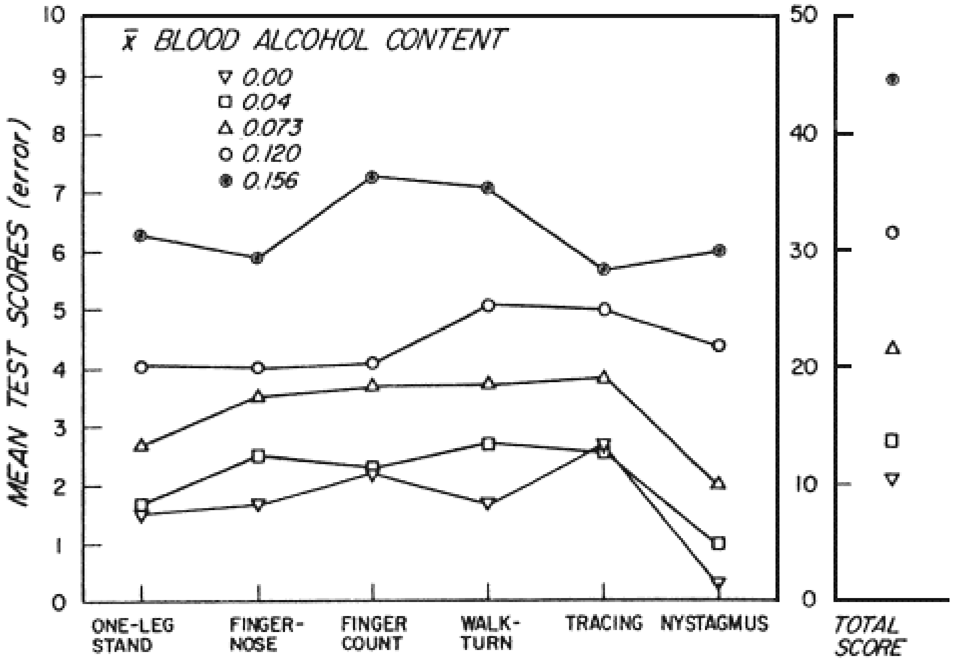

FIGURE 7: Performance Curves by BAC Group

The question of primary interest then is whether the officers were able to make the correct decision, that is, to arrest these persons at or above .10% BAC or to not arrest those below .10%, based on test performance. Their decisions are represented in the matrix below:

	OFFICERS' DECISIONS			
	Arrest	Don't Arrest		% Correct Decisions
≥.10%	Hit n = 54	False Negative n = 10	64	84
≥.10%	False Alarm n = 47	Correct Rejection n = 127	174	73
	101	137		
% Correct Decisions	53	93		76

At BACs ≥.10% the officers correctly decided to arrest 84% of the cases, and for BACs <.10% They made the correct decision to release 73% of the time. However, note that the officers indicated they would have arrested 101 persons, 47 of whom had BACs below .10%. Obviously, an error rate of 47% in making arrests is not acceptable. Actually, officers in the field are reluctant to err in the direction of false alarms, and observations indicate that the most common error probably is a false negative. In the laboratory where the same consequences do not ensue from false alarm decisions to arrest, there was a tendency to be less conservative and to lower the criterion for arrest.

There is a fundamental problem for the officers, stemming from the fact that BAC is a continuously distributed measure. As with any such distribution there is a limit on the related decision process, because the human organism can discriminate accurately only a limited number of points on such a scale. Since .10% is an arbitrary level which does not coincide with the onset of impairment, the difficulty of the task of categorizing DWI suspects is increased. If the officer was required simply to decide whether or not a driver showed impairment, or if the criterion BAC was closer to the point where impairment initially is apparent, there would be fewer decision errors at roadside.

It is of interest to examine the various possible sources of incorrect decisions about BAC and impairment. Some individuals, notably experienced heavy drinkers, are able to maintain the skills which are tapped by sobriety tests even at very high BACs. Hurst and Bagley (1972) reported acute adaptation to alcohol impairment on both cognitive and perceptual-motor measures. Moskowitz, Daily and Henderson (1974) also found evidence for acute tolerance, as well as the long-term chronic tolerance which reflects drinking history.

Very light or infrequent drinkers may show impairment after drinking a small amount of alcohol. Also, poor performance may be attributable to physical causes other than alcohol. Certain diseases, neurological impairment and aging processes interfere with motor skills. It is also the case that officers may base assessments of intoxication on behavioral cues which are not derived from the tests.

A breakdown of decision errors identifies some areas of difficulty. For example, the following six people received no alcohol but the officers indicated they would have arrested them:

Q-F-V Category	Age	Sex	Nystagmus Score	Total Test Score
Heavy	22	M	0	31
Heavy	48	M	0	27
Heavy	26	M	0	19
Heavy	24	M	5	23
Heavy	45	F	1	16
Light	30	M	1	19

The moderate-to-High total test scores reflect problems with balance and walking, which appear to have been interpreted as alcohol-related. That conclusion certainly was not unreasonable, particularly since these individuals tended to behave as though intoxicated. They were rather loud and jocular, bantering with the examiner in a party-like manner. What is of note here is that if the officers had felt confident with the nystagmus measure, which was new to most of them, but which accurately reflected the level of intoxication, in five cases they would have been less likely to make the decision to arrest.

The individual with the higher nystagmus measure was a very unusual man whose general behavior was strange. It is possible that he suffers some neurological impairment.

It is of interest to note that the observers would have made only one arrest in this group, the light drinker, who was given a total score of 25 and a nystagmus score of 2 by the observer.

The officers also made six incorrect decisions to arrest men who received small amounts of alcohol, as follows:

Q-F-V Category	BAC	Age	Nystagmus Score	Total Test Score
Heavy	.049	39	0	25
Heavy	.047	22	7	27
Moderate	.050	23	5	18
Moderate	.048	25	4	14
Moderate	.046	23	0	9
Moderate	.045	33	0	6

It is puzzling why decisions were made to arrest the two moderate drinkers who were given low total scores and who had no nystagmus. Apparently the officers disregarded test evidence and based their decisions on some other cues.

As with the 0 BAC group there were some highly unusual individuals among these men. For example, the 39 yr. old heavy drinker was scheduled to achieve .15% but in a hostile manner refused drinks after the first one. He showed distinct physical impairment which probably had no relation to the small amount of alcohol which he consumed. He was the only one in the group who would have been arrested by the observer.

Appendix 6 shows all false arrest decisions, that is, those cases where the officer indicated the person would be arrested but the BAC was less than .10%. It should be pointed out that 24 of these were administered alcohol doses calculated to produce .10% BAC, but the gas chromatograph reading fell short of the mark. The lower measured BAC may have resulted from inaccuracies in reported body-weight or because individuals had consumed food contrary to instructions. Also, some machine measurement error is possible. With the large number of participants at each session it was not practical to give booster treatments and disrupt the tightly scheduled administration of tests. It should be kept in mind that by dose level the officers were not in error as regards these participants. The important issue here, and one that appears consistently through-out these data, is that the decision errors occurred in relation to individuals whose BAC was just below .10%.

For most of the cases listed in Appendix 6 there was evidence of impairment as indicated by the total test score, and the jerking movement of the eyes (nystagmus) was observed. The officer's decision then is not at odds with evidence from the test battery. As discussed elsewhere and as apparent in the false alarms, decision errors occur most often with middle range levels of intoxication. Quite simply, there are no behavioral cue which differentiate infallibly in a ± .02% BAC margin.

In summary, analysis of false arrest decisions indicates at least four sources of errors in decision, assuming ≥. 10% is correct:

1. Borderline BAC levels.
2. Failure by the officer to heed the lack of test evidence for intoxication.
3. Impairment which is not alcohol-related.
4. Unusual individuals whose manner and appearance suggest intoxication.

The data show two basic kinds of errors. In one case the quantitative score did not reflect the measured BAC, either because the officer did not score properly or the performance was atypical. The second kind of error occurred when the score was appropriate to the performance expected for a given BAC, but the officer's decision was at odds with the score.

The officers' errors were almost evenly divided between the two possible kinds. For roughly half the participants the scores do not appear to represent the performance accurately, and for the other half the officer's decision doesn't mirror the score.

C. Criterion Score

An important objective is to locate a criterion score, which will dichotomize the BAC distribution into above and below .10%. An initial approach utilized a linear regression analysis, as graphed in Figure 8. As can be seen in the figure, this analysis locates the criterion at a total score of 28. On the assumption that the person who scored 28 or more was at .10% BAC or higher, and that a score of less than 28 indicated a BAC lower than .10%, the following matrix is generated (borderline cases are assumed to fall into the non-error category):

CRITERION SCORE CLASSIFICATIONS				
	Arrest Score ≥28	Don't Arrest Score <28		% Correct Classifications
≥ .10%	44	20	64	69
< .10%	20	154	174	89
	64	174		
% Correct Classifications	69	89		83

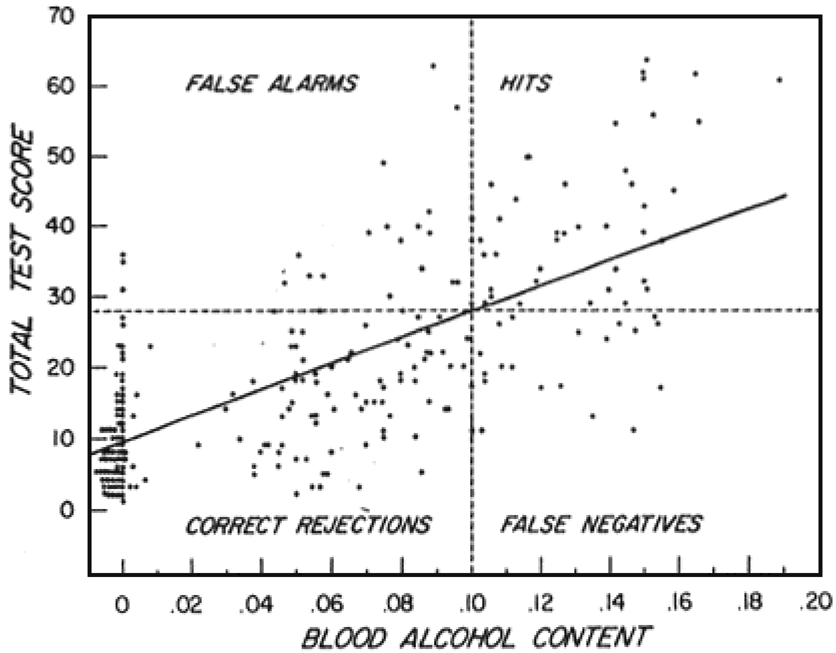

FIGURE 8: Scatter Plot of Total Score vs. BAC

Compared to the officers' decisions, this total score criterion yields more correct decisions overall, 198 vs 181, 83% vs 76%. Compared to other possible criterion scores, the use of the score 28 maximizes both the total number of correct decisions overall and the percent correct for arrest decisions.

It is of further interest to compare each cell of the matrix from the officers' scores with the matrix from the criterion score, as follows:

	Officers' Decisions	Classification by Criterion Score
Arrest Decisions:	%	%
Correct (Hits)	53.5	69
Errors (False Alarms)	46.5	31
Don't Arrest Decisions		
Correct (Correct Rejections)	93	89
Errors (False Negatives)	7	11

As discussed previously, almost half of the officers' decisions to arrest were erroneous. Their high false alarm rate is not typical of officers' decisions in the field, and it probably reflects a relaxed or lowered decision criterion. That is, in the laboratory they were willing to make an "arrest" decision on less evidence than they would require in a real-world situation. A stricter decision criterion would, of course, affect both kinds of errors, reducing false arrests, increasing false negatives. In actual practice, the most common error at roadside is a false negative; unless an officer has a high degree of certainty that an individual's BAC is over .10%, he is most likely to release rather than arrest.

There were four high BACs (>.15%) for which the associated total test score did not exceed the criterion score of 28. The individual differences in skill and in response to alcohol which underlie these misclassifications inevitably will be troublesome for a quantified test battery. A case in point is the male participant, age 28, whose drinking practices categorized him as a heavy drinker. He was of muscular build and appeared to be in top physical condition. His peak BAC reading was .147%, but there was no sign of intoxication in test performance, speech, or appearance. At the other extreme, a female, age 63, appeared to be intoxicated at .067% BAC, and could not perform the balance or walking tests. She is a light drinker, and she is arthritic.

Also, the accuracy of classification inevitably will be limited because of the form of the underlying distributions. In effect, we are attempting to classify continuous variables into discrete cells of the 2 x 2 matrix. Those cases which cluster near the criterion BAC or the criterion test score are particularly subject to classification error. Consider, for example, what performance differences could reasonably be expected between BACs of .095% and .105%? Observe that in the distribution graphed in Figure 8, 40% of the false alarm decisions and 45% of the false negative decisions occur within a ± .02% margin around the .10% limit.

D. Comparison of Officer and Observer Scores

Between-examiner consistency is of considerable interest in the examination of errors. As an officer administered and scored the tests, the participants' performance also was observed by an SCRI research assistant, and the two sets of scores can be compared.

The two persons, observer and officer, were able to watch a participant, independently evaluate the test performance, and arrive at closely similar decisions about impairment. Figure 9 graphs a comparison of the scoring by the ten officers and two observers. The scores correlate overall with r = .92 (Table 4).

The following cases were incorrectly classified by both the officer and observer:

False Alarms (BAC <.10% & Decision to Arrest		False Negatives (BBC ≥. 10% and Decision to Not Arrest)	
Participant's Q-F-V Category	Measured BAC	Participant's Q-F-V Category	Measured BAC
Heavy	.096	Heavy	.147
Heavy	.093	Heavy	.126
Heavy	.080	Heavy	.118
Moderate	.098	Moderate	.104
Moderate	.095	Moderate	.103
Moderate	.088	Moderate	.100
Moderate	.086		
Moderate	.075		
Moderate	.074		
Moderate	.056		
Light	.067		
Light	.054		

In 29 cases the officers' and observers' decisions differed. For 10 of these disagreements the officers were correct, and for 19 they were in error, including 16 wrong decisions to arrest and 3 wrong decisions to release. For the 10 cases which were observer errors, five were false-alarm arrests and five were false-negative releases.

Again, the source of errors in more than half of these cases appears to be that borderline BACs cannot be discriminated from each other. It is possible to identify a low or high BAC, usually with a high degree of certainty, but difficulties arise, for example, when a person at .098% shows impairment in performing the tests but the person at .103% does not.

