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EXPERIMENTAL EVALUATION OF  
SECOND-GENERATION ALCOHOL SAFETY-INTERLOCK  
SYSTEMS

John F. Oates, Jr.



INTERIM REPORT

1978

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Prepared for  
DEPARTMENT OF TRANSPORTATION  
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION  
Research Institute  
Washington DC 20590

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DEPARTMENT OF TRANSPORTATION  
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION  
TRANSPORTATION SYSTEMS CENTER  
KENDALL SQUARE, CAMBRIDGE, MA 02142

6 December 1978

REPLY TO ATTENTION OF: 532

M. M. Levy  
NHTSA  
TRPT  
NRD-40  
Washington, DC 20590

Dear Dr. Levy,

The four items enclosed cover the training data for the period during which TSC evaluated the CTT from its introduction through 1975 (Dunlap's second phase). The first enclosure contains training data for the CTT and three other devices for non-drinking TSC staff members taken during February 1973. The second contains training data for the CTT for non-drinking Dunlap staff members, for trainee subjects at Dunlap, and drinking data on the CTT for Dunlap subjects taken during February and March of 1973. The third is a technical memorandum which presents, analyzes, and interprets both training and drinking data on the CTT and three other devices for Dunlap subjects from mid-1972 to mid-1973, the same period covered by the two previous items. The fourth is a copy of a draft final report by Dunlap presenting training and drinking data on the CTT and other devices of 24 drinking subjects from July through November 1975.



DEPARTMENT OF TRANSPORTATION  
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION  
TRANSPORTATION SYSTEMS CENTER  
KENDALL SQUARE, CAMBRIDGE, MA 02142

REPLY TO ATTENTION OF:

I enjoyed talking with you; feel free to call again  
if you have further questions.

Sincerely,

*Charles N. Abernethy*

Charles N. Abernethy, PhD

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16. Abstract  This report documents the results of laboratory testing of four "second-generation" alcohol safety-interlock systems. As a group, these systems were found to produce appreciable discrimination between sober and intoxicated subjects.			
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- Mr. Jack Arakelian of JWM, Inc., who assisted in the preparation for testing of the Complex Coordinator ASIS manufactured by his firm.
- Mr. Lyle Hill of Raytheon Company, who provided valuable technical information concerning the Reaction Analyzer ASIS which he has developed.
- Drs. Edward Rem, Howard Zusman, William Johnson, Harold Dolberg, and G. A. Saviano of the Emergency Department, Norwalk Hospital, who provided medical supervision throughout testing.

Finally, most sincere thanks are due to the sixteen individuals who served as program Subjects. Clearly, this work could not have been accomplished without their cooperation.

## SUMMARY

This interim report describes the experimental program conducted by Dunlap and Associates, Inc. to investigate four candidate Alcohol Safety Interlock Systems. The program consisted of 64 Subject-days of experimentation designed to provide estimates of the performance of each device at blood alcohol concentrations up to and exceeding 0.18% wt./vol.

The contents of the report may be summarized as follows:

- . A definition of interlock performance is presented. This is tied to the proportion of drivers that a device would reject (i. e. , prevent from driving) at various blood alcohol concentrations. Specific experimental objectives are derived from the overall goal of determining performance across a wide range of concentrations.
- . Experimental procedures employed to satisfy the objectives are described in detail. These relate primarily to the selection, training, and testing of the 16 program Subjects, and to the conduct of analyses of test data.
- . Detailed descriptions of each of the four interlocks are presented. Specific training and testing procedures applied to each are stated. Equipment problems encountered are noted.
- . Tabulations of performance as a function of blood alcohol concentration are presented for each device. Results are given in a manner permitting comparison of alternate pass/fail criteria, various implementation strategies, and different categories of Subjects.
- . Conclusions are reached concerning the suitability of these instruments for future applications. Recommendations for additional investigations are also listed.

## 1. Introduction

### 1.1 Background and Purpose of Study

An Alcohol Safety Interlock System (ASIS) is a device designed for installation in an automobile to automatically determine if the driver is intoxicated and to prevent operation of the vehicle when intoxication is detected. This interim report, submitted to the U.S. Department of Transportation, Transportation Systems Center (TSC) under Contract DOT-TSC-251, presents the results of laboratory tests of four prototype ASIS units conducted by Dunlap and Associates, Inc. during February-March 1973. This study was an extension of previous tests\* on devices designed to detect alcohol-induced changes in coordinator, judgment, reaction time, and/or other psychomotor faculties. Like its predecessor, the present program was designed to test the ability of each candidate ASIS to detect alcohol impairment among volunteer Subjects, and thereby assess the instrument's merits as a drinking-driving countermeasure. However, the "second-generation" ASIS units tested during this study were designed to be more alcohol-specific than those evaluated in the previous program.

The prototype ASIS units examined in the present program were:

- . Critical Tracking Tester (CTT) - General Motors Corporation
- . Modified Reaction Analyzer (RA) - Raytheon Company
- . Complex Coordinator (CC) - JWM, Inc.
- . A Divided Attention Test (DA) - DOT-TSC

Detailed descriptions of the four devices, together with their respective tasks and pass/fail criteria, and the test results obtained from each are presented in succeeding sections of this report.

### 1.2 Approach and Methodology

The basic goal of the program was to measure the performance of the selected instruments across a wide range of blood alcohol concentration (BAC), with particular emphasis on relatively high levels ( $\geq 0.15\%$  wt./vol.). As defined in a previous report \*\* ASIS performance is the functional relationship

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\* Oates, J. F., Jr., and McCay, R. T. Experimental Evaluation of Selected Alcohol Safety Interlock Systems. Report No. DOT-TSC-251-4, August 1972.

\*\* Oates, J. F., Jr., and McCay, R. T. Methodologies for Estimating the Effectiveness of Alcohol Safety Interlock Systems. Report No. DOT-TSC-251-3, November 1971.

the device exhibits between BAC and rejection (or "fail") rate. Performance data in high BAC ranges are especially critical since some sources\* indicate that the median BAC of motorists arrested for driving while intoxicated-- a likely target population for ASIS application--exceeds 0.20% wt./vol. However, assessment of performance at very low BAC is also essential, since it indicates the extent to which the ASIS might unduly inconvenience a sober driver.

Within the context of this overall goal, the following specific objectives were pursued:

1. The selection of a sample of experimental Subjects, each of whom could be expected to attain elevated levels of BAC;
2. The examination of a variety of potential implementation strategies against each of which performance could be measured. One such strategy, for example, might require the driver to pass at least two of a series of three trials in order to start his vehicle.
3. The assessment of factors other than alcohol that might affect test results. These might include such items as Subject age or gender, fatigue, and continuation of learning effects during testing sessions.
4. The provision of sufficient pre-test training on all devices to each Subject, to insure that adequate familiarity with the instruments had been achieved.
5. The design and implementation of carefully controlled test sessions with specific provisions for:
  - . The administration of precise doses of ethanol required to achieve desired levels of BAC
  - . Frequent monitoring of Subject BAC
  - . The acquisition of sufficiently large samples of data, not only at high BAC, but also at low to moderate levels to permit identification of extraneous effects and comparison with previous studies of this type

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\*For example, the DOT-sponsored Alcohol Safety Action Projects. Specifically, see County of Nassau (N. Y.), Alcohol Safety Action Project Annual Report - 1971, Vol. 1; page 26.

- Insuring high motivation among Subjects
  - Protecting the health and safety of the Subjects
6. The application of suitable analytic techniques to derive and quantify ASIS performance

### 1.3 Summary of Findings

The data obtained during this program were analyzed to determine the degree to which the devices can discriminate between intoxicated and sober drivers. Such analyses are conducted relative to certain key design parameters, e.g., the criterion, or performance score, corresponding to a "pass" or "fail" of the ASIS trial, and the strategy selected for evaluation. Strategy is herein defined as the ratio between the maximum number of trials permitted to the driver and the minimum number he must "pass" in order to operate his vehicle. Clearly, the degree of discrimination afforded is affected by the particular combination of criterion and strategy selected.

Within this context, the two major findings of this program may be summarized as follows:

- (1) With the possible exception of the Reaction Analyzer, criteria and strategies can be identified for each device that offer large-scale discrimination between intoxicated and sober drivers. If "discrimination" is defined as the percentage of drivers prevented from operating their vehicles at peak BAC (0.18% or higher) minus the percentage of sober individuals similarly thwarted, then the Critical Tracking Tester, Complex Coordinator, and Divided Attention all exceed a discrimination rating of 75%. This far surpasses the discrimination (roughly 50%) produced by the ASIS devices tested in the previous program. The Reaction Analyzer, however, has a discrimination rating of approximately 50%.
- (2) At least two of the devices, the Critical Tracking Tester and the Complex Coordinator, produce this discrimination without penalizing sober drivers, i.e., these devices would prevent no one from operating his vehicle at low to moderate BAC ( $< 0.09\%$ ). The Divided Attention, owing to testing constraints discussed in Section 2.2.4, was analyzed only under relatively stringent combinations of criteria and strategies. Thus, while it was found to penalize some sober drivers, more lenient design parameters might enhance its performance at low BAC. The Reaction Analyzer was found to penalize some 3 to 5 percent of sober drivers, and thus performs similarly in that regard to devices tested in the previous program.