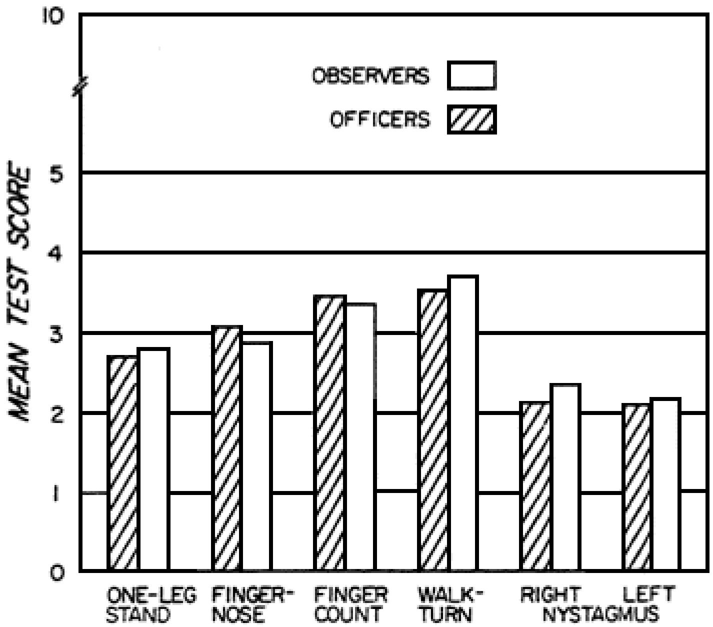

FIGURE 9: Mean Test Scores, as Scored by Officers and Observers

Table 4
Officer - Observer Test Score Correlations

Test	Participants (by BAC)		All Participants
	<.10%	≥.10%	
One-Leg Stand	.77	.81	.82
Finger-to-Nose	.60	.72	.70
Finger Count	.87	.79	.85
Walk & Turn, Heel-Toe	.70	.84	.80
Nystagmus - Left	.85	.72	.86
- Right	.83	.75	.86
- Total	.88	.78	.90
TOTAL TEST SCORE:	.88	.89	.92

E. Tolerance to Alcohol Effects

The literature on chronic use of alcohol demonstrates that resistance to alcohol impairment is a function of drinking frequency and history (Moskowitz, Daily and Henderson, 1974; Kalant, LeBlanc and Gibbons, 1971; Goldberg, 1943). This phenomenon of chronic tolerance creates an additional difficulty for sobriety testing. Widely differing drinking practices among drivers can be expected to give rise to different BAC points of impairment of test performance.

The regression analysis, as discussed previously, used a first-degree (linear) equation to examine the relationship between BAC and test score. However, in order to locate the exact BAC at which substantial impairment initially appears, a polynomial regression analysis (computer program BMDP6R) was performed to fit second-degree (quadratic) curves to the data.

The polynomial analysis was carried out separately for light, moderate and heavy drinkers, and the quadratic curves appear in Figure 10. It can be observed that the point of initial, substantial impairment, as indicated by a change in slope, varies as a function of drinking practices. Impairment appears well below .05% for light drinkers and is clearcut for moderate drinkers by .07%.

Heavy drinkers show relatively poor performance, in comparison to the other drinking groups, at any given BAC. This reflects in part the older ages of the heavy drinkers, as well as physical deterioration associated with long-term chronic drinking.

This analysis provides additional evidence that the point of a sharp increase in alcohol impairment varies according to the individual's drinking history. It also strongly suggests that the arbitrary DWI level of .10% is considerably beyond the point of serious impairment for most people, and that .08% would be a more reasonable level. The following section examines the utility of the test battery and a criterion score for discriminating between above and below .08%.

F. A Question of BAC Limit

A BAC of .10% is widely used as the point at which an individual can be charged with driving under the influence of alcohol or driving while impaired, and this report focuses for the most part on an assessment of the test battery based on that level of blood alcohol. Do the tests discriminate drivers whose BAC is above .10% from those who are below that level? This is the currently relevant question in terms of the utility of the tests for law enforcement, but there are other important questions.

In particular, there is considerable evidence in the data, as discussed elsewhere in this report, that the .10% level is not the point of initial, serious impairment for many drivers, and that

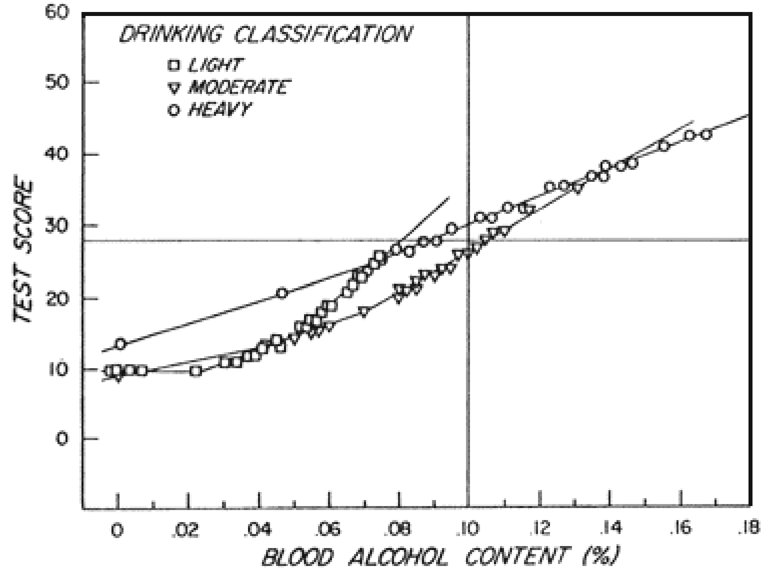

FIGURE 10: BAC vs. Total Test Score, by Drinking Classification (Q-F-V)

it may in fact be substantially lower. If the officers' decisions are sensitive indicators in that they adopt a criterion reflecting the lower BAC level where they first observe impairment, then their false-alarm rate is explicable. It actually may be an artifact of the arbitrary .10% BAC. This issue can be examined by constructing a matrix for a lower BAC, as in the following which is based on .08%.

	OFFICERS' DECISIONS			
	Arrest	Don't Arrest		% Correct Decisions
≥ .08%	71	22	93	76
< .08%	30	115	145	79
	101	137	238	
% Correct Decisions	70	84		78

A comparison of the above with the matrix based on .10% (page 25) suggests that the officers were making decisions "as though" .08% BAC were the limit. It is not likely that they consciously and deliberately departed from a .10% criterion. Rather it may be that they consistently noted impaired performance at the lower level and equated it in the decision-making process with the point for arrest.

If the analysis is extended to the criterion score, there is further evidence to suggest that .08% is an appropriate level which more effectively divides seriously impaired drivers from those who are less or non-impaired.

The matrix on page 28, based on a score of 28 and a BAC of .10%, shows 69% of the arrests would be correct. If on the other hand the BAC criterion were .08%, the criterion score becomes 25, and as can be seen below, 77% of the arrests would be correct. In other words, the quantitative scores accurately reflect the impairment which appears not at the legal limit but at lower levels.

	CRITERION SCORE					
	Arrest ≥25		Don't Arrest <25			% Correct Decisions
≥.08%	Hit	64	False Neg.	29	93	69
<.08%	False Arrest	19	Corr. Rej.	126	145	87
		83		155	238	
% Correct Decisions		77		81		80

In summary, it appears that the .10% BAC level is at odds with the observation and scoring of impaired performance. The consequence is that decisions are wrong in terms of the legal limit but are quite correct in terms of driving impairment.

G. Selection of a Final Test Battery

The key question for the project centers on the practical utility of the test battery. The police officer in the field is confronted with the single individual. He must make a decision to arrest or to release. If he arrests, he may later be required to present as evidence in court proceedings a report of the behavior which led him to make the arrest. The test battery has value for the officer only if it: 1) facilitates his arrest/release decision, and 2) enables him to give credible and convincing testimony in court.

The evaluation data demonstrate that the six tests which were studied can be used as a battery to assist officers in determination of drivers' levels of intoxication. However, the 6-test battery is too lengthy for roadside use. Careful administration of the entire battery, including demonstrations and thoughtful scoring, requires a minimum of 15 minutes. Officers typically do not allot that much time to roadside examination of a driver, and it is essential to select a subset of these tests which as a shorter battery will still fulfill the objectives of sobriety testing.

Selection of the final test battery has been accomplished by step-wise discriminant analysis, utilizing program BMDP7M from BioMedical Computer Programs. The discriminant model derives linear functions of the test battery scores so as to best separate the BAC groups. The success depends on the overlap of the distribution of scores generated by the test battery for each group. If there are many scores in common, there will be many wrong decisions. If the final test battery can be configured to yield scores with little overlap, then there will be few errors. This has been illustrated with clarity by Cooley and Lohnes (1971) (see Figure 11), who describe the graphic representation as follows:

> ". . . the two sets of concentric ellipses represent the bivariate swarms for the two groups in idealized form. . . Each ellipse is the locus of points of equal density (or frequency) for a group. . . The two points at which corresponding centours intersect define a straight line, II. If a second line, I, is constructed perpendicular to line II, and if the points in the two-dimensional space are projected onto I, the overlap between the two groups will be smaller than for any other possible line. The discriminant function therefore transforms the individual test score to a single discriminant score, and that score is the individual's location along line I." (P. 245)

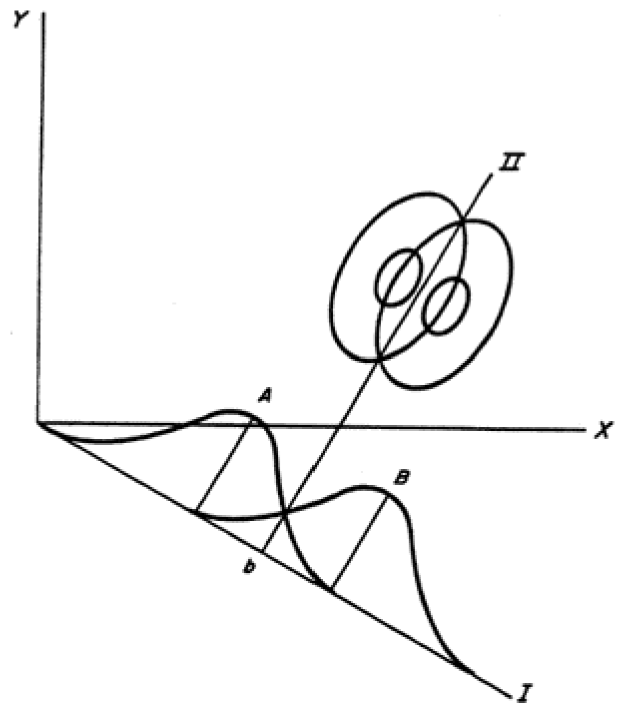

FIGURE 11: Graphic Representation of Discriminant Model (Cooley and Lohnes, 1971)

BMDP7M computes the set of linear classification functions by choosing variables in a stepwise manner. At each step the variable with the highest F (standard F statistic, hypothesis of equality) is chosen. Using specified prior probabilities and pooled within group variances, group classification functions are obtained and a classification table is produced.

Appendix 8 summarizes the classification tables obtained from a series of analyses with BMDP7M. On an initial run, all test scores were entered as variables for the analysis. Then various combinations of reduced test sets were explored in an effort to locate the optimal tradeoff between test battery length and percent correct classifications.

When all tests were entered as variables, the classification utilized scores from the following tests: total nystagmus, tracing, walk and turn, finger count, nystagmus-left eye, and one-leg stand. Almost 85% of the participants were correctly classified into the two BAC groups, above .10% (70% correct) and below .10% (90% correct). However, this is a relatively long battery, and the tracing test cannot easily be used at roadside.

At the other extreme, if only a single test is used, these data can be classified as follows:

Test	% Overall Correct	% <.10% Correct	% ≥.10% Correct
Walk and Turn	75.1	80.0	59.7
Finger-to-Nose	70.4	75.6	56.5
Finger Count	67.1	70.8	57.1
Tracing	76.5	84.4	55.6
One-Leg Stand	75.5	79.6	64.5
Nystagmus - left	80.1	89.9	54.0
- right	82.7	87.5	69.8
- total	81.8	86.9	68.3

The nystagmus measure is superior to any other single test and compares favorably to a long battery. (Note: the differences between left and right eye seem to be due primarily to vision problems. e.g., restricted vision in one eye due to brain injury, one artificial eye, etc.)

Table 5 gives the distribution of nystagmus scores. The criterion employed by the discriminant analysis was that a score ≥ 6 placed the person in the ≥.10% BAC group. As can be seen in the table, this criterion incorrectly classified 23 (13%) of the <.10% group and 21 (33%) of the ≥.10% group for an overall error of 18%.

However, predictors which have the highest correlations with a criterion variable, in this case correlation of tests with BAC, when considered singly may have little value in a combination of

Table 5
Distribution of Total Nystagmus Scores by BAC Group

Point Score	BAC Group <.10%		BAC Group ≥.10%		% of Participants at Each Point Score	
10 pts. per eye, max.=20	n	%	n	%	<.10%	≥.10%
0	92	52.6	2	3.2	98	2
1 - 5	59	33.9	19	29.7	76	24
6 - 10	19	10.9	17	26.9	53	47
11 - 15	1	.5	11	17.5	8	92
16 - 20	3	1.7	15	23.8	17	83
	174	100.0	64	100.0		

predictor variables. In order to locate an optimal combination of tests, the discriminant analysis was performed with various test sets (Appendix 8). The total score derived from the three measures, walk and turn, one-leg stand, and total nystagmus, appears to be the best predictor.

For these data, 83.4 percent correct classifications were made, with 68 percent correct arrests. This is essentially the same level as obtained with the entire battery. The involuntary jerking movement of the eyes (nystagmus), together with balance and walking problems, provide the examiner with information about three different indices of intoxication. An idiosyncratic response in one area probably will be balanced by a more typical response in another. Testing can be performed in any environment and requires less than five minutes. Also, use of the total score, rather than a number of single-test scores, facilitates the location of cutoff scores and probability levels.

A number of the same participants are consistently classified incorrectly by stepwise discriminant analyses, even though the subsets of scores entered into the analyses are varied across the range of possibilities (Table 6). It is of interest to examine these cases which it seems impossible to capture within a classification scheme. A participant's behavior may have been atypical, or the scores may not be an adequate representation of his performance.

It is important to first note that half of the cases shown in Table 6 fall into the BAC range .08-.12%. Again, it should be pointed out that all the evidence from these data suggests it is unrealistic to attempt to use behavioral tests to discriminate BACs in a ± .02% margin around a given level.

It proves to be highly informative to examine the misclassifications for the cases with BACs outside the .08-.10% range. Observe in Table 6 that eight participants with BACs <.08% were classified ≥.10%. Six of these were light drinkers, and the misclassification demonstrates their lack of tolerance to alcohol. On the other hand, ten people at BACs >.12% were classified as <.10%. All were heavy drinkers whose drinking experience appears to have led to the development of a chronic tolerance to the impairing effects of alcohol.

In summary, the discriminant analyses confirm findings which have emerged from other examinations of these data. Some individuals perform in a manner which appears not to be congruent with BAC level but which frequently is explicable in terms of a tolerance effect. These individuals inevitably will present a problem for any system of testing and scoring, as well as for the police officer, who rarely will have information about the person's drinking history.

Table 6
Summary for Participants Mis-Classified
by Discriminant Function Analysis

	Q-F-V Category	Total Nystagmus	Total Score	% BAC
Participants <.10% (Classified ≥.10%)	Light	9	23	.049
		8	25	.052
		20	33	.054
		10	19	.056
		6	28	.057
		13	49	.075
	Moderate	8	30	.077
		10	40	.085
		6	34	.086
		17	42	.088
		8	27	.091
		10	20	.098
	Heavy	4	39	.071
		8	19	.081
		10	39	.088
		20	62	.093
		9	33	.095
		16	57	.096

(continued)

Table 6 (continued)
Summary for Participants Mis-Classified
by Discriminant Function Analysis

	Q-F-V Category	Total Nystagmus	Total Score	% BAC
Participants ≥.10% (Classified <.10%)	Moderate	0	11	.100
		6	11	.103
		2	19	.104
		4	26	.108
		3	27	.112
	Heavy	4	36	.107
		5	20	.112
		0	17	.118
		4	17	.126
		4	25	.131
		5	29	.135
		2	13	.135
		2	26	.143
		3	11	.147
		4	32	.150
		4	27	.153
		4	26	.154
		4	17	.155

However, training in sobriety testing should acquaint the officer with the phenomenon of tolerance, so he can bring that information to bear in cases of uncertainty. On such occasions the DWI suspect's age and appearance and the locale will sometimes provide clues about the person's drinking habits.

H. Officer Experience and Training

Correlational analyses were performed to determine the relationship between a police officer's experience and his skill in assessing whether a participant should be arrested. Spearman rank-difference correlations revealed that the officer with the most experience and the second largest number of DWI arrests made the most correct decisions as to arrest/don't arrest. Also, his scoring of participants' test performances yielded the highest correlations (Pearson r) with BAC. Further, an examination of data, grouped by the law-enforcement agencies which the officers represented, showed that this man and his fellow officer were more skilled than the officers from other agencies. A key factor undoubtedly is assignment to DWI patrol where their sole regular responsibility is detection and arrest of intoxicated drivers.

Beyond these findings there were no additional significant relationships between experience and skill. Attitude and interest in the project varied considerably between officers, and it is believed that these variables had as much influence on decision processes and success rate as did the variable of experience.

If a test battery is to be widely useful and acceptable, it is important to be able to train officers in administration and scoring procedures in a relatively short period of time. Each pair of officers who participated in the study came to SCRI for a single training day during the week immediately preceding the validation sessions. They were given a general orientation to the purposes of the project, followed by specific instructions on administering the test battery. Correct administration was demonstrated, and then the officers practiced those exact procedures under supervision. A videotape system was used to facilitate learning.

When an acceptable level of administration of the tests was achieved, the scoring system was introduced. Again under supervision, the officers practiced testing and scoring. In all cases it was possible to train the men to follow the required testing procedures and to enable them to feel comfortable with the rather rigid instructions within 4-5 hours. The training procedure provided an opportunity for the officers to observe test performance by individuals at zero BAC. They thus were able to establish some standards of performance by which to gauge the study participants. It is extremely important that training in the use of tests of alcohol-related impairment be planned to include a range of BACs with immediate feedback to the officers.

A training period of one day or less probably is not prohibitively long. The question then concerns the level of competence demonstrated during the evaluation sessions. One approach to this question is to compare their scoring records with those of the two observers. The observers were SCRI research assistants who were involved with the project from the beginning. They performed the testing during the pilot studies, and they supervised the officers' practice during training.

The ten officer's scoring (total test score) correlated .699 with BAC. The equivalent correlation for the two observers was .727. Since the observers were involved with recruiting and scheduling participants, they had some knowledge of probable BAC levels and thus some advantage over the officers. Of course, it also is true that none of the officers were total novices, all having had training and experience with the balance and walking tests, as well as considerable skill in observation and experience in judging impairment under alcohol.

It is concluded that a short, intensive training in standard administration and scoring of the test battery is adequate. The ten officers, representing several agencies and a wide range of experience, demonstrated an acceptable level of competence in the laboratory following one training session.

I. Comparisons with Finnish Data

The study carried out by SCRI is similar in scope and methodology to a study of DWI tests by Pentillä, Tenhu and Kataja (1974) which examined the impairment-test records of 495 Finnish drivers. In Finland the examinations for intoxication are carried out by physicians, and the system utilizes 15 tests which are scored on a 0-3 scale. The investigators used the records of these examinations to develop a series of point value models in an attempt to standardize the physicians' evaluations in relation to BAC.

There is considerable similarity between the Finnish and the SCRI studies, and Table 7 presents correlations from each set of data where comparisons of similar tasks are involved. However, there also are basic differences which are pertinent to interpretations of the data. The participants for Pentillä, et al., were drivers who the police suspected of drunk driving, and the examiners were physicians highly experienced with the tests. Only 22% of the drivers were at a BAC lower than .10%. For the SCRI study, paid volunteers were administered alcohol, and the ratio of BACs below .10% to BACs above .10% was established at approximately 3:1 in order to avoid biasing the examiners to expect intoxication. Examiners were police officers with varying skill levels derived from minimum field experience at one extreme to DWI specialists at the other. Only two of the officers had prior experience with examining the eyes for nystagmus.

Table 7
Correlations Between Test Scores and BAC

Finnish Data		SCRI Data	
BAC	0-.30+%	BAC	0-.15+%
N	495		238
Tests:	r	Tests:	r
Walking along a line	.55	Walk and Turn	.55
Gait in turning	.50		
Romberg (body sway) with eyes open	.59	One-Leg Stand.	.48
Finger-finger test	.36	Finger-to-Nose.	.47
Nystagmus	.48	Nystagmus - Left Eye	.64
		- Right Eye	.65
		- Both Eyes	.67
Six-Test Battery	.715	Total Score, All Tests	.699
		Total Score (Walk and Turn, One-Leg Stand and Total Nystagmus)	.702

The Finnish report states: “The cases with an obvious disease, ingestion of drugs, injuries, disabilities or fatigue affecting the test performance in some way were omitted from the material.” These restrictions were not imposed for selection of SCRI participants since the intent was to sample the entire population of drivers who police officers may have occasion to test. These differences should bear upon interpretation of the respective findings. The task of the Finnish investigators was easier in that all the cases were drivers presumed to be drunk.

From the study of drivers in Finland the investigators conclude that the following comprise an optimal test battery:

1. Walking along a line
2. Romberg’s test with eyes open
3. Counting backwards
4. Collecting small objects
5. Nystagmus after movement of the eyes
6. Time to onset of nystagmus after rotation of the individual.

The correlation coefficient of this battery with blood alcohol was .715. As alternate or additional tests, the following are specified: Walking test with eyes closed, Gait in turning, Finger-finger tests, and Orientation as to time.

Tests No. 3 and 4 were pilot-tested at SCRI, but the results did not warrant retaining them in the battery. Test No. 2 also was pilot-tested (as Romberg, eyes closed), and was found to be a sensitive measure which is offered as an alternate test for the battery proposed by SCRI. However, One-Leg Stand also involves balance and was found to be a better index of intoxication. Time of nystagmus after rotation has not been investigated at SCRI as a measure; it is not a technique which can be readily adapted to field use.

The Finnish and SCRI investigators are in general agreement as to the merit of nystagmus, balance and walking tests. In regard to nystagmus Pentillä, et al., state:

> “When the blood alcohol level was lower than 1.26 or 1.51 ‰ the correlation coefficients of the nystagmus tests were highly significant...” (p. 22)
>
> “In cases with blood alcohol lower than 1.26 or 1.51 ‰ the nystagmus tests proved to be the only adequate tests on the basis of the results of several regression analyses.” (p. 29)
>
> “...the nystagmus tests were the most valuable and objective tests on various blood alcohol levels...” (p. 38)

> “The nystagmus tests proved more valuable than other tests on lower (<1.26 or <1.51 ‰) blood alcohol levels.” (p. 39)

As discussed previously, SCRI also found nystagmus to be the best single index of intoxication. It is particularly valuable because it is an involuntary response. Police officers can readily learn to observe and evaluate the jerking movement. A simple device can be used to control the extent of eye deviation precisely, but the phenomenon also can be induced and observed in any environment without special equipment. SCRI data show a substantially larger BAC-nystagmus correlation than reported in the data from Finland. It is believed that this reflects procedural differences. The manner of conducting the test is described in the Finnish report as follows:

> “The subject was asked to fix his eyes on a small object 40 cm in front of his face and to follow the object with his eyes. The object was moved horizontally from one end of the sight field to the other one and backwards. The examiner fixed the head of the subject in normal position so that only the eyes were moving. The test was repeated three times.” (p. 53)

The SCRI procedure provided more precise control of the eye movement. The apparatus which was utilized was designed to control head position, head movement, rate of eye movement and angle of visual gaze. Examiners were instructed as follows:

> Move the light slowly to 30°. Hold at that position to determine if eye is jerking. Move the light to 40° and take second observation.
>
> Check: Head centered in chin rest.
One eye covered.
Continuous following with other eye.

The Finnish tests Walking-along-a-line and Gait-in-turning are together roughly equivalent in skill demands to the single SCRI test, Walk and Turn. Equivalent correlation coefficients were obtained (Table 7).

Also, the Romberg with eyes open and the One-Leg Stand tap similar balance skills, though the latter is considerably more difficult. Finger-finger and Finger-to-Nose have obvious similarities; in both data sets the correlations are smaller than for balance, walking and nystagmus.

Pentillä, et al., also report:

> "There was a considerable variation in the mean degree of error between various clinical tests on the same blood alcohol levels. There was also a wide individual variation in the performance results of clinical tests." (p. 18)
>
> "There were numerous slightly unstable or slightly incorrect performances in the walking a line test, Romberg's test with the eyes closed and the finger-finger test on lower blood alcohol levels." (p. 21)
>
> "If these total point values are compared with the respective total point values of the tests based on subjective estimation (quality of speech or behavior, relaxation of inhibitions and pulling oneself together) the negligible importance of these tests in the models is obvious." (p. 31)
>
> "The walking along the line and Romberg's tests were also included in the various adequate and optimal models." (p. 38)

The SCRI data are in agreement with all of the foregoing. It appears that the overall findings from the two studies are essentially the same. The differences which do exist appear to be attributable largely to procedural and population differences. In summary, both sets of data identify nystagmus as the best index of alcohol impairment, and both develop optimal batteries which include walking and balance tests.

IV. DRIVING TEST

An additional objective of the project was the examination of the relationship between the effects of alcohol on the performance of the test battery and the effects of alcohol on driving skills. Selection of a valid driver performance measure is a difficult problem which is further complicated by the conditions of this application. Even a simplified representation of driving demands requires a relatively complex apparatus and task, and the performance by participants who have had no training reflects the influence of novelty and learning variables as well as BAC.

The SCRI Stimulus Programming System (SPS) was utilized as an analogue of driving. This apparatus is described in detail in Appendix 9. The display unit consists of a visual arc with a tracking display located in the central field and 40 LED numeral lamps evenly spaced from 15° to 100° in the right and left visual fields. For this study the system was configured as the simplest form of a driving simulator, requiring the division of attention which is characteristic of driving; that is, performance of a tracking task together with search-and-recognition for visual targets. Because it was desirable to minimize the learning requirement, the two components of driving were simplified as:

(1) Pursuit tracking with a pure gain controlled element,

and (2) near-peripheral signal detection task.

The tracking display was a 5“ oscilloscope screen located 30” from the subject’s eyes. The tracking cursors were two horizontally moving dots which the subject controlled by movement of a displacement fingertip stick.

The signal detection task used LED lamps located at 10°, 15°, and 20° right and left and 5° and 10° above and below the central line of sight for a 6 x 4 array of numbers. The target number 2 appeared at a different position on each trial in random order with changes occurring on the average every 5 secs. Response to the target was made by moving a 4-position switch to indicate the quadrant in which the target appeared. If the target was not detected, the display changed after 28 sec.

The following measures were obtained and automatically printed for 10 mins. of tracking with 21 targets:

1. RMS error integrated over time for the tracking task.
2. Latency of response to target LEDs.
3. Response errors (false alarms and false negatives).

A. Procedure

Participants equally representing the groups tested by each officer-examiner were selected at random within the constraints of the schedule of the sobriety test battery. A sample of 97 participants was tested immediately following the completion of the sobriety test battery. No training was given since the objectives include possible adaptation of the technique for impairment test purposes under circumstances of one-time testing.

B. Results

Appendix 9 gives a summary of SPS data and sobriety test data for the subset of validation study participants who also were tested on the SPS.

In examining the SPS data, it appeared that a performance trade-off between different components of the task occurred with considerable frequency. That is, under demands for division of attention when processing capacity had to be allocated across multiple task components, the individual's performance was maintained on one task while on the other impairment became apparent. Consequently, a single score, for example the tracking measure, may not adequately represent the total performance. To deal with this characteristic of the data, an additional index of performance was created by calculating Z scores for each measure and using the sum of the Z scores as a single measure of total performance.

Table 8 shows the t statistic for the various measures. These are interpreted as demonstrating the SPS task to be alcohol sensitive and also as lending support to a performance tradeoff between the two major task components. When the three measures, E^2, RT, and number of errors, are combined as Z scores, there is a significant difference between the two BAC groups. However, the tracking measure taken singly does not reflect significant impairment at the higher BACs (non-sig. t) whereas RT does. These results would be expected if the individual is attending primarily to the tracking task and taking the alcohol-related performance loss on response time to the LED targets. This interpretation must be viewed as tentative pending further study.

It should be pointed that distribution of attention is highly subject to factors which influence the person's perception of task priorities, e.g., task instructions. In this case, instructions placed equivalent emphasis on both parts of the task, but the participants apparently viewed the tracking task as being of first importance. It is a continuous central vision task which demands ongoing attention as opposed to the intermittent demands of the peripheral targets. This task structure, of course, parallels the attention demands of driving.

Table 8
t Tests for SPS Data

Participants ≥.10% BAC vs Participants <.10% BAC

Measure	t	ρ
Tracking E^2	1.61	.118
Reaction Time to LED Targets	3.27	.002
Number of Errors	1.51	.143
Σz Scores(Tracking, RT, Errors)	3.13	.003

It has been demonstrated that the SPS task is sensitive to the impairing effects of alcohol, but the primary issue here concerns the relationship of performance on this simple form of a driving simulator and performance of the impairment test. Does the person who shows impairment on the behavioral tests also show impaired driving skills? The analysis focuses on the three tests which are proposed as the final form of a sobriety test battery, i.e., One-Leg Stand, Walk and Turn, and Nystagmus.