It is also important to note that these four devices are, in general, at an earlier stage in their practical development than were the previous program's instruments. Basic design parameters are yet to be optimized (these are discussed in subsequent sections of this report). Thus, it is reasonable to expect that all four devices ultimately will be capable of producing improved performance.

These findings, then, support the notion of a "second generation" ASIS, a device at least theoretically alcohol-specific in the faculties it exercises. The results demonstrate that such instruments yield greatly increased discrimination as compared to devices that measure generalized debilitation via a simple psychomotor test.

Table I and Exhibit A summarize the findings for the four devices. Table II lists critical comments concerning these instruments, including applicable criterion types (Universal--i. e., single criterion applied to all drivers, or Individual--i. e., a separate criterion for each driver), effects noted, and potential improvements.

Table I

Summary of Subject Failure Percentages as  
a Function of BAC

BAC Range	ASIS DEVICES			
	CTT	RA	CC	DA
.00 - .03	0.0	3.1	0.0	3.1
.03 - .06	0.0	0.0	0.0	8.6
.06 - .09	0.0	5.6	0.0	16.6
.09 - .12	13.0	4.4	8.7	29.2
.12 - .15	18.4	12.2	23.4	67.5
.15 - .18	57.1	33.9	56.6	81.1
.18 - .21	77.8	50.0	83.3	100.0
$\Delta$ *	77.8	46.9	83.3	96.9

Table entries are percent of drivers prevented from operating their vehicles.

---

\* Discrimination: Failure at peak BAC  $\geq$  .018 minus  
Failures at BAC  $<$  .03

EXHIBIT A

Rejection Percentage vs. B A C for each Device at its Best Strategy

90-

80-

70-

60-

50-

40-

30-

20-

10-

0-

Per Cent Rejection Rate

B A C .03

.06

.09

.12

.15

.18

-6-

DA Task  
Strategy:  
Criterion:  
Track 5  
per. 15

CC Task  
Strategy:  
Crit. : Ind

CTT Task  
Strategy:  
Crit. 4.2

RA Task  
Strategy  
Crit. M

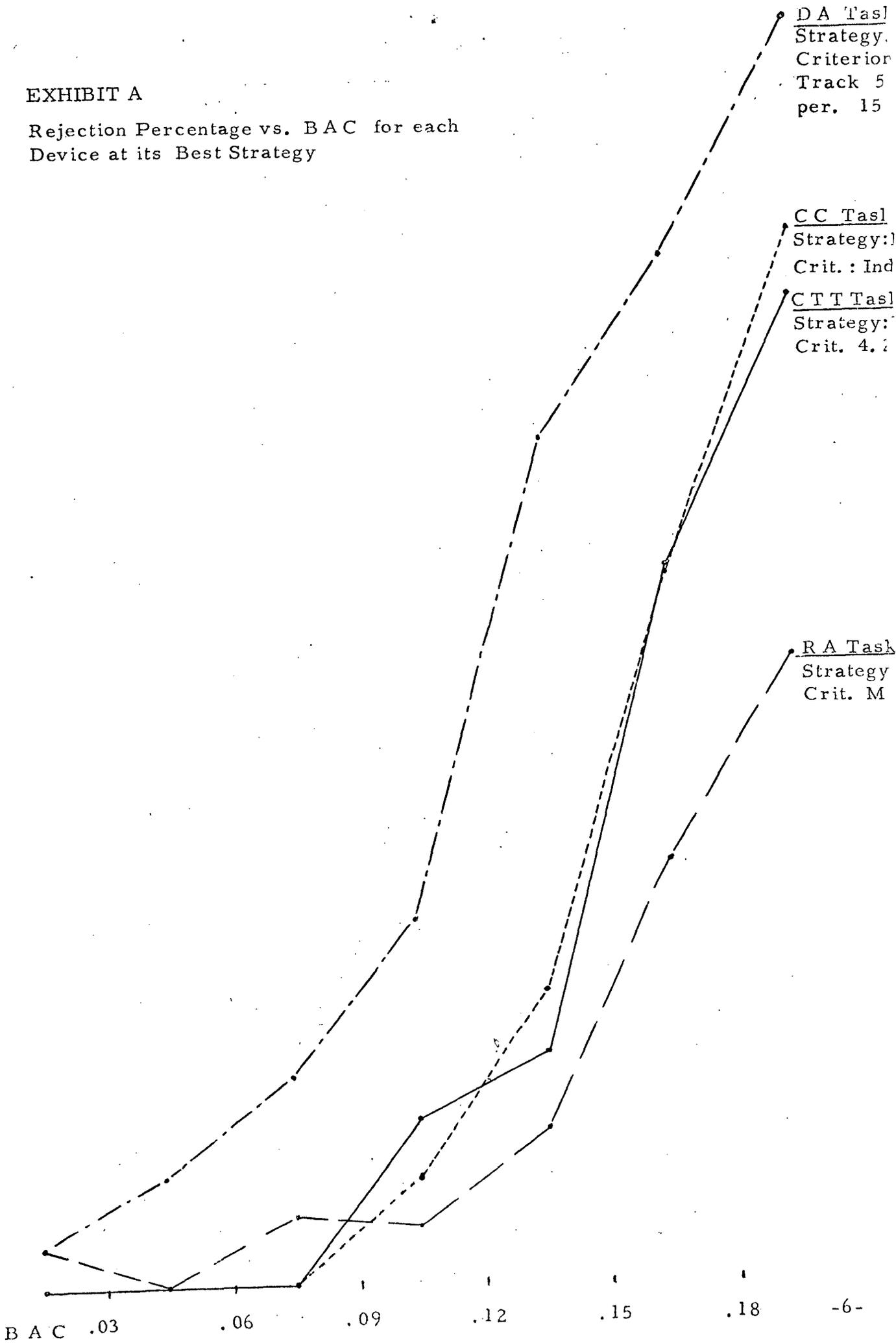


Table II

Conclusions and Commentary

Device	Applicable * Criterion Type	Differences		Trial Duration (seconds)	Ratings by Operators	Comments Concerning Possible Changes
		Sex	Age			
CTT	Both	No	No	15 - 20	Very high, perhaps due to realism of simulation. Least nuisance.	Rate of increase of difficulty. Initial degree of difficulty.
RA	Universal	No	No	15	Low. Lack of trust in pass/fail results.	No raw scores known. Change feedback from lights to continuous indicator.
CC	Both, though wide range of individual differences point to an individual criteria.	No	No	Mean of 58 sec.	Very high, perhaps due to its being perceived as "fun." Difficulty in seeing how it would be implemented.	Long learning curve. The interrelationship among trial duration, number of problems presented, and holding time needs exploration. Sequence should not repeat.
DA	?	?	?	Set at 120 sec.	Moderate. Trial duration too long. Much difficulty with far periphery due primarily to spectacles. Great difficulty in seeing how it would be implemented.	Further analysis will indicate which peripheral lights (near, middle, far) can be eliminated and by how much a trial can be shortened. May be a problem with spectacle wearers.

\* Universal or individual

## 2. Technical Discussion

### 2.1 General Procedures

#### 2.1.1 Subjects

Sixteen (16) Subjects, all licensed drivers, participated in this program. They were selected from among the thirty-seven individuals who served in the 1972 program. The recruitment of these "experienced" Subjects was motivated primarily by their known tolerance to elevated BACs. Additionally, in view of the relatively small Subject populations of the two programs, employment of the same individuals was to facilitate comparison\* of the test results for all ASIS devices. Finally, since an appreciable time had elapsed between the two programs (eleven months in the case of some Subjects, and at least nine months for all), exposure to the first set of devices was not felt to contaminate the Subjects' training or testing on the present instruments.

Of the sixteen individuals, seven were males and nine females. Three of the males and four of the females were 30 years of age or less, the category considered "young" for purposes of data reduction and analysis. The remainder ranged in age from 31 to 56 years.

One fact that bears emphasis is that these Subjects may be considered "heavy" drinkers (at least colloquially). Their usage of alcoholic beverages as reported in their initial selection interviews\*\* indicates that they often attain BAC above the presumptive limit for driving while intoxicated (DWI). Accordingly, they may have acquired a tolerance for alcohol not typically found among "social" or "light" drinkers, and thus may exhibit less impairment than might be observed with Subjects representing more moderate drinking behavior. Hence, the test results may be conservative estimates of the performance (rejection rate) of these instruments.

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\* To insure comparability of data, the Subjects were reassigned the same identification numbers they had held during the previous testing program. These identification numbers are used to denote individual Subjects in the data summaries submitted as companion volumes to this Report.

\*\* See again, Experimental Evaluation of Selected Alcohol Safety Interlock Systems, Appendix B, for detailed description of the selection interview and quantitative measures of the Subjects' drinking behaviors.

As a more direct measure of these Subjects' drinking behavior, it should be noted that the peak BACs observed during this program\* ranged from 0.128% to 0.211%, with a mean of 0.179%.

The sixteen Subjects were subdivided into three classes. One class (six members) participated in training and testing sessions conducted during the daytime hours on Mondays, Wednesdays, and Fridays. A second class (five members) took part in sessions held during Monday, Wednesday, and Friday evenings. The sessions conducted for the third class (five members) were held on Tuesday and Thursday evenings and during the daytime on Saturdays.

### 2.1.2 Program Phasing

The program consisted of three major phases, which conveniently may be labelled Training, Testing, and Analysis of Performance. General descriptions of each phase are presented below.

#### 2.1.2.1 Training

As applied to each Subject, the training phase consisted of three sessions averaging roughly six hours duration each. The first session for each class commenced with a detailed "hands-on" demonstration of each ASIS unit conducted by the Project Director. Care was taken to insure that all Subjects fully understood the nature of the task and the proper manner of conducting a trial. Once this was accomplished, the Subjects were briefed on the major components of the training paradigm. These were:

- . The Training block:

For each instrument, a specified number of trials were taken to constitute a single training block. Subjects were required to complete blocks in the specific order listed in the training booklet issued at the beginning of each session. This order dictated that the Subject repeatedly cycle through the ASIS devices on a block-by-block basis until all assigned work had been completed.

- . Buddy system:

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\* As measured on the Alco-Analyzer gas chromatograph.

Subjects worked in pairs on each training session.\* When one Subject was undertaking an assigned block of trials, his partner recorded the results in the training booklet; once a block was completed, they exchanged roles. This scheme not only insured orderly progression through the ASIS devices, but also enforced frequent rest periods for each Subject, thus minimizing fatigue. A light meal midway through the session provided another rest period of longer duration.

. Reward system:

Subjects received \$10 base pay for attendance at each training session. In addition, incentive payments were issued for achieving pre-defined scores on each ASIS. This was done to maintain high motivation and thus, hopefully, to accelerate the "learning curve."

2.1.2.2            Testing

Each Subject participated in four testing sessions of roughly eight hours duration each. Two of these sessions were experimental (i.e., involved the ingestion of large quantities of alcohol), and two were controls (i.e., essentially alcohol-free). Subjects were unaware of this fact. For those sessions in which they served as controls, they received placebo beverages, consisting of fruit juice diluted with water, with two (2) milliliters of 95% grain alcohol floated on top of the drink to convey the odor of ethanol. Although this placebo produced BACs no higher than 0.003%, it proved sufficient to mask the fact that controls were being conducted. The project staff took other precautions to preserve the confidentiality of the controls. For example, since many of the Subjects had learned to interpret (at least roughly) the chromatograms produced during breath tests, breath alcohol simulator tests were run repeatedly, and labelled with control Subjects' names and fictitious BACs. In addition, no attempt was ever made to convince a control Subject that his BAC exceeded roughly 0.14%. Thus, the expectation of drinking, the concrete "evidence" of the chromatograms, and the relatively "low" levels of BAC reported combined to convince all Subjects that they were ingesting alcohol during all testing sessions. The success of this subterfuge was one of the more interesting sidelights of this program, and is supported by considerable anecdotal evidence. Several control Subjects, for example, stated that they

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\* For those sessions during which an odd number of Subjects trained, a Dunlap staff member served to round out a team.

were beginning to feel the effects of their drinks, while another commented that his second drink of the session had been a good deal stronger than the first. Most impressively, one control stated that, while she didn't feel extremely "high," she would certainly not attempt to drive a car.

The purpose in obtaining control data was to permit better assessment of the effects of alcohol impairment upon ASIS performance. As discussed below, sober data (i. e., at 0.00% BAC) were also collected during experimental sessions. However, at those times such data were obtainable only at the very beginning of the sessions, when the Subjects were least affected by fatigue or boredom. Control data, then, when compared with experimental results on a time-into-session basis permit better estimation of the true effects of alcohol.

Subjects were assigned (without their knowledge) to a particular subgroup in accordance with the order in which they took experimental and control sessions. These orders are listed below:

Subgroup	No. of Members	1st Session	2nd Session	3rd Session	4th Session
1	5	E	E	C	C
2	6	E	C	C	E
3	5	C	C	E	E

A random assignment of Subjects to subgroups was followed, constrained only in that at least one young male, young female, older male and older female was to belong to each subgroup. At least one experimental and one control took part in every testing session conducted.

The primary purpose in constructing subgroups as above was to facilitate assessment of the effects upon the test results of continued learning beyond the formal training phase. If the Subjects' learning on the instruments continues during testing sessions, this should be evident from data produced by the subgroups. Specifically, Subgroup 1, producing experimental data immediately following termination of training, would--if the hypothesis were true--show higher rejection rates than Subgroup 3, whose members had the benefit of additional practice acquired during two control sessions, and the data produced by Subgroup 2 would fall somewhere between these two extremes.

The major components of testing sessions are described below:

. Medical examination:

At the beginning of each session, Subjects received a brief medical examination conducted by the attending physician to insure that no impediments to their participation existed. Occasional re-examinations were conducted during the sessions whenever the physician deemed necessary.

. Administration of alcohol:

Each Subject ingested four (4) drinks during the course of the session. For experimental Subjects, these consisted of measured volumes of 95% grain alcohol mixed with the Subject's choice of fruit juice. The volume of alcohol assigned to each drink was based on the Subject's weight and observed rate of absorption. Typical target BACs for each drink are listed below:

Drink #1	0.04% - 0.06%
Drink #2	0.08% - 0.11%
Drink #3	0.12% - 0.16%
Drink #4	0.16% - 0.20%

. Drinking and waiting periods:

Fifteen minutes were devoted to the ingestion of each drink. This was followed by a twenty minute waiting period to allow for absorption of alcohol into the blood stream and dissipation of alcohol from the mucous membranes of the mouth; at the end of this period the Subject was required to rinse his mouth with water to further insure elimination of residual alcohol.

Subjects were permitted to play cards, read magazines, and take part in similar diversions during the drinking/ waiting periods in order to maintain a relaxed, comfortable atmosphere. Smoking was permitted during the drinking period and through roughly the first fifteen minutes of the waiting period. No eating whatsoever was allowed during these times.

• Test cycles:

All testing took place during discrete cycles consisting of the following events:

- submission to a breath test
- completion of a block of trials on ASIS device #1
- completion of a block of trials on ASIS device #2
- submission to a breath test
- completion of a block of trials on ASIS device #3
- completion of a block of trials on ASIS device #4
- submission to a breath test

Two test cycles always preceded ingestion of the first drink.\* One cycle immediately followed the waiting period after each of the four drinks. The final two cycles were run following a short rest period/light meal. On one testing session, a delay caused by equipment malfunction forced elimination of the eighth testing cycle.

• Reward system:

As in the case of the training phase, Subjects received \$10 base pay for each testing session. In addition, a reward was given for each ASIS trial passed. This was done to simulate the motivation a driver would experience if passing the trial were a prerequisite to starting his car. Subjects received their rewards in the form of poker chips immediately upon the completion of each test cycle. The spirit of competition this fostered seemed to enhance motivation.

Members of the project staff transported all Subjects to their homes at the close of each testing session.

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\* At the beginning of the first cycle of each testing session, Subjects completed one or two "warm up" trials on each device. Results of these practice trials were not considered for data analysis.

### 2.1.2.3

### Analysis of Performance

Analysis of test results began with the computation of ASIS performance (rejection rate) as a function of BAC. To accomplish this, it is first necessary to define the criterion (i. e., minimum or maximum allowable score) relative to which each trial is considered a "pass" or "fail." In general, two approaches may be taken to satisfy this requirement. First, a single or universal criterion value may be employed for all Subjects; second, each individual may be assigned a unique criterion. The first approach is clearly preferable for operational applications of ASIS, since it eliminates the need to obtain extensive baseline data from each affected driver and avoids other implementation problems discussed in the final section of this report. However, in some cases the second approach can produce more nearly optimum performance, and may, in fact, be mandated by the parameters of the particular ASIS. For purposes of this program, the ASIS units were evaluated relative to both universal and individual criteria whenever possible.

Relative to a given criterion, the performance of an ASIS will depend upon the strategy under which it is implemented. The simplest strategy is one in which the outcome of a single trial determines whether the vehicle will be started. More complex strategies could permit the driver to attempt a set of trials, some subset of which must be passed if the car is to start. In this report, the general form of an ASIS strategy is represented by N/M, where M is the number of attempts allowed and N is the minimum number which must be passed if a "START" is to be recorded.

During each test cycle, Subjects completed a block of three trials on each ASIS unit. This permitted the devices to be evaluated relative to six distinct strategies. First, each block was viewed as a unit, and results were computed for strategies 1/3, 2/3, and 3/3. Second, by examining only the first two trials in each block, strategies of 1/2 and 2/2 were assessed. Finally, by treating each individual trial as an independent unit, performance was computed for a simple 1/1 strategy.

Analysis of performance under each strategy consisted of the computation of the percentage of test units (blocks, subblocks, or trials) rated as rejections ("fails to start") at each interval of BAC. Ideally, one would wish to treat BAC as a continuum for such analysis; however, sample size limitations necessitated the adoption of BAC class intervals. Both to insure adequate representation in each interval and to permit comparison with the previous program, the following class intervals were employed:

1. 0.000% - 0.029%
2. 0.030% - 0.059%
3. 0.060% - 0.089%
4. 0.090% - 0.119%
5. 0.120% - 0.149%
6. 0.150% - 0.179%
7. 0.180% and above.