The bivariate correlations between the SPS measures and behavioral test data are of interest, but as can be seen in Table 9, the nature and extent of the relationship is obscured by the necessity for interpreting nine correlations simultaneously.

This difficulty is avoided by the canonical correlation method which expresses the relationship as the maximum correlation between linear functions of the two data sets, subject to restrictions of orthogonality. The analysis obtains two linear combinations, one of the impairment test scores and one of the SPS scores; the coefficients for these linear combinations are those vectors which make the Pearson product-moment correlation as large as possible. Canonical correlation answers the question as to what extent individuals maintained the same level of performance on the two tasks.

The canonical correlation analysis was performed with computer program BMDP6M. Figure 12 is the computer graph of the first canonical correlation value of .576. "CNVRS1" on the ordinate represents the three sobriety tests, and "CNVRF1" on the abscissa represents the three SPS measures. (Note that the analysis continues to locate additional functions that correlate, but CNVR2 and CNVR3 are trivial.) This correlation means that the linear combination of the sobriety test scores accounts for 33% of the total variation in the linear combination of the SPS scores.

The source of the relationship can be examined by means of the coefficients for computing the canonical variates:

.802 Tracking + .024 RT + .498 Errors,

and

.522 One-Leg Stand + .616 Walk and Turn + .035 Nystagmus.

The relationship is primarily between tracking (SPS) and balance and walking (Sobriety test battery). This finding is not surprising; since the impairment tests include no perceptual tasks, it is only with the psychomotor component of the driving test that a correlation can appear.

Table 9
Correlations: Impairment Tests Scores and SPS Data

	SPS Data		
	Tracking E^Z	Reaction Time	Errors
One-Leg Stand	.420	.150	.280
Walk and Turn	.436	.123	.316
Total Nystagmus	.314	.268	.137

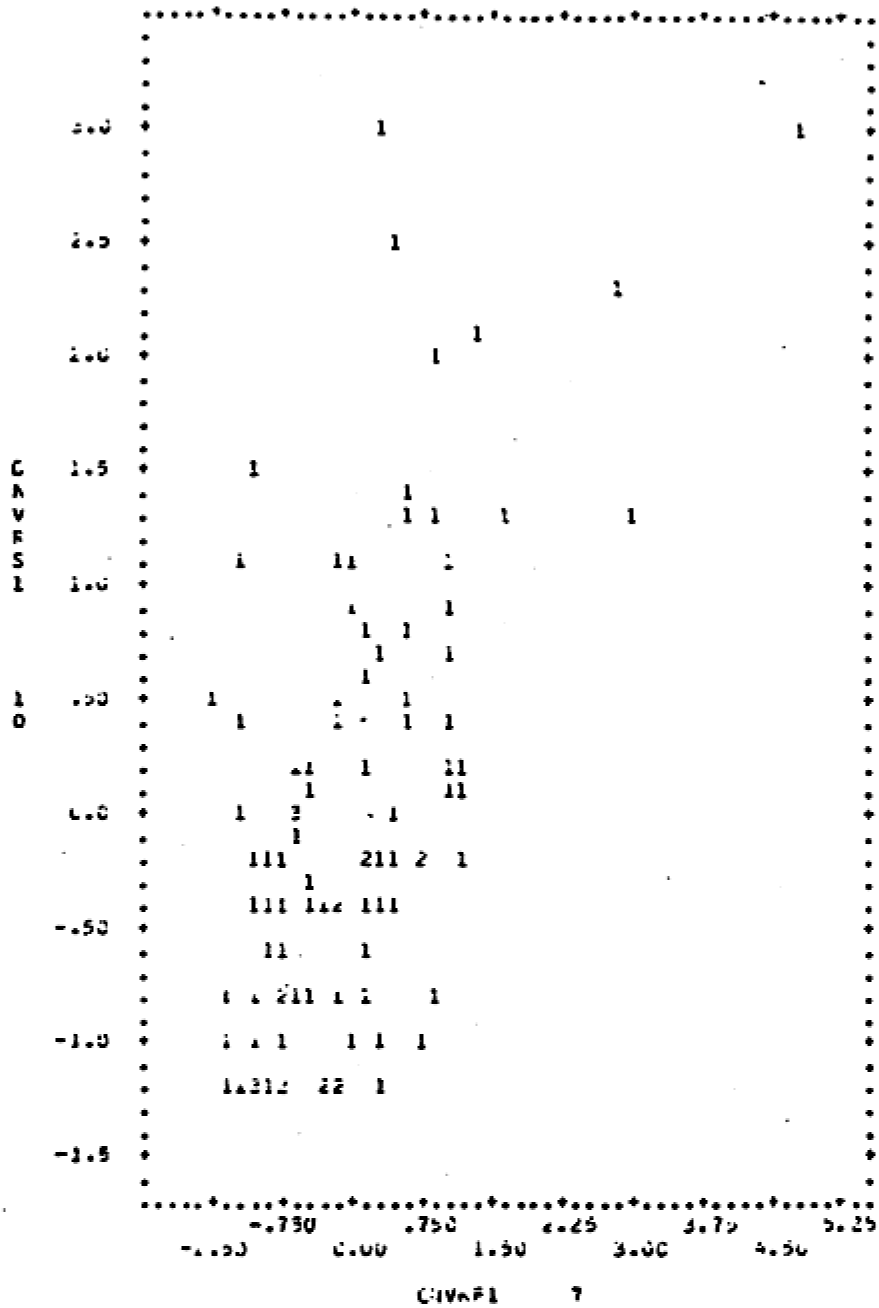

FIGURE 12: Computer Graph of Canonical Correlation (DWI Battery and Driving Test Scores)

In summary, for these participants there was a significant relationship between the driving task and the test battery. Further investigation of the divided attention task as utilized here with the SPS is suggested. It is possible that the task can be further adapted and simplified hardware developed so that it will have utility as a test of impairment to be used in the setting of the police station or a van.

V. SUMMARY AND CONCLUSIONS

The study objectives which were set forth in the work statement have been achieved as follows:

1. Evaluate currently used tests to determine their relationship to intoxication and driving impairment.

Examination of the sobriety test literature, and observations of tests of impairment as performed by police officers indicate that currently the same tests are used in most locales. Administration and evaluation procedures vary widely, but the tests usually include some version of walking the line, touching the finger to the nose, picking up small objects, and body sway or balance. All of these tests have been evaluated in the laboratory during this study.

2. Develop more sensitive tests to provide better evidence of impairment and to have a closer relationship to driving impairment.

A number of potential techniques, as derived from a diverse literature, have been examined. However, the conditions of roadside testing impose stringent constraints which few tests can meet. The measure of Alcohol Gaze Nystagmus (AGN) was found to be a highly sensitive index of impairment which presently is under-utilized. The identification of AGN as a sensitive test is a major contribution from this study.

3. Standardize the tests and observation procedures.

It became apparent during field visits that this objective is highly important. There are wide differences between officers in using tests to assess a driver's state of intoxication, and they may exist within a department as well as between agencies and locales. These differences seriously detract from reliability as well as from the credibility of the officers in court proceedings.

Insofar as possible within the limitations of this study, test administration and scoring have been standardized. Instructions for use of each test are presented in the test manual together with performance criteria for scoring on a 1-10 scale.

The choice of tests for a recommended battery is based on the study findings and additionally on the assumption that a DWI suspect will be examined at roadside where conditions vary widely and where no test hardware is likely to be available.

At the present time, roadside testing is practiced extensively, but there are other DWI systems in use, as well as potential systems, which merit consideration. Those which were observed during field visits include at one extreme some which use no behavioral tests. The driver is informally observed and interrogated at roadside, and if the officer believes the BAC to be higher than .10%, the DWI suspect is transported directly to the station for breath testing.

In one locale where observations were made, a Metro-DWI program is jointly sponsored by the city police and the sheriff's department. They utilize a camper mounted on a pickup truck to transport an Intoximeter (gas chromatograph) to any location within the jurisdiction where an alcohol-involved driver has been detained. Two such vehicles are on the street during night hours, one during the day, available for call by any patrol unit. The officer who drives the vehicle administers the breath test. If the BAC reading is found to be .10% or above, the driver then is arrested and transported by the officer who originally made the stop. No behavioral tests are administered.

Two cities were visited where tests of impairment are first given at roadside and then repeated at the station for purposes of videotaping. Some disadvantages with this system are apparent. It lengthens the procedures which in most cases already are viewed by the officers as too costly in terms of demands on their time. Also, the videotape which is intended to be used as court evidence is likely to show less impairment than was observed at roadside; time has elapsed and the BAC may have declined. The person has had a chance to pull himself together and also has in effect "practiced" the tests at roadside. Unless BAC is very high, the videotaped performance of sobriety tests may not reveal any impairment at all.

A highly effective DWI system was observed in Denver, Colorado, where the police department fields special DWI patrol units, two officers per car. In addition to their own DWI detection activities, these units are radio-summoned by regular patrol officers to handle alcohol-involved drivers. This is an important aspect of the system since it alleviates officers' reluctance to become involved with time-consuming DWI arrests at the expense of other activities, and thus significantly increases the level of surveillance.

It also is highly important in the Denver system that turnaround time (from detection through arrest and booking processes back to the street) has been reduced to a reasonable minimum. No testing is performed at roadside. The DWI suspect is transported immediately and the reading of rights and chemical-test consent or refusal are accomplished enroute. The behavioral tests are administered and videotaped in the station in a highly standardized format. The tapes which are obtained provide court evidence which is consistent in quality and content.

An additional feasible system might utilize a van or motorhome to go to the location where a DWI suspect is detained. Such a vehicle could accommodate (1) gas chromatograph, (2) videotape equipment, and (3) space and equipment for behavioral tests. In this case, as with testing at the station, there is the considerable advantage of having the same environment for every case and also the potential for using equipment which cannot be made available at roadside. For example, with some additional effort the divided-attention task which was presented during this study with the SCRI Stimulus Programming System probably could be adapted to become an important component of testing for alcohol impairment.

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APPENDIX 1
LITERATURE REVIEW

The literature of three general areas was searched: (1) alcohol effects, (2) alcohol and driving, and (3) sobriety tests and procedures. In addition, a diverse literature relating to various stressors other than alcohol was examined. Overall, the materials with a direct bearing on project objectives were found to be relatively sparse. The following review is limited to those which have specific relevance to test selection, or administration and scoring procedures.

Alcohol Effects:

There is, of course, a very large literature on the effects of alcohol on performance. It is reviewed here only to the extent that a direct contribution was made to this project.

Jellinek and McFarland (1940) produced a comprehensive review of behavioral changes under alcohol. Tests which emerge from the review as potential candidates for a sobriety test battery, falling within the constraints of time, environment, and apparatus, include the following: letter cancellation, 2-point tactile discrimination, color perception and grip strength. Jellinek and McFarland report experiments in which these measures were demonstrated to be alcohol sensitive.

The reviewers conclude that the experimental evidence indicates that simple psychological variables are less affected by alcohol than complex ones, that in any sensory modality discrimination is much more impaired than acuity, and that the main effect is cortical rather than peripheral.

Goldberg (1943) performed a series of laboratory studies to investigate the following:

- the effect of alcohol on sensory functions (fusion frequency of eye, corneal sensitivity)
- the effect of alcohol on motor functions (Romberg, finger-finger test)
- the effect of alcohol on psychological functions (subtraction and letter cancellation)
- the influence of food on alcohol tolerance
- the influence of habituation on alcohol tolerance

The entire test battery as utilized by Goldberg required 25-40 minutes, as well as considerable experimental apparatus. However, adaptations of the Romberg and finger-finger tests currently are widely used by police officers, both in the field and in the station, and the subtraction test and the cancellation test are tentative candidates for a sobriety test battery.

The conditions which Goldberg enumerates as necessary for the purpose of following the influence of alcohol on a function also are essential for DWI test purposes and merit repetition hers, as follows:

"1. The criteria of the alcohol effect as tested by the method should be constant, and should preferably leave no room for subjective judgment, if this factor cannot be ruled out, the method must permit of measuring its magnitude and bearing upon the results.

2. The variability of the method must be slight as compared to the changes which occur during alcohol ingestion.

3. If the test is to be applied for practical purposes, and no basal values are available, the variability between individuals should be slight as compared with the departures from normal due to alcohol.

4. The method must be 'sensitive' in order to react on slight degrees of intoxication. The word 'sensitive' can be interpreted in four different manners at least, as far as methods are concerned to reveal alcohol intoxication:

   a) A slight variability under normal conditions.

   b) Significant departures from normal at low alcohol concentrations, which correspond to a low appearance threshold.

   c) A steep slope of the line of regression between log symptoms and blood alcohol, indicating a regularly increasing degree of intoxication with slight changes in blood alcohol.

   d) A slight variability after alcohol intoxication in relation to the slope of the regression line, giving highly significant departures from normal already at low degrees of intoxication." (p.76)

In comments on the appropriateness of the methods is tests for intoxication, Goldberg interprets the data as showing test sensory functions were influenced at the lowest and psychological functions at the highest BAC. Motor functions (in particular, as measured by the Romberg) showed the largest departure from normal and are claimed to be useful even when a performance baseline is unknown since the alcohol effects greatly exceed between individual variation. The investigator also concludes that flicker frequency, corneal sensitivity and subtraction are not suitable absolute tests of intoxication.

Numerous studies have investigated acute alcohol tolerance, but findings have been confounded by procedural problems centering on measurement of BAC (Harger, 1963; Begg, Hill and Nickolls, 1963) and failure to control for practice effects (Eggleton, 1941; Alha, 1951). However, in experiments which controlled these variables, Hurst and Bagley (1972) and Moskowitz, Daily and Henderson (1974) found that acute tolerance does develop and that impairment is less at a given BAC on the falling than on the rising curve. Note that the impairment differential is quite small.

Colguhoun and Edwards (1975) report a study of the interaction of noise with alcohol on a task of sustained attention. They interpret the data as supporting the view that noise is an arouser and alcohol is a cortical depressant.

Alcohol Effects on Driving:

The extant literature specific to alcohol effects on driving skills has been comprehensively reviewed elsewhere (Carpenter, 1962; Wallgren and Barry, 1970; Moskowitz, 1973). These reviews, as well as recent reports of laboratory data, appear to be virtually unanimous in converging on an information processing model of driver impairment by alcohol. Moskowitz in his 1973 review concluded that "...drivers under the influence of alcohol have their information processing capacity reduced and thus must restrict some of their information inputs which might normally have been processed concurrently." (pp. 196-197).

Stressors Other Than Alcohol:

Methods which aid in the assessment of impaired functioning, whatever the source of the behavioral deficit, may have possible utility in a test battery. From this point of view a diverse literature was searched in an effort to locate either innovative techniques or more standard evaluative procedures which have not previously been utilized in alcohol enforcement.

Nathanson and Bergman (1958) reviewed medical procedures for evaluating patients with altered states of consciousness. They describe a face-hand test which potentially might be adapted for sobriety testing.