Each testing block was assigned to a particular BAC interval in accordance with the breath tests results obtained during the test cycle in which the block was taken. Control data were also analyzed with respect to the various criteria and strategies applied to each device. Performance estimates resulting from these data were examined as a function of elapsed test session time (i. e., test cycle number) rather than BAC.

The next step in these analyses examined the variation in ASIS performance exhibited by different categories of Subjects. Data were reduced independently for males, females, young Subjects (age  $\leq$  30), and older Subjects (age  $>$  30), and each of the three subgroups. Visual inspection was relied upon to disclose the combinations of pass/fail criteria and strategies that seemed to offer the "best" performance for each device. Appropriate tests of the significance of any differences among the various categories of Subjects were then applied to the data representing the selected combinations.

Detailed discussions of the training, testing, and analysis applicable to the four devices selected for this program are presented in succeeding sections of this report. Compilations of training and testing data for each Subject on each ASIS have been submitted to the Contract Technical Manager and are on file at TSC.

### 2.1.3 Facilities, Equipment and Personnel

All training and testing sessions took place in a suite of rooms located in an isolated wing of the Dunlap and Associates, Inc. headquarters in Darien, Connecticut. These facilities permitted each ASIS device to be located in a separate room, thus allowing simultaneous training/testing of two

or more Subjects. The suite also included a spacious, carpeted, and well-ventilated lounge area conducive to the maintenance of a relaxed, pleasant atmosphere; Subjects remained in this lounge during drinking and waiting periods. Additional rooms were set aside for the medical examinations, materiel storage, and the conduct of breath tests.

Apart from the ASIS devices, the major equipment items employed in this program were two breath testing instruments, the Alco-Analyzer Gas Chromatograph\* and the Breathalyzer,\*\* Model 900. The Gas Chromatograph was employed for the breath tests taking place at the beginning and end of each test cycle, the Breathalyzer for the mid-cycle test. Several days were devoted to conducting breath alcohol simulator tests of both instruments. The Gas Chromatograph, which produces a graphic output rather than direct, numerical values of BAC, was found to provide highly accurate and repeatable measurements. The Breathalyzer does provide direct output of BAC. However, simulator tests disclosed that the particular unit employed produced consistently high readings. The simulator data were used to derive the analytical relationship between "raw" and "true" measurements, and all Breathalyzer results were adjusted accordingly.

It should be noted that, technically speaking, measurement of BAC is obtainable only from direct blood analysis. Breath testing devices such as those used in this program generally are considered to produce breath alcohol equivalents (BAQ), which may be viewed as estimates of BAC. However, for the sake of consistency, the term BAC is employed throughout this report.

Control of all training and testing sessions was exercised by the Project Director, who conducted breath tests, assigned the magnitude of each alcohol dosage, and insured adherence to the testing schedule. Three or four staff members served as Subject Escorts during each session. In addition to recording the results of all ASIS trials and breath tests, their duties included mixing and administering drinks, transporting Subjects to and from testing sessions, and providing close observation of Subjects to protect their safety. Finally, one physician attended each testing session. His duties included conducting the medical examinations and protecting the general health and safety of all Subjects.

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\* Luckey Laboratories, Inc., San Bernadino, California.

\*\* Stephenson, Inc., Eatontown, New Jersey.

## 2.2 Specific Procedures and Results

### 2.2.1 Critical Tracking Tester

The Critical Tracking Tester (CTT), developed by General Motors Corporation, employs a compensatory tracking task requiring the Subject to attempt to stabilize the output of a system whose level of instability (or degree of difficulty) increases monotonically with time-into-trial. The unit provided for testing consisted of a Chevrolet Vega dashboard and driver's bucket seat. The display portion of the unit consisted of a meter mounted on the right-hand side of the dashboard. A pointer on the meter served as the task stimulus. The control portion was the standard Vega steering wheel mounted in the normal position with respect to the driver and dashboard.

At the beginning of the trial, the pointer rests in the center of the meter. As the trial progresses, the pointer undergoes random oscillations of increasing magnitude. The Subject attempts to maintain/return the pointer to the rest position by appropriately turning the wheel (the response is compatible, i. e., turning the wheel toward the right causes the pointer to swing toward the right, etc.). Relatively small wheel motions suffice to control the pointer. The trial ceases when the Subject is unable to sufficiently compensate for the system instability, at which time the pointer swings to either extreme position on the meter. Thus, trial duration is a function of the Subject's proficiency: the better he does, the longer the trial lasts.\* In this program, trial duration exceeded 25 seconds only rarely.

The measure ("score") employed in this program was the forcing voltage of the system corresponding to the degree of difficulty at which the Subject lost control. The higher the score, the better the Subject had performed. At the commencement of the trial, the output is roughly 1.00 volt; if the task is allowed to proceed without control input (i. e., steering wheel not moved) the pointer reaches extreme excursion on the meter at an output of roughly 1.50 volts, at which time the trial ceases. Thus, this is (approximately) the minimum attainable score.

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\* In an operational application of the CTT, a pre-determined degree of difficulty would be selected as the criterion for passing a trial. In all likelihood, the trial would cease as soon as that criterion was achieved. Hence, there would be an absolute maximum for trial duration.

### 2.2.1.1

#### Procedures

Training procedures employed for the CTT called for Subjects to complete 10 blocks of 10 trials (100 trials) on each of the three training sessions. Subjects received an incentive payment of \$0.25 for each score above 5.25 volts. A bonus award of \$0.50 for scores above 7.00 volts was also offered; however, no Subject ever achieved this bonus.

The scores required for training pay-off were purposely set a good deal higher than those that might reasonably serve as pass/fail criteria for testing and/or operational applications. This was done to motivate all Subjects to achieve their highest possible scores on the device. This procedure may be termed "open-ended" training. It offers the advantage of allowing assessment of individual differences in capability; as such, it is the scheme that might be employed in operational applications if each driver were to be assigned an individual pass/fail criterion. On the other hand, the procedure permits Subjects to acquire practice over varying ranges of system instability. If a single pass/fail criterion were to be assigned universally to all drivers, it might be preferable to restrict their training to the instability range defined by that criterion. However, the selection of an optimum universal criterion that would permit this second procedure to be adopted must await the results of additional testing of the CTT. In any event, the 5.25 volt criterion selected for training proved sufficient for present purposes, and all Subjects were able to achieve this score at least occasionally during their three training sessions.

CTT testing procedures required Subjects to complete a block of 3 trials on each test cycle. Subjects received \$0.25 for each score of 4.20 volts or more. The reward was doubled if all three trials produced scores at or above this criterion. In addition to noting pass or fail relative to this criterion, the Escorts recorded the actual scores produced by Subjects on each trial. This permitted subsequent analysis of results relative to alternate criteria.

During one of the early training sessions, a malfunction occurred in the CTT that rendered the device inoperable.\* As a result, Subjects affected worked on the CTT only during their second and third training sessions. However, those individuals were still able to complete all (or nearly all) of the scheduled 300 training trials.

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\* The project staff are deeply grateful for the assistance rendered by Mr. Fred Gruhl and Dr. Richard Thompson of General Motors Corporation, who arrived from Detroit and repaired the CTT less than 24 hours after the failure occurred.

2.2.1.2

Results

2.2.1.2.1

Universal Criteria

CTT data were analyzed relative to several pass/fail criteria. As a first step, four distinct universal criteria were examined. These were 4.40 volts, 4.20 volts, 4.00 volts, and 3.80 volts (i.e., scores at or above those values were considered "passes"). In each case, one or more strategies were found to offer attractive performance. However, under all strategies, the highest criterion (4.40) was found to produce a non-zero failure rate among sober Subjects. For the three lower criteria, one or more strategies can be found that avoid penalizing sober drivers. These latter cases are summarized below (all CTT results for all criteria and strategies may be found in the Appendix):

		UNIVERSAL CRITERION						
		4.20	4.00			3.80		
Strategy \ BAC		1/3	1/2	1/3	2/3	1/2	1/3	2/3
	< 0.03%		0	0	0	0	0	0
0.03-0.06		0	0	0	8.7	0	0	4.4
0.06-0.09		0	5.6	0	5.6	5.6	0	5.6
0.09-0.12		13.0	4.4	4.4	17.4	4.4	0	4.4
0.12-0.15		18.4	10.2	8.2	18.4	4.1	4.1	10.2
0.15-0.18		57.1	48.2	41.1	66.1	26.8	23.2	50.0
≥ 0.18		77.8	66.7	61.1	77.8	61.1	50.0	72.2

(Table entries are rejection rates expressed as percentages.)

Perhaps the most impressive point to note in the above table is that all selected strategies produced zero rejection rate during sober (BAC < 0.03%) trials.\* However, these computations are based only on experimental session ("drinking") data. After examining the larger number of sober trials produced during control sessions, the following average sober rejection rates were noted:

\* All other combinations of criteria and strategies produced non-zero sober rejection rates.