Parker, et al. (1963), performed a study for NASA to develop tests intended primarily for assessing the effects of weightlessness and other space environment characteristics on human performance. The project objectives were defined as the development of a small battery of tests to measure the primary dimensions of perceptual-motor performance. The following factors were selected as representing ability dimensions for which performance tests should be developed:

1. Fine manipulative abilities
    - arm-hand steadiness
    - wrist-finger speed
    - finger dexterity
    - manual dexterity
2. Gross positioning and movement abilities
    - position estimation
    - response orientation
    - control precision
    - speed of arm movement
    - multilimb coordination
    - position reproduction
3. System equalization abilities
    - movement analysis
    - movement prediction
    - rate control
    - acceleration control
4. Perceptual-cognitive abilities
    - perceptual speed
    - time sharing
5. Reaction time ability
6. Mirror tracing ability

An integrated instrument console was developed to present tests of these 18 perceptual-motor abilities. Administration time was approximately 90 minutes. Only preliminary data are reported, for which it is stated that subjects showed wide individual differences on all task skills. As demonstrated by these investigators, variability is a main source of difficulty for sobriety tests.

The effects of Librium, meprobamate, alcohol, and altitude were examined by Pearson and Neal (1970). The experimental tasks included a tracking and monitoring task, choice reaction time, auditory vigilance and the welford serial performance, problem-solving apparatus. In general, no decremental effect of alcohol and drugs on performance of these tasks occurred. The investigators attribute the negative findings to the mitigating factors of task load, feedback and subject set.

The utility of four psychomotor tests in diagnosing cerebral lesions was examined by Dee and Van Allen (1972). The tests were grip strength, tapping rate, simple auditory reaction time and simple visual reaction time. It was concluded that performance of these tests, when assessed quantitatively, might aid in the detection of cerebral disease. However, the actual utility would be contingent on determining performance base rates for brain-damaged and nonbrain-damaged as a function of sex and age.

Fregly, et al., (1972) standardized the procedures for testing a person's ability to walk on the floor with eyes closed (WOFEC). The test, which has been used as a qualitative clinical test of ataxia, is recommended as a subtest in a quantitative test battery. However, the investigators caution that its validity is dependent upon strict adherence to rigid, standardized test procedures.

These preceding three studies serve to illustrate the source of some difficulties with sobriety tests. Even for data collected within the controlled environments of laboratories, the investigators cite the influence on performance of the variables of subject set, sex, age, and rigid, standardized test procedures.

A study designed to vary attention demands presented brief tones at irregular intervals which were counted by subjects while they performed the Romberg test. Njcobiktjen (1973) designed the task to raise the general attention level and divert attention from standing. Healthy subjects tended to reduce postural sway under the loading of the auditory task. Neurological patients behaved differently according to the particular disorder. Subjects described as having “severe central processes“ were found to sway more when the two tasks were combined.

McFarland (1973) exposed subjects to low levels of carbon monoxide and then tested their ability to perform driving-related laboratory tasks, as well as on-the-road driving. The laboratory tests included: (1) complex psychomotor reactions including simultaneous performance of both a primary and secondary task, (2) dark adaptation and glare recovery, (3) peripheral vision, and (4) depth perception. All of the tasks require laboratory apparatus. The overall pattern of results indicated no serious impairment of driving abilities by carbon monoxide.

A standardized battery, of performance tests was developed by Theologus, et al., (1973) for use in assessing the effects of noise stress on human performance. A Perceptual-Motor Performance Console (PEMCON) was utilized to present three tasks: a reaction time task, a rate control task, and a divided-attention task (performance of the RT and rate control task simultaneously). The data on the effects of noise are complicated by the differences between patterned and randomly intermittent noise and by the time course of noise effects. It is pertinent here to note that the investigators stress the importance of standardizing procedures and conventions for administering and scoring tests.

Note that although these laboratory studies of performance are of general interest, they are not feasible for roadside use. Possibly instrumentation could be developed if a test battery were to be designed solely for use in a police station or van.

Sobriety Tests and Procedures:

A highly important study of sobriety tests was carried out in Finland. From the United States the DWI Law Enforcement Training Project materials, prepared under contract DOT-HS-334-3-645 (Carnahan, et al., 1974) present comprehensive and accurate information for training purposes. Driving Under the Influence of Alcohol or Drugs, as prepared by the Traffic Institute, Northwestern University has somewhat less merit. State and local agencies provide driver handbooks and materials for officers on DWI patrol which contain useful, general information about alcohol effects and the DWI suspect. However, the Finnish study is the most comprehensive and rigorous investigation.

Sobriety testing is of major importance in Finland where there is no statutory blood alcohol limit. Clinical examinations for intoxication are performed by physicians, and courts mete out sentences of considerable severity for driving while under the influence of alcohol. License suspension is usual and imprisonment is not uncommon. Understandably the examination procedures, including the psychophysical tests, have come under close scrutiny. Pentillä. Tenhu and Kataja (1971) have performed extensive analyses of data from the clinical examinations by physicians, and their reports represent the most systematic and thorough study of sobriety tests to be found in the literature.

In an initial study they analyzed the records from 6,839 clinical examinations for intoxication which were performed at the Department of Forensic Medicine, University of Helsinki during the years 1965-1969. The test battery included the following: walking tests, gait in turning, Romberg tests, finger to finger test, match test, speech and behavior, counting backwards, and orientation to time and place. They found significant correlations for all tests with blood alcohol level, but there was a substantial overdiagnosis of intoxication due principally to incorrect and unreliable performance of the tests at low blood alcohol content (BAC). The investigators recommend that procedures be improved by "...carefully defining what constitutes a state of intoxication on the basis of all the clinical tests and observations." (p. 40)

A second study by the same Finnish investigators (1974) utilized the data from 495 clinical examinations in an effort to configure an optimal test battery. The tests varied slightly from those previously listed, the most important change being the inclusion of three measures of nystagmus. The most pertinent conclusion is that a reliable test battery which correlates significantly with BAC can be developed and that it hinges largely on specification of exact test procedures, performance criteria, and quantified assessment methods.

The nystagmus measures were found to be the most valuable indices of intoxication with the other tests in decreasing order of value as follows: walking along a line, walking test with eyes closed, Romberg's test with eyes open, collecting small objects test, counting backwards test, orientations as to time, finger-finger test, and gait in turning. Tests which were based solely on the physicians' estimate of intoxication were found to be of no value.

The reported results with regard to nystagmus, the involuntary jerking movements of the eyes, are of particular interest as a potential measure for sobriety tests. There are several kinds of nystagmus: note that these investigators are reporting on Alcohol Gaze Nystagmus (AGN) and on nystagmus induced by rotation, described in the report as follows:

> "The subject was asked to fix his eyes on a small object 40 cm in front of his face and to follow the object with his eyes. The object was moved horizontally from one end of the sight field to the other one and backwards. The examiner fixed the head of the subject in normal position so that only the eyes were moving. The test was repeated three times.
>
> The subject was rotated horizontally on chair 5 times during ten seconds. After rotating the subject was asked to fix his eyes on the small object 40 cm in front of him. The time of oscillatory movements of the eyeballs (i.e., nystagmus) was taken with an accuracy of one second by using a stop watch." (p.53)

AGN appears as a jerking in the direction of gaze when the eyes are laterally deviated 30-40°. It increases in intensity with increasingly eccentric fixation of the eyes, and appears much more distinctly when fixation is monocular rather than binocular. It appears at a BAC as low as .06% and typically it is quite distinct at .10% BAC.

Aschan (1958) studied both positional alcohol nystagmus (PAN) and alcohol gaze nystagmus (AGN). The former requires nystagmographic recording and therefore cannot be readily adapted to the typical circumstances of sobriety testing. AGN can be observed easily without special instrumentation.

Aschan points out that ". . . AGN resembles other manifestations of alcohol intoxication related to a critical threshold value. . . from the fusion frequency of the eye, corneal reflexes, and a quantitative Romberg's test to disturbed visual attention. . . which have been studied by Goldberg (1943)."

Goldberg (1943) also reports on both PAN and AGN as studied in a series of experiments with a total of 260 subjects. He concluded that AGN is the one most easily observed, appearing when BAC exceeds 60-70mg/100ml and disappearing when BAC falls below that level. He suggests that nystagmus may have value for clinical examinations but requires study with persons with varying alcohol consumption practices.

There are a number of other studies of optokinetic nystagmus (Blomberg and Wassen, 1962; Honrubia et al., 1968; Mizoi et al. 1969), vestibular nystagmus (Schroeder, 1971, Schroeder et al., 1973; Oostervelo and van der Learse, 1969; Collins 1963), and positional nystagmus (Fregly, 1967; Oosterveld, 1970) These serve to elucidate the mechanisms of nystagmus and the role of such variables as alcohol, gravity, and acceleration. However, the time-and-equipment limits imposed by sobriety testing render measurements of these forms of nystagmus impractical for the purposes at hand.

APPENDIX 2
Field Visits to Observe
Police Officers Administering Sobriety Tests

Interviews and observations of law enforcement officers were undertaken as an initial project effort in order to assess current sobriety-testing practices. Field visits were made to eight locations, as detailed below, where the project director engaged police officers in informal interviews and rode with a patrol unit for one night-time work shift. Assessment objectives of these visits included the following:

<u>Interviews</u>:

Attitudes of officers toward alcohol enforcement.

Officers' knowledge of alcohol effects and DWI role in traffic accident statistics.

Officers' knowledge of psychophysical tests, procedures, and evaluation.

<u>Observations</u>:

Environmental conditions of interrogation and testing.

Tests (which tests, how administered, how scored, face validity, reliability).

Total DWI-arrest procedure (detect, apprehend, test, arrest, transport, book).

Total DWI system (specialized units, deployment of vehicles, roadside vs. station testing and video-taping, level of alcohol enforcement effort).

Influence on test administration of sex, age, ethnic group, and economic status.

The following were visited:

1. Los Angeles County Sheriff 's - ASAP Unit
   City of Industry, California
2. Seattle DWI Squad
   Seattle, Washington
3. California Highway Patrol
   West Los Angeles, California
4. Chicago Police Department
   Chicago, Illinois
5. Denver DWI Unit
   Denver, Colorado

6. Memphis Metro DWI Unit
   Memphis, Tennessee
7. Texas Highway Patrol
   Denton, Texas
8. Santa Monica City Police
   Santa Monica, California

The following tests have been observed in use:

Walk the line, heel-toe

One-Leg stand

Romberg

Finger-to-nose

Finger count

Tongue twisters

Recite alphabet

Pick up coins

Nystagmus

The level of alcohol enforcement varies between agencies and locales and ranges from an extremely low-priority effort to intensive attacks on the DWI problem by specialized units. In a typical system the detection and arrest of intoxicated drivers is the responsibility of regular patrol units, and the decision as to priorities rests within the division, possibly with a lieutenant or sergeant who must allocate available manpower.

There are also marked differences in the reliance on behavioral tests. In some areas no tests are administered either at roadside or in the station. The chemical test together with the officer's report (observation of vehicle, interrogation and observation of driver) suffice as court evidence. In one metropolitan area the gas chromatograph is taken to the scene of a vehicle stop or to an accident and the breath analysis determines whether there is alcohol involvement.

In other locations tests are used and behavioral test evidence is required by the courts, either as videotapes or from the officer's report and testimony, but the officers make an arbitrary, case-by-case selection of tests. Also, the same test may be administered with different instructions and procedures by different officers. Finally, there also are departments which require routine, standardized administration of an established battery to every DWI suspect.

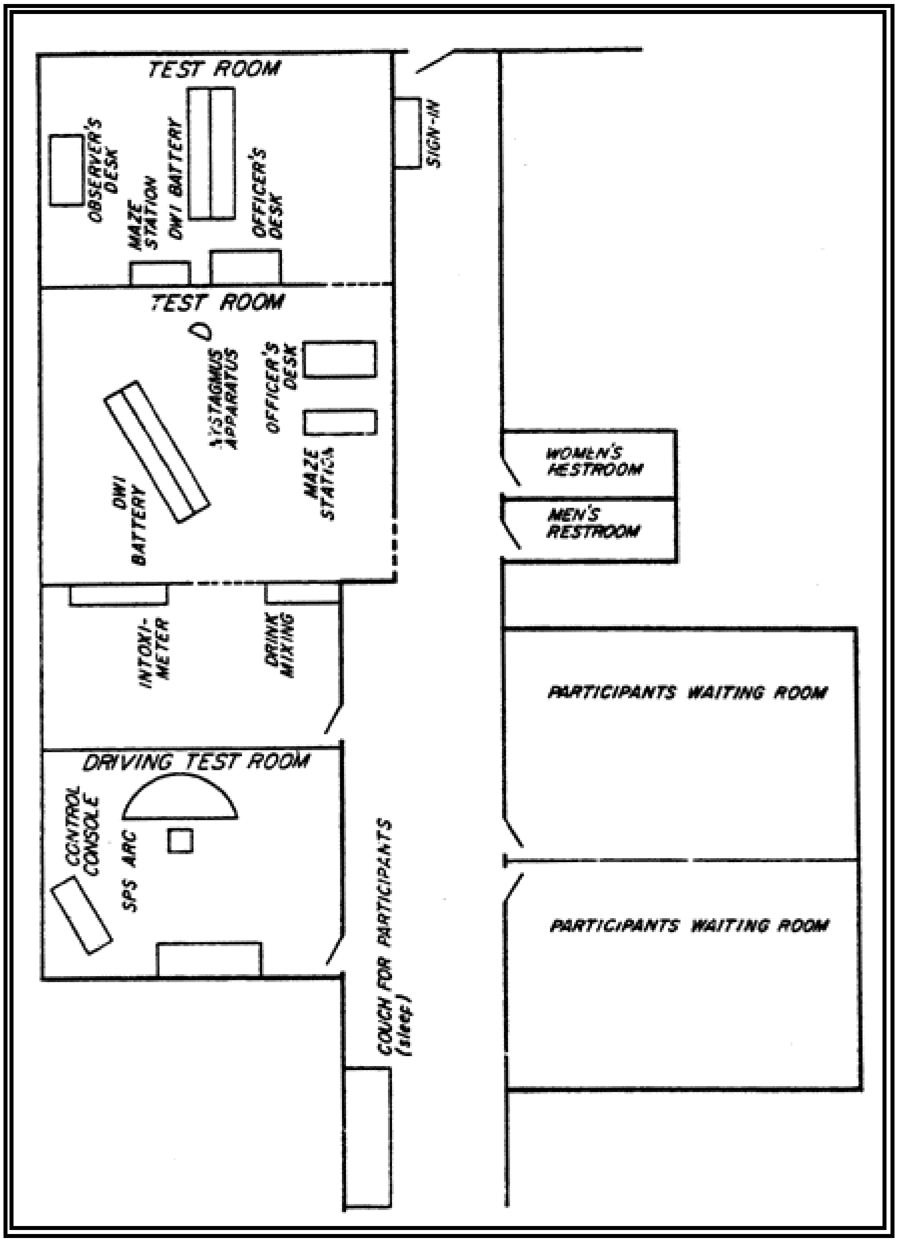
Videotapes are utilized effectively by departments where skilled officers rigidly adhere to standardized testing procedures. High quality tapes can be obtained at roadside, as well as in the station, and are considered a valuable adjunct to the officer's testimony in court proceedings.