<u>Criterion</u>	<u>Strategy</u>	<u>Sober Rejection Rate</u>
4.20	1/3	0.8%
4.00	1/2	0.00%
	1/3	0.00%
	2/3	1.2%
3.80	1/2	0.00%
	1/3	0.00%
	2/3	0.4%

Based upon this consideration, the combination of criterion and strategy that appears most impressive is 4.00 volts, 1/2. This would offer the highest rejection rate at elevated BAC achieved without penalizing alcohol-free individuals. All other combinations listed above, however, clearly merit further consideration.

Figures 1, 2, and 3 graphically depict the results discussed above.

Using the data obtained from the 4.00 volt criterion, 1/2 strategy, analyses of variance were conducted to test the significance of the main effects of BAC, Subgroup, Subject Age, and Subject Sex upon CTT performance.\* Results of these analyses are listed below.

	BAC	Sex	BAC	Age	BAC	Subgroup
F value:	57.12	2.26	5.02	3.87	24.11	2.91
Significance:	P<.001	P>.05	P<.05	P>.05	P<.001	P>.05

\* These analyses--and others described in this report--were simple two-way analyses of variance in which BAC served as one main effect and subgroup, age, or sex as the other. Cell entries were rejection rates expressed as proportions and transformed by the arcsine, as suggested in Snedecor, G.W., Statistical Methods, Iowa State University Press, 1956; pg. 316.

80-

70-

60-

50-

40-

30-

20-

10-

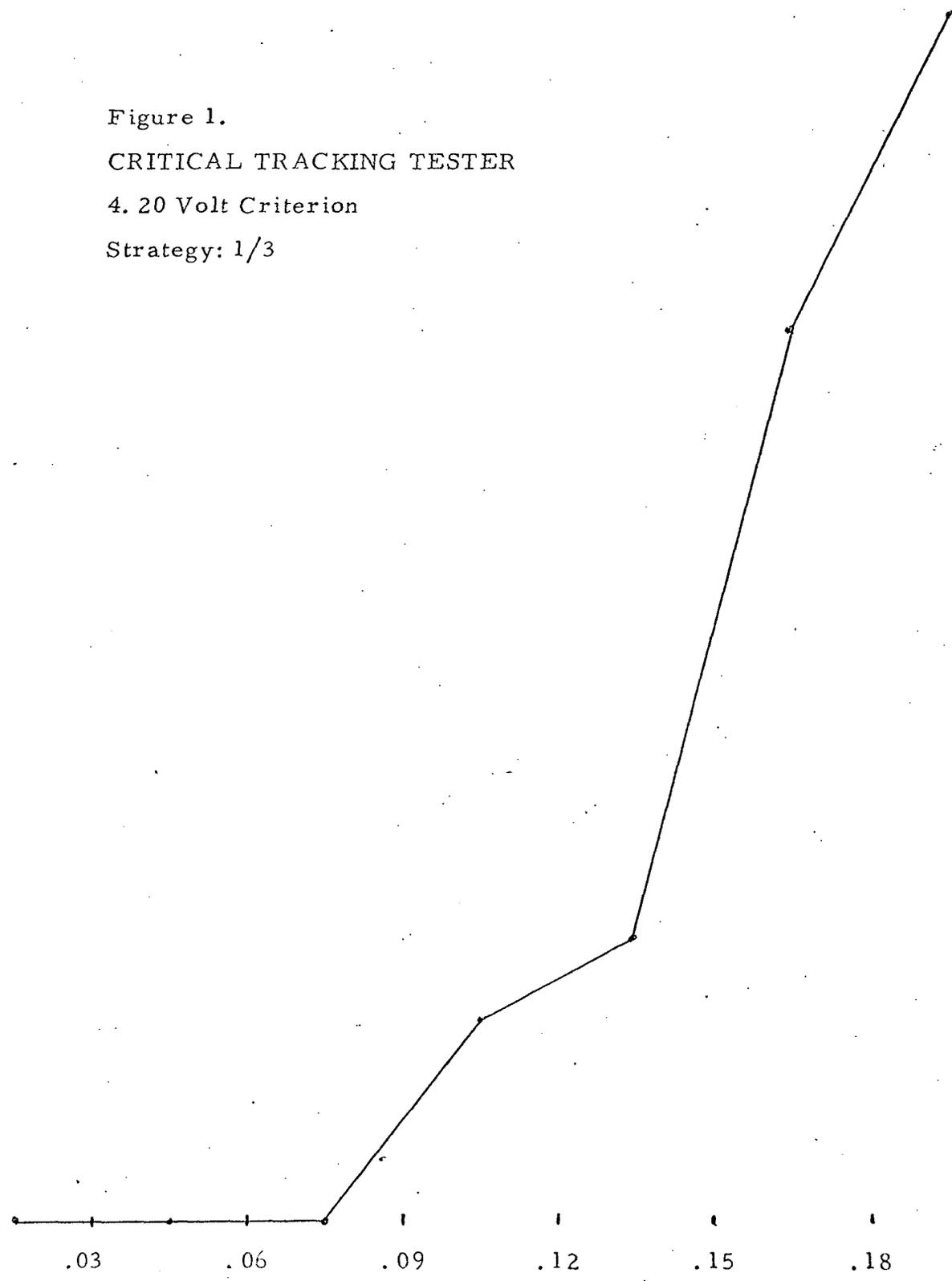
0-

Figure 1.  
CRITICAL TRACKING TESTER  
4. 20 Volt Criterion  
Strategy: 1/3

Per Cent Rejection Rate

.03 .06 .09 .12 .15 .18

B A C



80-

70-

60-

50-

40-

30-

20-

10-

0-

Figure 2.  
CRITICAL TRACKING TESTER  
4.00 Volt Criterion

Per Cent Rejection Rate

.03

.06

.09

.12

.15

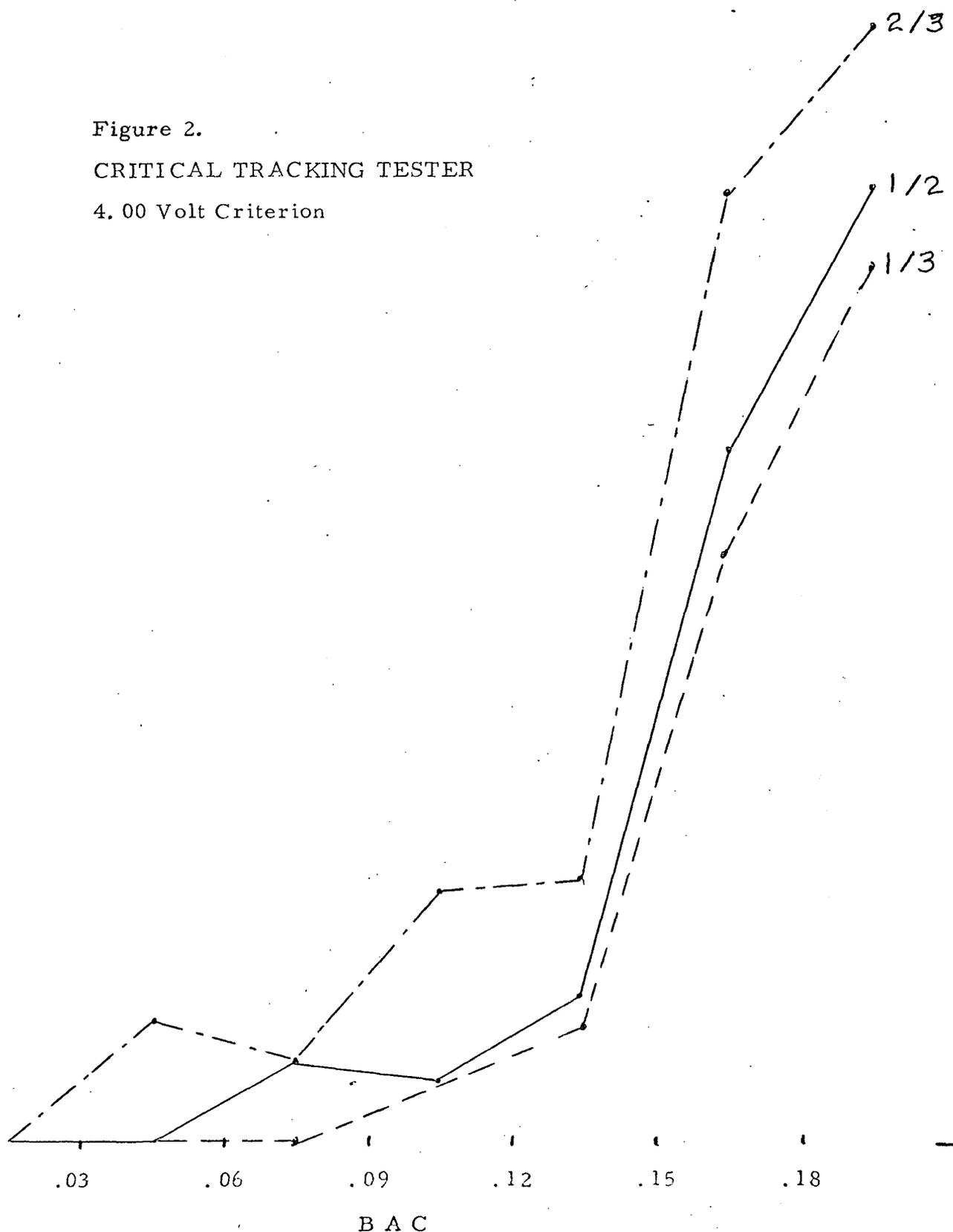
.18

B A C

2/3

1/2

1/3



80-

70-

60-

50-

40-

30-

20-

10-

0-

Figure 3.  
CRITICAL TRACKING TESTER  
3.80 Volt Criterion

Per Cent Rejection Rate

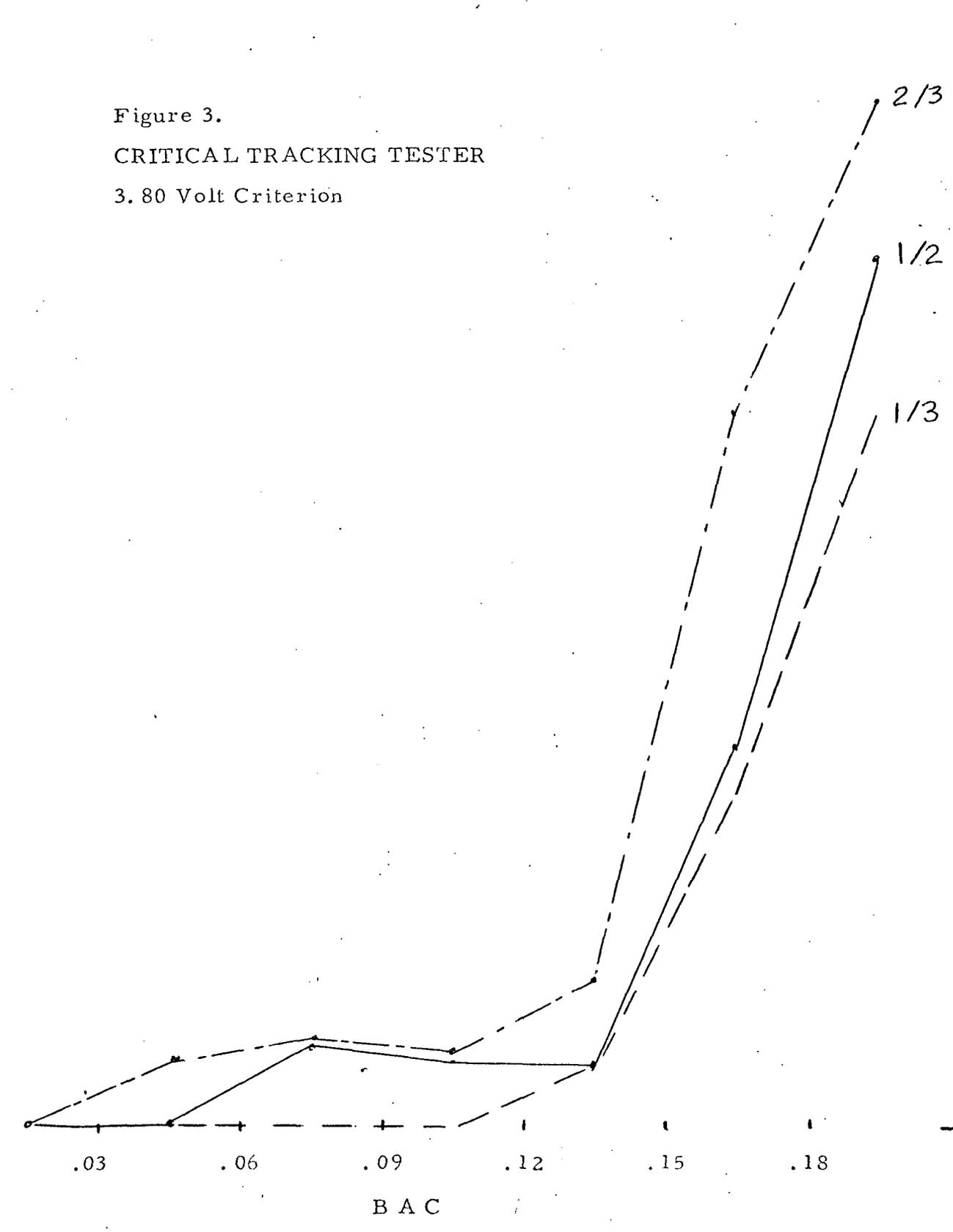
.03 .06 .09 .12 .15 .18

B A C

2/3

1/2

1/3



Although neither sex, age, nor subgroup was found to have a statistically significant effect upon CTT performance, the differences in rejection rate observed between young and old Subjects (see Appendix) suggests that closer attention should be paid to the effects of age. Had it been possible to test a large sample of Subjects, a more significant result might have been obtained. It is suggested that future evaluations of the CTT examine the Subject Age variable in greater detail.

2.2.1.2.2 Individual Criteria

The second step in the assessment of CTT test results examined performance relative to pass/fail criteria assigned to Subjects on an individual basis. As a point of departure, the fifth (5th) lowest score achieved by each Subject during the 100 trials of his third training session was selected. A similar set of criteria was next computed from the tenth (10th) lowest of the 100 scores. Resulting individual criteria are listed below for each Subject:

<u>Subject No.</u>	<u>Sex</u>	<u>Age</u>	<u>Criteria</u>	
			<u>5th Percentile</u>	<u>10th Percentile</u>
102	M	26	5.05	5.15
103	F	31	3.09	3.21
105	F	25	2.64	2.98
107	M	40	4.73	4.86
108	F	42	4.06	4.16
110	F	42	3.43	3.61
111	F	56	3.92	4.12
115	F	29	3.81	4.04
117	F	23	4.67	4.78
120	M	30	5.25	5.35
123	M	47	3.06	3.27
125	F	35	3.22	3.52
126	M	26	4.25	4.54
129	M	39	3.78	3.95
136	F	22	3.99	4.29
138	M	32	3.67	3.94

In these cases, too, performance appears quite reasonable under a number of strategies, as indicated in the following table:

		Individual Criterion					
		5th Percentile			10th Percentile		
BAC	Strategy	1/2	1/3	2/3	1/2	1/3	2/3
	<.03%		0	0	0	0	0
.03 - .06		0	0	0	0	0	0
.06 - .09		5.6	0	5.6	5.6	0	5.6
.09 - .12		4.4	4.4	13.0	13.0	4.4	26.1
.12 - .15		16.3	12.2	22.5	28.6	22.5	32.7
.15 - .18		38.2	30.9	61.8	48.2	39.3	69.6
≥.18%		72.2	66.7	83.3	83.3	83.3	88.9

Control session data showed the following average sober rejection rates for these criteria and strategies:

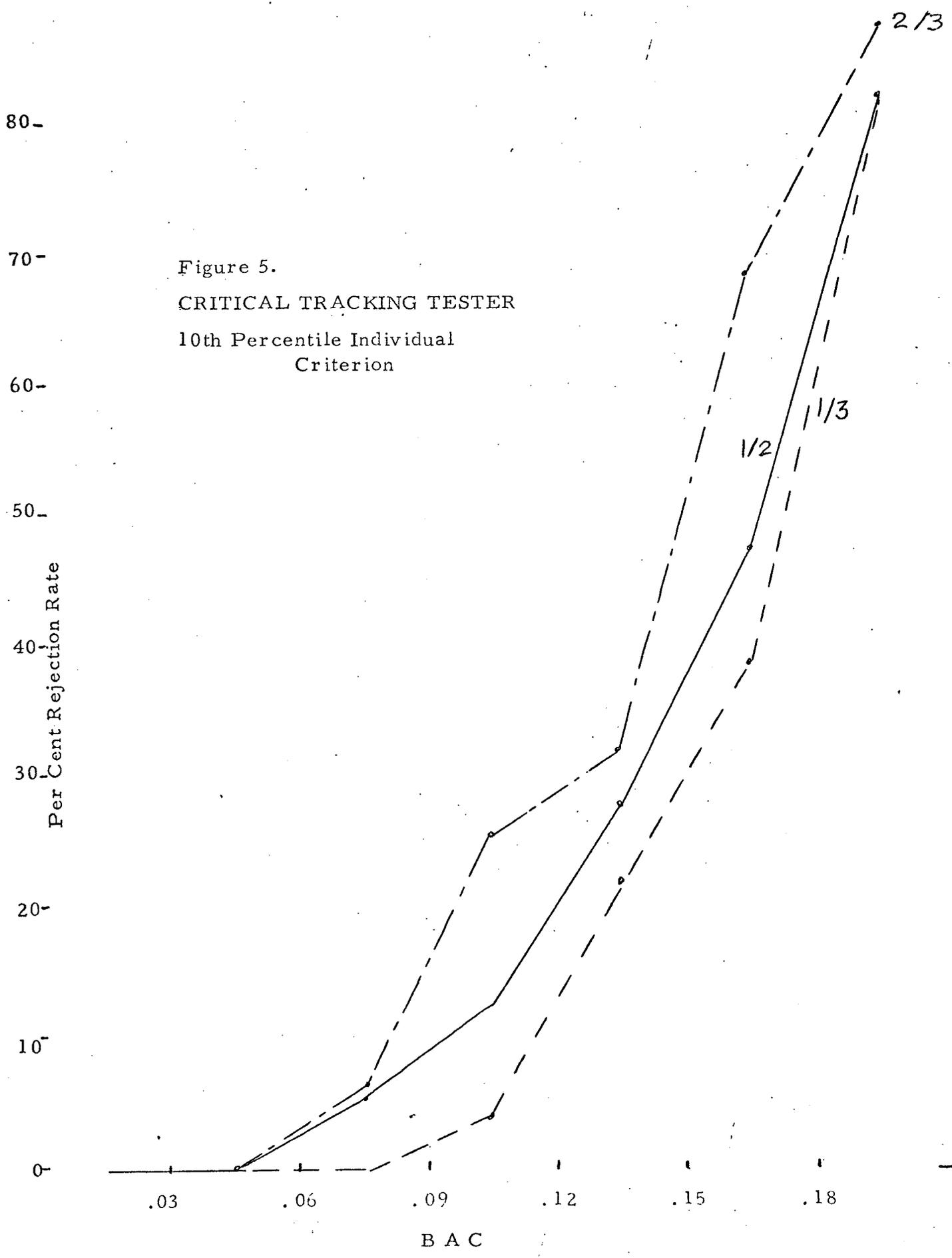
<u>Criterion</u>	<u>Strategy</u>	<u>Sober Rejection Rate</u>
5th Percentile	1/2	0.4%
	1/3	0.0%
	2/3	0.8%
10th Percentile	1/2	1.2%
	1/3	0.4%
	2/3	1.6%