Balance and walking tests are the most widely used tests of impairment. In addition, officers rely on cues of odor, speech and appearance as routinely noted during initial questioning. It also is common practice to inspect the subject's eyes for unusual dilation or redness.

APPENDIX 3
Criteria for Test Selection for Impairment Test Battery

1. Test results are quantifiable.
2. Test variance is small relative to the alcohol effect. Individual differences in performance are not expected to obscure alcohol effects.
3. Test is sensitive to alcohol effects at .05% BAC and higher.
4. Scores from the test battery correlate with BAC in the range .05-.30%
5. Test is short and easily administered.
6. Standardized administration and scoring methods can be learned readily by officers.
7. Tests to be administered at roadside require no hardware.
8. The test battery examines for a range of abilities, including alcohol impairment of motor, cognitive and divided attention skills, as well as involuntary responses.
9. Use of the roadside test battery will substantially improve officers' ability to evaluate an individual's level of impairment, as compared to evaluations which are not based on test results.
10. Test is expected to be credible and acceptable to DWI suspect, law enforcement personnel, and the judiciary.
11. Alternate test is available if individual cannot perform task due to some characteristic other than impairment by alcohol.

APPENDIX 4
LABORATORY LAYOUT



APPENDIX 5
Test Protocol and Score Sheet

Test Battery Instructions and Procedures

In order to obtain valid results from the DWI test battery, it is necessary to conduct the testing with standardized instructions and procedures. All persons tested must be given the same opportunity to understand how the test is to be performed.

Circumstances in the field or station will vary widely, but every effort should be made to adhere closely to the basic instructions as outlined in this manual. Exact wording is not mandatory, but deviations should be minimal.

Effective use of videotapes depends on camera placement and on test procedures which make poor performance clearly visible. The examiner's correct demonstration of the task will serve as a criterion performance for the viewer. Both video and audio should clearly emphasize the nature of errors which require a trial to be interrupted. The viewer may not have observed the failure, for example, to touch heel to toe or the improper use of arms for balance. Camera angle, lighting, and background contrast also can facilitate quality videotapes.

1. One-Leg Stand

Position person facing camera and examiner.

> Watch what I do but don't begin until I tell you. Stand with your feet together, arms at your side, and hold one leg straight and forward like this. (Demonstrate with foot held 8-12" off the floor.) Do you understand? Ready? Begin. Don't put your foot down until I tell you.

Trial length: 30 seconds.

Check: Feet together
Arms at side
Leg straight.

If position is incorrect, interrupt trial and repeat demonstration. Give second trial or discontinue.

2. <u>Finger-to-Nose</u>

Position person facing camera and examiner (back to wall stripes).

Watch what I do so you will be able to do the same thing. Don't begin until I tell you. Stand with your feet together and hold your arms out like this (demonstrate arms fully extended level with shoulders). I want you to close your eyes and when I say "Right," bring your right index finger to touch your nose, then return your arm. When I say "Left," touch your nose with your left index finger. (Demonstrate for right and left.) Do you understand? Ready?

Give a random sequence of five: e.g.,	R-L-L-R-L
	L-R-R-L-R

Check: Eyes closed

Arms fully extended

Arms at shoulder height

Nose touched only with index finger

Arms returned to position after each trial

Interrupt if there is significant deviation from the above. Repeat demonstration. Give second trial or discontinue.

3. <u>Finger Count</u>

Face me and watch carefully what I do, but don't begin until I tell you. I am going to touch my thumb and finger and count like this. (Demonstrate slowly and with slight exaggeration.) 1-2-3-4-5-5-4-3-2-1. Touchcount. Do you understand? O.K., you do it.

Check: Thumb-finger touched correctly

Correct count

Give repeat demonstration and second trial if first trial is incorrect.

4. Walk and Turn, Heel-Toe

The following instructions are for a test location where a line is marked on the floor. Under other circumstances adapt the same instructions. Line to be walked should be at slight angle to camera.

Again, watch what I do so you will be able to do it the same way. I want you to put one foot here on the line, and then take exactly 9 steps along the line, touching your heel to your toe each step (demonstrate). Then turn and take nine steps back along the line, touching heel-toe. Do you understand? Come here to the line and begin.

Check: Heel-toe position each step.

Trial should be interrupted if person fails to touch heel to toe. Also, if number of steps is incorrect, at end of trial ask person how many steps were taken each direction.

5. Tracing Mazes

Person to be tested should be seated at table. Place first maze on table and point appropriately while giving instructions.

Begin here with the pencil and trace between these lines. Try not to touch or cross the lines. Keep going around and around. Go as fast as you can, but don't pick up your pencil and try not to touch the lines. You have three pages to trace. Do you understand? Ready? Begin.

Trial length: 20 seconds each maze.

6. Nystagmus

The following instructions are for use with the SCRI nystagmus apparatus. If that equipment is not available, adapt the procedure using pencil or finger movement and estimating the visual angles. Observation of the characteristic jerking at a gaze more extreme than 45° should not be relied upon as an index of intoxication.

> Put your chin here in the chin rest. Cover your left eye and without turning your head, follow this light, using only your right eye. Don't move your head, and keep looking at the light.
> Now cover your right eye, and do the same thing.

Move the light slowly to 30°. Hold at that position to determine if eye is jerking. Move the light to 40° and take second observation.

Check: Head centered in chin rest

One eye covered

Continuous following with other eye

Alternate Test:

Romberg (Body Sway)

Position person to be tested at right angle to camera and examiner (in front of wall stripes, if available).

> Watch what I do so you can do the same thing. Watch me, and don't begin until I tell you. Stand with your feet together, arms at your side. Tilt your head back and close your eyes. (Demonstrate.)
> Do you understand? You are to stay in that position until I tell you to stop. Ready? Begin.

Trial length: 45 seconds.

Check: Feet together

Arms at side

Head tilted back

Eyes closed

If position is incorrect, interrupt trial and repeat administration. Give second trial or discontinue.

Alternate Test:

Subtraction

> I'm going to tell you a number. I want you to subtract 3 from it, then subtract 3 from that number, and keep going until I tell you to stop. For example, if I told you to start at 25, you would say 22, 19, 16, 13, etc.
> Do you understand?
> Start at 102 (or 101) and subtract 3. Keep going until I tell you to stop.

Trial length: Time to 60 (59).

If the subtraction task is too difficult for reasons other than intoxication, ask the person to count backwards. Adapt instructions for counting.

Alternate Test:

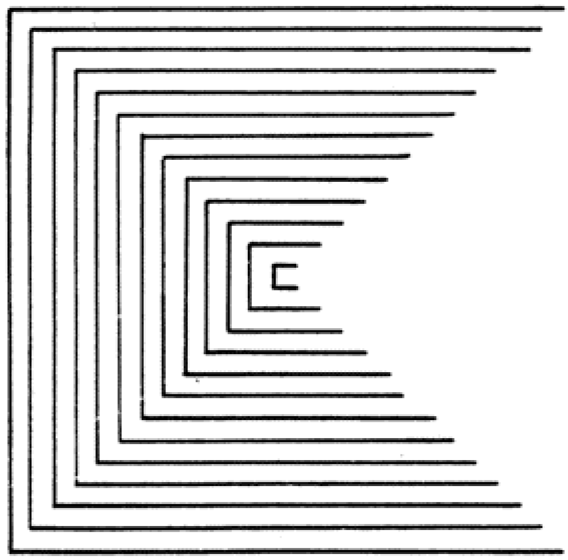
Letter Cancellation

Person to be tested should be seated at a table. Place the test page face down in front of the person.

> On this sheet of paper there are several paragraphs of printed material. When I tell you to begin, I want you to turn the page over and go through the material line by line, canceling every letter "E". (Demonstrate by marking on back side of page ~~e~~.) Go as fast as you can without skipping any "E' s".
> Do you understand?
> Ready? Turn the page over. Begin.

Trial length : 30 seconds.

TRACING TEST



<u>LETTER CANCELLATION TEST</u>

RECONSTRUCTION OF POST ACCIDENT FORE-BATTERY OF DRIVING RELATED VISION TESTS SCHOOL BUS SEAT BACK PADS: THE CALIHEAD INJURY EVALUATION: CRITERIA FOR

wearing of seat belts compulsory in the province. And, for larger distribution, related print messages driving a car. Some 696 motorcyclists have been

He pointed out that even Nova Scotia had decided mats with varying complexity and completeness are pulsory because of a lack of citizen support and a provide information through many channels—mass The argument I've heard most often is that if I were from the Throne that it was considering making the printed material and folders; a community action derstandable way what happens in a collision, as law. Why? Because too many people were against it,

"It started three years ago as a love affair with a ed by the Ministry, showing in a dramatic and unregistrations went from 34,000 to 50,000, the number "But, like governments in all other nine provinces, it columnists in most Ontario newspapers have convince the unconvinced that seat belts can and do do prevent injuries and do save lives," the Minister

SCORING RECORD

Participant # __________ Sex ____________ Officer _______________________________
Date of birth___/___/___ Date_____
Approx. weight_________

QUESTIONS

Without looking, what time is it now?_____________ Actual time_______________

Have you been drinking? ___________ Are you under the influence of alcohol now?______

When did you last eat? _____________ What did you eat at that time?_____________________

When did you last sleep? _____________________ How many hours? ___________

Do you have any physical defects? Yes ______ No______ If yes, describe:

Are you ill? Yes ____ No ____. Are you hurt? Yes _______ No _______. If yes, what is wrong? ____
Have you recently been to a doctor? Yes_____ No ____; a dentist? Yes ___ No ____
If yes, when? ____
Reason for seeing doctor or dentist____
Are you taking medicine? Yes ______ No __. If yes, what? _________________________
Last dose taken when? _________________ a.m.________ p.m._______

OBSERVATIONS

CLOTHES: Orderly ______ Mussed______ Soiled______ Disorderly___ Disarranged____

Describe____

BREATH (odor of alcoholic beverage): Strong _____ Moderate______ Faint______ None_______
ATTITUDE: Excited______ Hilarious______ Talkative______ Carefree______ Sleepy______
Combative______ Indifferent______ Insulting______ Cocky______ Cooperative___
Polite______ Other____
UNUSUAL ACTIONS: Hiccupping______ Belching______ Vomiting______ Fighting___
Profanity______ Other______________________________________
SPEECH: Incoherent______ Mumbled ______ Slurred______ Confused______ Thick tongued___
Stuttered ______ Accented ______ Good ______ Fair ______ Other ________
COLOR OF FACE: Normal ______ Flushed ______ Pale______ Other________
EYES: Normal ______ Watery ______ Bloodshot______
PUPILS : Normal ______ Dilated ______ Contracted ___ Slow reaction to light _______

1. One Leg Stand:

Preferred leg, 30 sec trial

No problem with balance	(0)	________
Slightly unsteady	(2)	________
Moderately unsteady	(4)	________
Extremely unsteady	(6)	________

Add <u>1 point for each</u> of the following, if applicable:

Required repeat of demo/instruc.	________
Put foot down	________
Use of arms to keep balance	________

Falling/no attempt/discontinued (10) ________ Total ________

Comments: ____

____

---

2. Finger-to-Nose (5 Trials):

On 2 or more trials, touching nose was:

Sure, accurate	(0)	________
Slow but accurate	(2)	________
Uncertain, fumbling, but touches	(5)	________

Add 1 - 2 points, as applicable:

Requires repeat instruction/demo.	________
Does not return arm to starting position.	________
Uses entire hand instead of finger	________

OR

Misses completely (10) ________

Total ________

Comments:____

____

3. Finger Count (1 trial each hand):

Check all applicable: (Maximum score =10)

No problem	(0)	_________
Required repeated instruction, demo.	(2)	_________
Confused, started over	(3)	_________
Did not correctly touch thumb - finger	(5)	_________
Counting errors	(5)	_________
OR		
No attempt/discontinued/failed	(10)	_________
	Total	_________

Comments:____

____

---

4. Walk-and-Turn, Heel-Toe (9 steps, return):

No problem	(0)	_______
Slow or minor problem	(1-4)	_______

OR

Check below to describe unsteadiness:

(1-2 points each. Max. score = 10).

Loses balance, walking	_________	
Loses balance, turning	_________	
Cannot stay on line	_________	
Extreme use of arms and/or body to maintain balance	_________	
Does not touch heel-toe	_________	
Incorrect no. of steps	_________	
Stops to steady self	_________	
Requires repeat of demo	_________	—OR—

4. Walk-and-Turn, Heel-Toe (9 steps, return): CONT

Falling/will not attempt/discontinues (10) ______

Total ______

Comments:____

____

---

5. Tracing (3 trials, 20 sec. each):

Score: 5 points each completed loop minus 1 point each cross-over or touching of line. Loop is scored if tracing is past top center.)

Points for Maze 1 _____ Points for Maze 2 _____ Points for Maze 3 ____ Total Points _____

(÷ 3 = average)———

Points	Average Earned Score
over 20	0
16 - 20	2
10 - 19	5
less than 10	10

Score ______

---

6. Nystagmus:

(Max. score = 10 each eye)		LEFT EYE 30°	LEFT EYE 40°	RIGHT EYE 30°	RIGHT EYE 40°
No jerking	(6)				
Minimal	(2)				
Moderate	(3)				
Distinct, easily observed	(5)				
		TOTAL_____		TOTAL______	

Alternate Tests:

Romberg:

Anterior/Posterior - 45 sec trial

No significant sway	(0)	________
Slight sway, brief	(1)	________
Slight sway (Several episodes or continuous	(2)	________
Moderate sway, brief (1 or more stripes	(3)	________
Moderate sway (Several episodes or continuous)	(4)	________
Extreme sway, brief (Several stripes)	(6)	________
Extreme sway (Several episodes or continuous)	(8)	________

Add 1 - 2 points for following (max. score = 10)

Does not tip head, very rigid, tense, opens eyes, uses arms for balance.

OR

Required support/would not attempt/discontinued (2)

Total ________

Comments: ____

____

Subtraction: (or substitute counting)

Record TIME to perform sequence.

Record # of errors (omissions, repeats, wrong answers)

102-99-96-93-90-87-84-81-78-75-72-69-66-63-60

or

101-98-95-92-89-86-93-80-77-74-71-68-65-62-59

TIME_______ Number of Errors_______

Counting:

(Use if subt. appears too difficult for reasons other than intoxication)

Record TIME and ERRORS.