One point that should be mentioned in this context is that several Subjects (notably, numbers 103, 105, and 110) were assigned criteria through these approaches that resulted in very few or no failures, even at the highest ranges of BAC. Apparently, the scores they produced during their last 100 training trials did not accurately reflect their capabilities on the CTT. Possible reasons for this may include lack of motivation (fostered, perhaps, by the relatively high criterion for training reward), self-induced distraction\*,

\* Subject 105, in particular, may have been affected by this. That Subject was extremely loquacious and inattentive, and... despite repeated urging to concentrate on the task... often continued to talk while a trial was in process.



Figure 5.  
CRITICAL TRACKING TESTER  
10th Percentile Individual  
Criterion



direction.\* After tracking through roughly 200°, the control input requirement reverses, and the Subject must turn the knob counterclockwise and continue tracking until the START position is reached. The reversal point is not labelled; however, training experience indicates that Subjects rapidly learn its location.

The only performance measure obtainable from the Reaction Analyzer unit employed in this program is a binary-valued indication of pass or fail (provided by two additional light-emitting diodes). This measure depends upon the criterion defined by the potentiometer setting. The lack of a criterion-independent score severely limited the range of analyses that could be conducted for Reaction Analyzer data.

### 2.2.2.1 Procedures

Reaction Analyzer training called for Subjects to complete up to six blocks of 10 trials (60 trials) on each training session. The objective was for all Subjects to attain at least a specified level of success at a universally applied criterion value. To facilitate this, six positions had been marked on the criterion-defining potentiometer. These were labelled E, 1, M, 2, 3, and D, with E denoting "easiest criterion," D "most difficult," and the others representing intermediate values in ascending order of difficulty. On their first sessions, all Subjects commenced work at the E criterion. They were required to remain at that level until they succeeded in passing at least 8 trials in a single block. Having done so, they advanced to criterion 1, where the same requirement applied. Finally, they trained at criterion M, which had been selected as the universal value for testing.\*\* Once having reached this criterion, Subjects never reverted to the E or 1 settings.

Training rewards consisted of \$1.00 each for mastering criteria E and 1 and \$5.00 for passing at least 19 trials out of two consecutive blocks at criterion M. On their first and second sessions, Subjects ceased

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\* The configuration of the unit is such that the Subject must control the knob with his right hand; use of the left hand would obstruct his view of the stimulus indicators. Thus, the device may discriminate against left-handed individuals.

\*\* This selection was based upon Reaction Analyzer experience gained at TSC prior to this program. It was learned at that time that few if any Subjects could consistently pass trials at more difficult criteria.

training if the \$5.00 reward was achieved, regardless of whether they had completed all 60 trials. On their third session they completed the full complement of trials. For training blocks taken after the \$5.00 reward had been achieved, \$1.00 was paid for passing 9 trials, and \$3.00 if all 10 were passed. In a few instances, Subjects who clearly were experiencing difficulty were permitted more than the scheduled 60 trials in a session.

The Reaction Analyzer training phase succeeded in satisfying the previously mentioned objective, in that all Subjects achieved the \$5.00 reward on at least one session.

During testing sessions, Subjects completed a block of 3 trials on the Reaction Analyzer during each test cycle. All trials took place at criterion M. Subjects received \$0.25 for each pass, with the reward doubled if all three trials were passed.

No equipment problems occurred with the Reaction Analyzer at any time during the training or testing phases. However, it should be noted that the intensity of the stimulus indicators always diminished near the end of a trial, making tracking very difficult. It was also observed that the device required an extremely stable and well-controlled power supply.

#### 2.2.2.2 Results

As discussed previously, Reaction Analyzer test results could be analyzed solely with respect to the universally-applied criterion M. The outcome of the analysis was not encouraging, in that all strategies produced non-zero sober rejection rates and less than optimum performance at elevated BAC. The only strategy that appears to offer some promise is 1/3, results for which are summarized below (a summary of all strategies may be found in the Appendix):

BAC	Criterion M, Strategy 1/3
< .03%	3.1
.03 - .06	0.0
.06 - .09	5.6
.09 - .12	4.4
.12 - .15	12.2
.15 - .18	33.9
≥ .18%	50.0

The average sober rejection rate determined from control data was 3.5%, thus agreeing fairly closely with the results of sober trials taken during experimental sessions. However, the fact that no failures were noted over the BAC range from .03 to .06 may indicate that the sober rejection rate is somewhat inflated. Possible bases for such an hypothesis could be Subject anxiety or hostility toward this device,\* which might be present at the beginning of a session but dissipate after a drink has been served. Nevertheless, the data indicate that this device would penalize some sober drivers as the cost for preventing 50% of grossly intoxicated motorists from operating their vehicles.

The results tabulated above are exhibited graphically in Figure 6.

Analyses of variance applied to Reaction Analyzer data relative to the 1/3 strategy yielded the following results:

	BAC	Sex	BAC	Age	BAC	Subgroup
F value:	2.39	1.13	2.52	4.10	6.03	0.79
Significance:	P > .05	P > .05	P > .05	P > .05	P < .01	P > .05

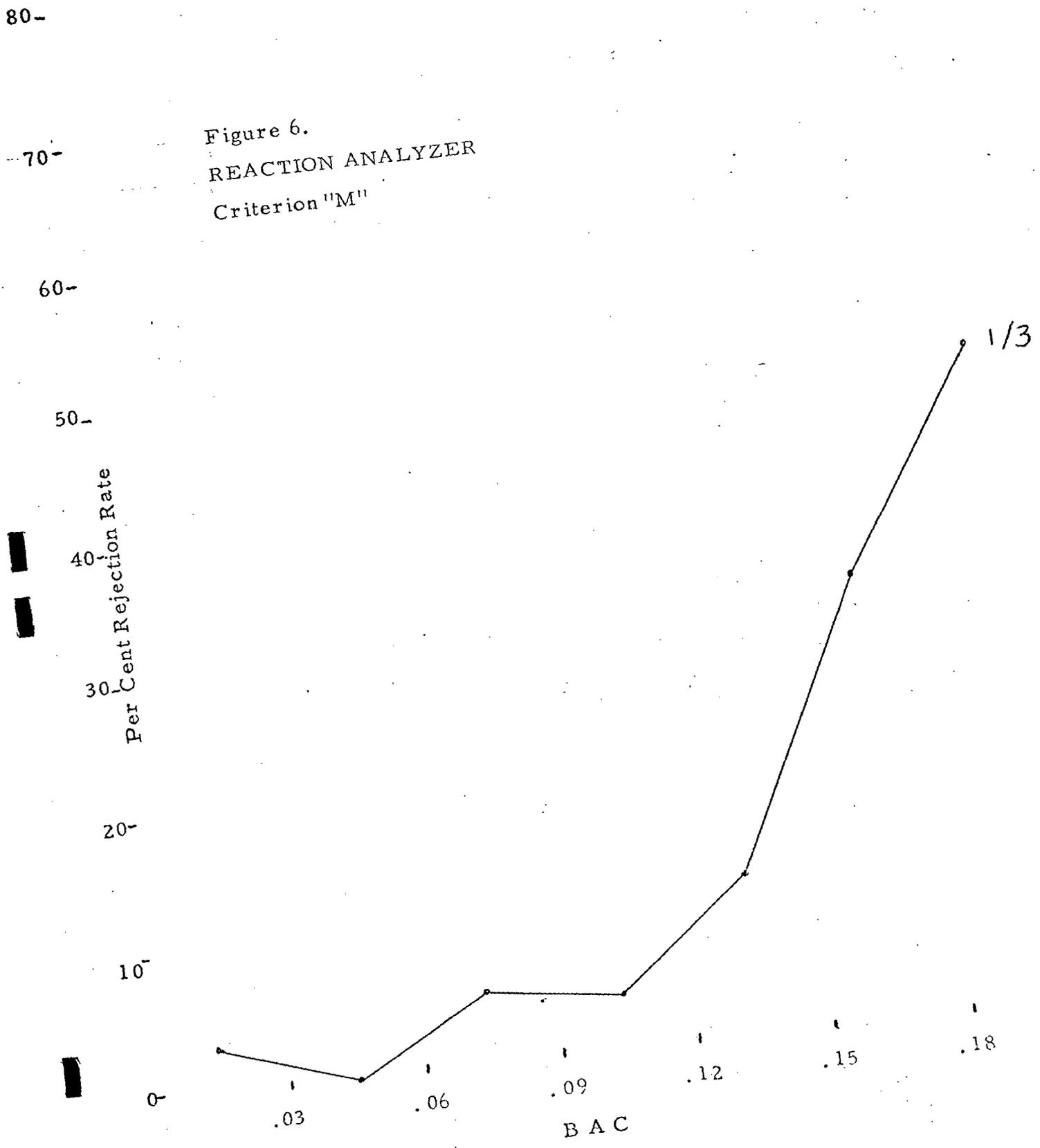
Thus, the only statistically significant effect noted was for the main effect of BAC in the BAC versus Subgroup analysis. Other effects may have been masked by interactions between the relevant variables (such interactions are treated as error terms in these analyses). It seems particularly likely that this may have been the case with the Age variable, since younger Subjects produced much lower rejection rates at all BACs than did their older counterparts.