102-101-100-99-98-97-96-95-94-93-92-91-90-89-88-87-86-85-84-83-82-81-80-79-78-77-76-75-74-73-72

TIME_______ Number of Errors_______

Comments (Subt. or Count.)____

____

Letter Cancellation: 30 secs.

Line #________ = ________ minus ________ omissions = ________

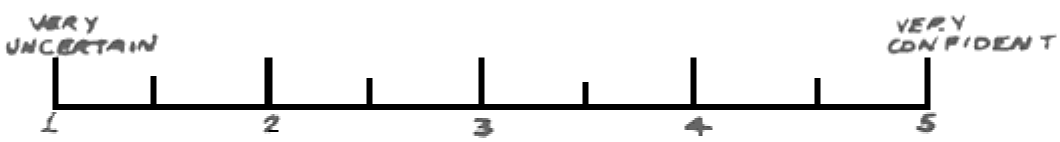
Comments ____

____

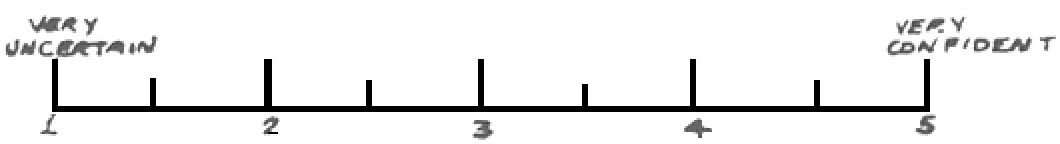
SUMMARY:	Test	Earned Score	Alternates
	1 - leg stand	________	Romberg________
	Finger-Nose	________	Subtraction________
	Finger-Count	________	Count backward________
	Walk-Turn	________	Letter cancel________
	Tracing	________	
	Nystagmus:		0 = No impairment 10 = Maximum impairment
	Left eye	________	
	Right eye	________	
	Earned total	________	Total possible = 70

Estimate of BAC:		
	________	0
	________	above 0, below .05%
	________	above .05, below .10%
	________	above .10, below .15%
	________	above .15, below .20%
	________	above .20%

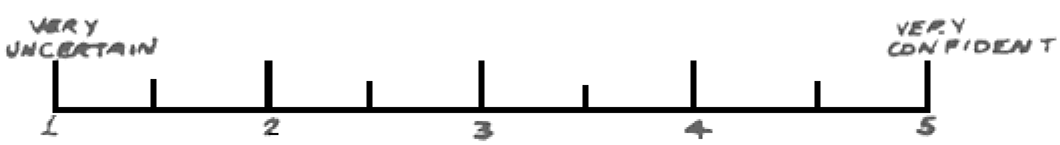
Mark on the scale below to indicate your confidence in your estimate of BAC.



Is this person impaired by alcohol?________Yes________ No.



Arrest?________Yes________no.



APPENDIX 6
False Alarms:
Arrest Decisions for Participants with BAC <.10%

Q-F-V Category	BAC	Nystagmus Score	Total Test Score
Heavy	.096	0	32
	.095	16	57
	.092	20	52
	.088	10	39
	.084	0	18
	.080	8	19
	.071	4	39
	.049	0	25
	.047	7	27
	.008	5	23
	.004	1	16
	.000	0	31
	.000	0	19
	.000	0	27
Moderate	.099	4	24
	.098	10	20
	.095	9	33
	.093	2	14
	.091	8	27
	.088	17	42
	.088	4	22
	.088	4	25
	.087	4	21
	.086	6	34
	.085	2	27
	.085	10	40
	.081	0	28
	.077	0	13
	.077	8	30
	.074	8	15
	.070	2	26
	.056	4	18
	.051	4	36
	.050	5	18
	.048	4	14
	.046	0	9
	.045	0	6

Light	.075	13	49
	.069	2	14
	.060	3	20
	.058	4	33
	.057	6	28
	.056	10	19
	.055	0	13
	.052	8	25
	.052	0	18
	.000	1	19

APPENDIX 7

Years of Service and DWI Arrest Experience of Officers Who Participated in Evaluation Study

Law Enforcement Agency	Officer's Yrs. of Service	Current Rate of DWI Arrests/Mo.	Total DWI Arrests
Santa Monica Police Dept. 2 Officers	2-1/2	10	110
	5	10	200
Calif. High-way Patrol 4 Officers	7	10	600
	2	10	180
	2-1/2	10	200
	10-1/2	10	400
Los Angeles Police Dept. 2 Officers	8	15	500
	3	0	150
Los Angeles County Sheriff 2 Deputies	7	30	2000+
	15	10	1000

APPENDIX 8

Summary of Stepwise Discriminant Analyses, BMDP7M

Classify participants as above/below .10% BAC

F to Enter/Remove	Variables Entered	Classification Matrix			% Correct	Classification Variables	Canonical Correlation
1.0	All test scores (without total score)		Below	Above		Total Nystagmus Tracing Walk-Turn Finger Count Nystagmus, Left Eye One-Leg Stand (Walk-Turn Removed)	.62978
		Below	156	17	90.2		
		Above	19	43	69.4		
			175	60	84.7		
2.0	All test scores (without total score)		Below	Above		Total Nystagmus Tracing Walk-Turn	.62278
		Below	152	21	87.9		
		Above	20	42	67.7		
			172	63	82.6		
2.0	Single tests: One-Leg Stand		Below	Above		One-Leg Stand	.39932
		Below	133	34	79.6		
		Above	22	40	64.5		
			155	74	75.5		
	Finger-Nose		Below	Above		Finger-Nose	.34414
		Below	127	41	75.6		
		Above	27	35	56.5		
			154	76	70.4		

F to Enter/Remove	Variables Entered	Classification Matrix			% Correct	Classification Variables	Canonical Correlation
(2.0)	Finger		Below	Above		Finger Count	.25049
	Count	Below	119	49	70.8		
		Above	27	36	57.1		
			146	85	67.1		
	Walk-Turn		Below	Above		Walk-Turn	.44165
		Below	135	32	80.8		
		Above	25	37	59.7		
			160	69	75.1		
	Tracing		Below	Above		Tracing	.40988
		Below	141	26	84.4		
		Above	28	35	55.6		
			169	61	76.5		
	Nystagmus-Left		Below	Above		Nystagmus-Left	.57470
		Below	151	17	89.9		
		Above	29	34	54.0		
			180	51	80.1		
	Nystagmus-Right		Below	Above		Nystagmus-Right	.59986
		Below	147	21	87.5		
		Above	19	44	69.8		
			166	65	82.7		

F to Enter/Remove	Variables Entered	Classification Matrix			% Correct	Classification Variables	Canonical Correlation
(2.0)	Nystagmus-Total		Below	Above		Nystagmus-Total	.60618
		Below	146	22	86.9		
		Above	20	43	68.3		
			166	65	81.8		
2.0	Test Subsets:		Below	Above		Total Nystagmus Tracing One-Leg Stand	.62232
	-One-Leg Stand	Below	153	20	88.4		
	-Finger-Nose	Above	21	41	66.1		
	-Tracing		174	61	82.6		
	-Total Nystagmus						
	-Finger-Nose		Below	Above		Total Nystagmus Tracing Walk-Turn	.62278
	-Tracing	Below	152	21	87.9		
	-Total Nystagmus	Above	20	42	67.7		
	-Walk-Turn		172	63	82.6		
	-Tracing		Below	Above		Total Nystagmus Tracing Walk-Turn	.62278
	-Total Nystagmus	Below	152	21	87.9		
	-Walk-Turn	Above	20	42	67.7		
	-Finger Count		172	63	82.6		

F to Enter/Remove	Variables Entered	Classification Matrix			% Correct	Classification Variables	Canonical Correlation
(2.0)	-Tracing		Below	Above		Total Nystagmus Tracing One-Leg Stand	.62232
	-Total Nystagmus	Below	153	20	88.4		
	-Finger Count	Above	21	41	66.1		
	-One-Leg Stand		174	61	82.6		
	-Tracing		Below	Above		Walk-Turn Tracing One-Leg Stand	.50848
	-Finger Count	Below	138	35	79.8		
	-One-Leg Stand	Above	19	43	69.4		
	-Finger-Nose		157	78	77.0		
	-Walk-Turn						
	-Walk-Turn		Below	Above		Total Score Tracing Walk-Turn	.50559
	-Finger-Nose	Below	140	33	80.9		
	-Finger Count	Above	19	43	69.4		
	-Tracing		159	76	77.9		
	-One-Leg Stand						
	-5-Score Total						
	-Walk-Turn		Below	Above		Total Nystagmus Total Score	.62394
	-Finger Count	Below	153	20	88.4		
	-Tracing	Above	20	42	67.7		
	-Total Nystagmus		173	62	83.0		
	-4-Score Total						

F to Enter/Remove	Variables Entered	Classification Matrix			% Correct	Classification Variables	Canonical Correlation
(2.0)	-Finger Count		Below	Above		Total Nystagmus Total Score	.62325
	-Tracing	Below	154	19	89.0		
	-Total Nystagmus	Above	18	44	71.0		
	-One-Leg Stand		172	63	84.3		
	-4-Score Total						
	-Tracing		Below	Above		Total Nystagmus Total Score	.61903
	-Total Nystagmus	Below	152	21	87.9		
	-Finger-Nose	Above	17	45	72.6		
	-Walk-Turn		169	66	83.8		
	-4-Score Total						
	-Tracing		Below	Above		Total Score Total Nystagmus	.61877
	-Total Nystagmus	Below	151	22	87.3		
	-Finger-Nose	Above	19	43	69.4		
	-One-Leg Stand		170	65	82.6		
	-4-Score Total						
	-One-Leg Stand		Below	Above		Total Nystagmus Total Score	.61722
	-Walk-Turn	Below	152	22	87.4		
	-Nystagmus	Above	18	44	71.0		
	-3-Score Total		170	66	83.0		

F to Enter/Remove	Variables Entered	Classification Matrix			% Correct	Classification Variables	Canonical Correlation
(2.0)	-Walk-Turn		Below	Above		Total Score Total Nystagmus	.61340
	-Total Nystagmus	Below	152	22	87.4		
	-2-Score	Above	17	45	72.6		
	Total		169	67	83.5		
	-One-Leg Stand		Below	Above		Total Score Total Nystagmus	.61236
	-Total Nystagmus	Below	152	22	87.4		
	-2-Score	Above	22	40	64.5		
	Total		174	62	81.4		
	Total Score (only) of:		Below	Above		Total Score	.60535
	-One-Leg Stand	Below	146	21	87.4		
	-Walk-Turn	Above	17	45	72.6		
	-Total Nystagmus		163	66	83.4		

Note N ≠ 238 because computer program excludes cases with extreme or missing values.

APPENDIX 9

STIMULUS PROGRAMMING SYSTEM (SPS)

System Description

The SPS is a versatile system for studying human control and information processing functions. It consists of four major subsystems:

(1) A control unit, including a punched paper tape reader and printer,

(2) A display unit,

(3) Subject response controls, and

(4) A tracking task generator.

The control unit is the heart of the system. It contains a microprocessor which is programmed to read experimental sequence instructions from a paper tape, execute the instructions, record response data, and print output data such as trial number, response accuracy, and response time.

The display unit presently contains three display systems:

(1) A tracking display located in the subject's central field of vision,

(2) Forty peripheral lamps located at the subject's eye level, and spaced every 5° from 15° to 100° visual angle, right and left, and

(3) Forty single-light numerical readouts which can be located in various arrangements in the visual field, typically 10 in each of four quadrants.

The response controls include:

(1) A tracking control lever which can either be a force stick or a displacement stick,

(2) A four-way switch to indicate the quadrant in which a target digit appears, and/or

(3) A push-button switch which can be used to indicate the occurrence of a target digit or a peripheral lamp signal.

The tracking task generator allows selection of a variety of tracking task configurations, including a choice of:

(1) Pursuit or compensatory tracking display,

(2) Position or rate control,

(3) Forcing function bandwidth, and

(4) Forcing function and display gains.

Two types of scores are displayed on digital readouts: (1) absolute error, and (2) absolute error squared. The tracking generator can be manually operated as a completely separate unit or can be controlled via the SPS control unit from punched tape commands. In the latter case, tracking error scores are also printed on the printer in addition to the discrete response data.

The experimental sequence instructions, which are punched in the paper tape, allow extremely flexible control over stimulus presentation. Typical applications of this system are described below.

Applications

The primary application of this system is to the study of division of attention, as related to task and stress variables. Task variables include central and peripheral task difficulty levels and the type of central and peripheral tasks (e.g., pursuit versus compensatory tracking; peripheral signal detection versus visual search and recognition).

A typical experimental configuration is the combination of a tracking task with a search and recognition task. While tracking, the subject must search a field of digits for a target digit. The digit field changes intermittently, i.e., one or more digits may change every few seconds. A target digit is presented at given intervals within the changing background field - the subject must search for and recognize the target digit and respond with the four-way switch to indicate the quadrant in which the target digit occurred. During the test session, cumulative tracking error scores are printed out at regular intervals and the time and accuracy of all responses, including false alarms and incorrect responses, are also printed out along with identification data.

Each type of task can be presented separately as well as in combination with the others to examine the effects of task loading and configuration on performance. If desired, the tracking task generator allows recording of appropriate analog signals for spectral analysis and human operator studies of control performance. Finally, facilities are available for incorporating eye movement recording into the system, permitting study of the relationships among visual search behavior, division of attention task loading, and task complexity.

Applications to Driver Performance Studies

The driving task consists of several components, including visual search, visual signal detection and recognition, manual control and information processing. A critical aspect of the overall driving task is the integration of each component task into a well-organized sequence of actions in which an appropriate level of attention is directed toward each component.

As indicated previously, the SPS system allows component tasks important for driving (e.g., control, visual search, detection, recognition, information processing) to be studied separately or in combination. Thus, the driving situation can be abstracted and performance can be examined under well-controlled conditions. Relative difficulty levels of component tasks can be varied, and the differential effects of stress or other independent variables on specific aspects of driving performance can be studied.

Summary of Data for
Stimulus Programming System (SPS) Participants

	BAC Group		All SPS Participants
	≤.10%	≥ .10%	
	n=71	n=26	N=97
	45 men	19 men	64 men
	26 women	7 women	33 women
Mean Age (years)	26.82	27.54	27.00
Mean BAC	.033%	.123%	.057%
Q-F-V Classification:			
Light	29	0	30
Moderate	30	10	40
Heavy	12	16	27
Mean Scores:			
SPS			
Track E^2	73.75	81.78	75.90
RT (secs.)	7.02	8.65	7.45
Response Errors	4.55	8.65	5.65
∑z (Tracing, RT, Errors)	-0.43	1.15	-0.11
Sobriety Test Battery			
One-Leg Stand	2.31	3.48	2.61
Finger-to-Nose	2.51	3.87	2.86
Finger Count	2.58	4.69	3.14
Walk & Turn	2.58	4.96	3.23
Tracing	3.23	5.08	3.79
Nystagmus - Left	.94	4.58	1.92
- Right	.77	4.12	1.67
- Total	1.71	8.70	3.59
Total Score:	14.92	30.78	19.22

ADDENDUM
COMPARISONS OF MALE AND FEMALE PARTICIPANTS: DRINKING PRACTICES, BAC, AND TEST SCORES

Questions of gender-related differences are important to interpretations of the evaluation study findings and to potential use of the recommended sobriety test battery. It seems to be rather widely believed that, compared to men, women are (1) poorer drivers, (2) more susceptible to alcohol effects, (3) less likely to be arrested by the police, and (4) more difficult to deal with when under the influence of alcohol. Whether or not any of these beliefs is based in fact, some police officers report being reluctant to confront the intoxicated woman, who has a reputation for being uncooperative, belligerent, and tearful. This reluctance could create a bias in arrest rates, as could impairment assessment problems associated with sex-related differences in drinking-and-driving habits and alcohol-related impairment of driving skills.

In recruiting participants for the evaluation study, the variables of foremost interest were drinking practices and history, and it was not feasible to additionally specify exact numbers of men and women. Consequently the actual gender distribution simply reflects the male: female ratio of applicants. The total of 238 participants was comprised of 168 (71%) men and 70 (29%) women. Thus, in comparison to roadside survey data (Wolfe, 1974) which show 84% men and 16% women, or to the Borkenstein accident data (1964) with 78% men and 22% women, there is an over-representation of women. However, note that the two cited studies sampled night-time drivers primarily, and thus are not representative of the total driving population.

As will be discussed in detail in the following pages, the evaluation study data do not reveal any significant or important differences as a function of gender. However, it is necessary to add the qualifying statement that there are characteristics of these data which render findings in this particular area somewhat equivocal. Specifically, there were important differences, as can be seen in the following tables (Table A-1 and Table A-2) and figures (Figure A-1), between male and female participants in drinking practices and therefore in alcohol treatment level and BAC.

For example, almost half the men were heavy drinkers. In contrast, only 13% of the women were in the heavy-drinker category. These differences, which complicate the male-female comparisons, can be compared to drinking-category distributions in the general population. Cahalan et al. (1969) reported data from a nation-wide study of drinking practices. If those data are truncated, excluding abstainers and infrequent drinkers, as was the case

TABLE A-1
CLASSIFICATIONS OF PARTICIPANTS BY
DRINKING CATEGORY

	Q-F-V Category	Number of Participants	Percent of Participants
Men	Light	33	20
	Moderate	54	32
	Heavy	81	48
Total:		168	100
Women	Light	29	41
	Moderate	32	46
	Heavy	9	13
Total:		70	100

TABLE A-2
BAC DISTRIBUTIONS, BY GENDER

	Number		% of Gender Group		Proportion by Gender of each BAC Level	
BAC	Men	Women	Men	Women	Men	Women
0	55	23	33	33	71	29
0><.05%	11	10	6.5	14	52	48
.05%≥<.10%	49	27	29	39	64	36
.10%≥<.15%	37	10	22	14	79	21
.15%≥<.20%	16	--	9.5	-	100	-
	168	70				
	(71%)	(29%)				

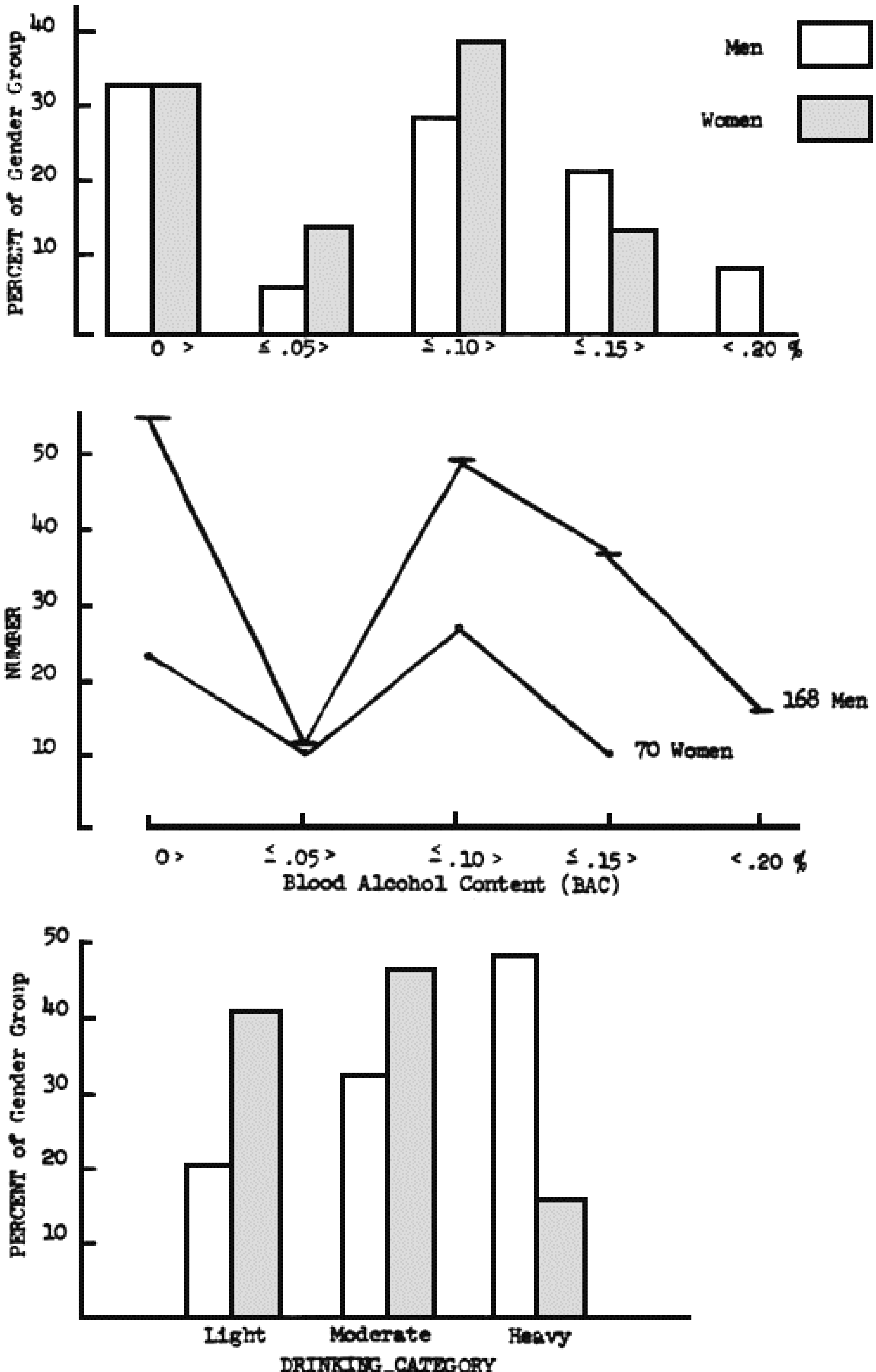


FIGURE A-1: Drinking Category and BAC Distributions with the evaluation study, and combining light and moderate drinkers as in the national data, the two samples can be compared. It can be seen in Table A-3 that classifications of the women in the two samples are remarkably similar, but there are substantial differences for the men. The evaluation study participants included a higher proportion of heavy drinkers than were reported by Cahalan et al.

Table A-4 presents a summary of correlation coefficients for test scores correlated with BACs. All r values are significant at the .01 level (with the exception of Finger Count Test, Women). Although the coefficients are higher for the men's data than for the women's, the differences are not statistically significant. Since the size of a correlation coefficient is directly related to the range of the correlated measures, the higher r for men in this case can be largely attributed to a wider range of both BAC and test scores (men: BAC 0 - .19%, scores 0 - 64; women: BAC 0 - .15%, scores 0 - 49). The correlations do not provide any evidence of differential scoring by the officers.

Of considerably more interest are the scatter plots of Figure A-2 and Figure A-3. Linear regression analyses, as detailed in Table A-5, locate the total-test-criterion scores (for prediction of above or below .10% BAC) at 28 for the men and 29 for the women. Using these criterion scores 81% of the women are correctly classified and 84% of the men are correctly classified. As can be seen in Table A-6 the officers' arrest/don't arrest decisions were considerably less accurate, but they demonstrated no important gender-related biases in the laboratory setting.

It is concluded that in the context of the evaluation study the tests served equally well for men and women, and the officers appear to have followed the same procedures and criteria for both. However, field study is needed to determine whether real-world circumstances would alter these findings with regard to differences by sex.

TABLE A-3
DRINKING CLASSIFICATION COMPARISONS:
EVALUATION STUDY AND NATIONWIDE
DRINKING PRACTICES STUDY

	Evaluation Study		Cahalan et al. (1969)	
	% of Men	% of Women	% of Men	% of Women
Light + Moderate	52	87	69	88
Heavy	48	13	31	12

TABLE A-4
CORRELATIONS: TEST SCORES - BAC

	Women n=70	Men n=168
One-Leg Stand,*	.469	.483
Finger-to-Nose	.419	.511
Finger Count	.190	.334
Walk-and-Turn*	.418	.590
Tracing	.393	.450
Alcohol Gaze Nystagmus*		
Left Eye	.549	.666
Right Eye	.507	.684
Both Eyes	.542	.698
Total Test Score	.618	.719

*Recommended Test Battery

All values of r sig. at .01 level with exception of non-sig. r for Women - Finger Count.

TABLE A-5
LINEAR REGRESSION ANALYSIS

Equation: $y = a_1x + a_0$

Women		Men	
$a_0 = 8.70$		$a_0 = 8.87$	
$a_1 = 201.06$		$a_1 = 189.55$	
BAC	Score	BAC	Score
.025	13.73	.025	13.61
.05	18.75	.05	18.35
.075	23.78	.075	23.09
.10	28.81	.10	27.83
.15	38.86	.15	37.30
.20	48.91	.20	46.78

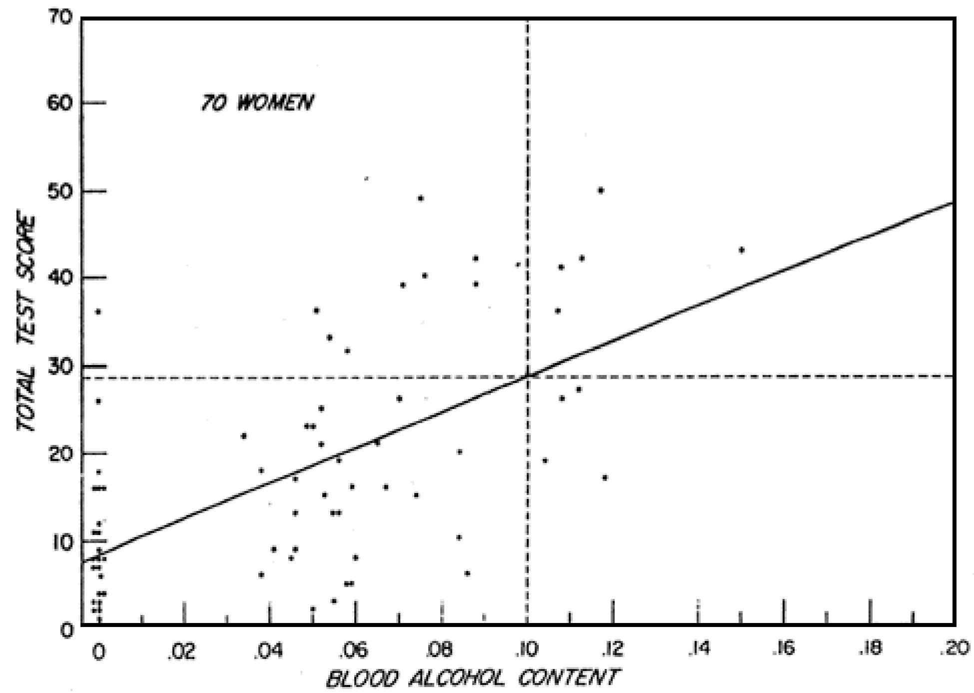


FIGURE A-2: Scatter Plot of Total Test Score/BAC for 70 Women

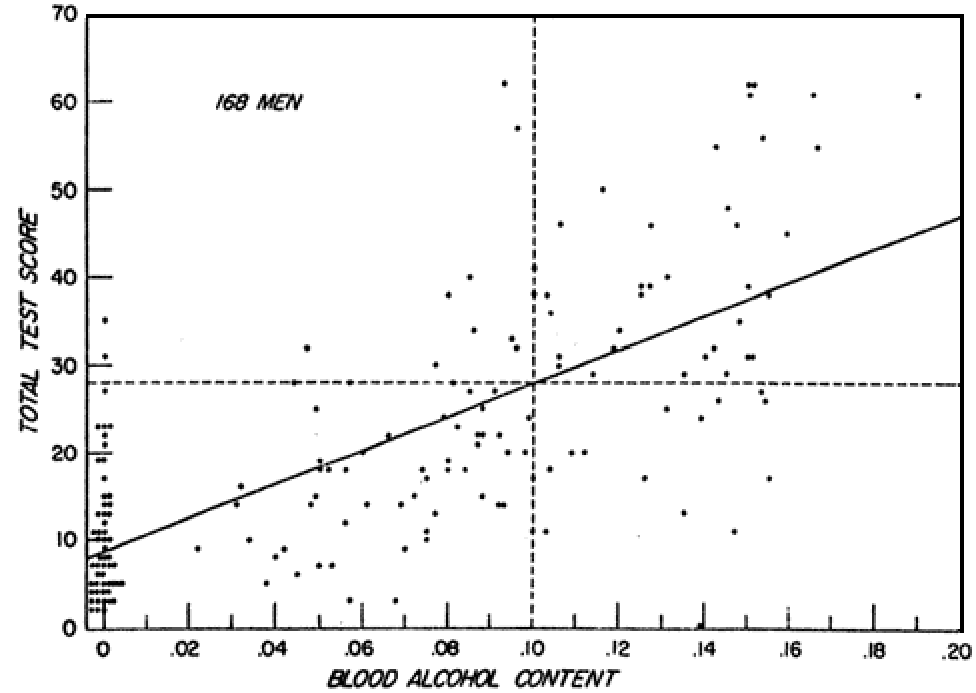


FIGURE A-3: Scatter Plot of Total Test Score/BAC for 168 Men

TABLE A-6
PERCENT CORRECT ARREST DECISIONS
BY MEN AND WOMEN

		%	
		Women	Men
Officers' Decisions:	Correct	77	76
	Incorrect	23	24
By Criterion Score:	Correct	81	84
	Incorrect	19	16

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