One additional analysis was applied to these data. In view of the positive rejection rates noted during control sessions, analysis of variance was conducted to assess the main effects of Treatment (i. e., experimental or control) versus Test Cycle Number (roughly equivalent to elapsed test session time). This process required re-computation of experimental session rejection rates as a function of cycle number rather than BAC. Resulting data for both Treatment conditions are tabulated below:

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\* The relative preferences expressed by the Subjects for the four devices studied in this program are discussed in the final section of the report.

Figure 6.  
REACTION ANALYZER  
Criterion "M"



Cycle	Treatment	
	Experimental	Control
1	6.25	3.13
2	0.0	12.5
3	0.0	3.13
4	9.39	0.0
5	18.75	3.13
6	43.75	6.25
7	28.2	0.0
8	12.5	0.0

The analysis produced the following result:

F value:	3.89	0.87
Significance:	P>.05	P>.05

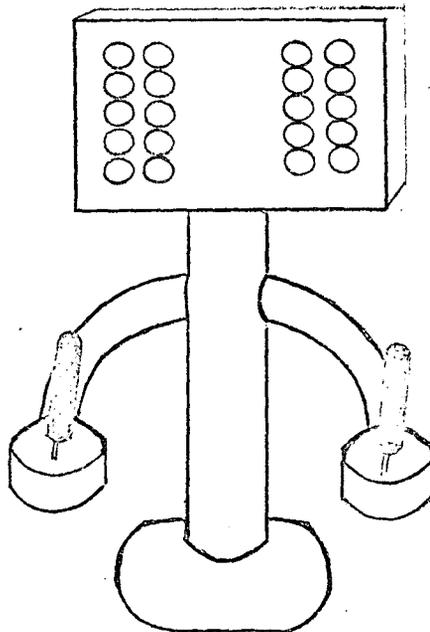
Thus, neither Treatment nor Cycle number was found to have a statistically significant effect upon rejection rate. Again, the interaction between these variables may have masked their main effects in this analysis.

### 2.2.2.3 Discussion

Any attempt to draw conclusions from these test results concerning the feasibility of the Reaction Analyser for future applications is frustrated by the lack of raw score measures of the instrument's performance. At this stage of development, insufficient data exist from which the optimum pass/fail criterion might be derived. Thus, the criterion used as the basis for Reaction Analyzer analysis must be considered somewhat arbitrary, and may not indicate the performance that the device is actually capable of producing. This fact alone necessitates very cautious interpretation of the test results. Even worse is the fact that the characteristics of the unit submitted for this program preclude examination of how performance might be affected by even slight adjustment of the criterion. It is thus clear that, if additional testing is to prove meaningful, the device must be modified to produce a criterion-independent score--tied directly to tracking error--as the outcome of each trial.

### 2.2.3 Complex Coordinator

The Complex Coordinator,\* produced by JWM, Inc., tests motor coordination and reaction time as measures of alcohol intoxication. As configured for this program, the display portion of the unit consists of four columns of five indicator lights, with a different color indicator in each of the five positions (from top to bottom, these were red, amber, green, white, and yellow). The columns are arranged in two pairs mounted on either side of a display panel, as shown in the rough sketch below.



The Subject sits facing this display panel and grasps the two spring-loaded control levers shown in the sketch. Each lever is associated with the column pair on its side of the unit.

At the commencement of a trial, one indicator in the left-hand column of each pair illuminates (not necessarily--or generally--the same color indicator in the two columns). By moving the levers, the Subject seeks to illuminate the corresponding lights in the right-hand columns. Once he has

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\*The manufacturer's trade name for this device is the Electronic Programmable Interactive Coorditester/trainer (EPIC).

done so, and succeeds in holding the match for a predetermined time (0.5 seconds in this case) a new pair of "target" indicators illuminates, and the Subject adjusts the levers to effect the new match. The control function is so designed that pulling back on the lever causes illumination to travel up the corresponding column, etc.

In this program, Complex Coordinator trials consisted of thirty-five (35) "problems" (i. e., required matchings of pairs of indicators). All trials presented precisely the same sequence of problems, a limitation imposed by the system rather than by the intent of the experimenters. Two distinct scores were recorded for each trial:

- (1) The total time required to complete the 35 problems.
- (2) The right-hand and left-hand "coordination counts."

The second measure necessitates clarification. Two digital counters, one devoted to the left-hand control lever and the other to the right, recorded the number of times the Subject illuminated a target indicator. Clearly, a "perfect" coordination count would be 35 on each hand, or a total of 70, corresponding to the number of target indicators presented in the course of a trial. However, if the Subject overshot the indicator, or slipped off it before the 0.5 second match duration had elapsed, his count would increase beyond this minimum value.

It should be noted that the Complex Coordinator possesses much more complexity than the preceding description would indicate. For example, two additional pairs of indicator columns may be employed to require foot pedal activations; thus, coordination of all four limbs may be tested. Parameters such as the match duration time and the number of problems constituting a trial may be varied over fairly wide ranges. Also, a maximum solution time for each problem may be specified, thus affording yet a third measure, or "score" (i. e., number of "unsolved" problems). The Subject may also be constrained to solve problems by achieving matches in a fixed sequence (e. g., left hand, right foot, left foot, right hand). Finally, the definition of problem solution may be changed, e. g., instead of having to "match" a target indicator, the Subject may be required to illuminate the indicator immediately above (or below) the target. The test results discussed herein thus apply only to one of the simplest configurations of this system, a configuration chosen since it appeared most transferable to an automobile environment.

### 2.2.3.1

#### Procedures

As originally planned, Subjects were to complete twelve blocks of two trials on the Complex Coordinator on each of their three training sessions. However, an unforeseen delay in the shipment of the instrument resulted in only two sessions of training for each Subject. Accordingly, blocks of three (3) trials were employed. While not all Subjects completed all 72 trials scheduled, each had taken at least 60 before the conclusion of the training phase.

In order to maintain motivation throughout the "learning curve," a number of different criteria were adopted for training rewards. These were:

- . \$0.25 for times not exceeding 70 seconds and coordination counts not exceeding 85;
- . \$0.50 for times not exceeding 60 seconds and coordination counts not exceeding 80;
- . \$1.00 for times not exceeding 45 seconds and coordination counts not exceeding 78.

In each case, the reward was contingent upon satisfaction of both time and coordination criteria.

Training disclosed that Subjects varied widely in their capabilities with respect to the Complex Coordinator. Some acquired the ability to consistently win \$1.00 while others only rarely achieved even the \$0.25 reward. As a result, a decision was made to assign individual criteria for testing. These criteria were computed from the scores produced by each Subject during his next-to-last set of 10 training trials\* as follows:

- . First, the time scores of those trials were averaged; the result was increased arbitrarily by 5 seconds to produce the time criterion.
- . Second, the total coordination counts were averaged and increased arbitrarily by 3 to produce the coordination criterion.

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\* It was desirable to compute criteria from the results of trials taken toward the end of training since (it was hoped) these would be least contaminated by learning effects. However, to insure that fatigue effects would not produce overly lenient criteria, the last 10 training trials were discounted.

Resulting sets of criteria are listed below.

<u>Subject Number</u>	<u>Sex</u>	<u>Age</u>	<u>Time (sec.)</u>	<u>Coordination Count</u>
102	M	26	56	80
103	F	31	65	80
105	F	25	70	87
107	M	40	60	82
108	F	42	76	87
110	F	42	72	77
111	F	56	88	84
115	F	29	59	77
117	F	23	59	77
120	M	30	52	78
123	M	47	61	82
125	F	35	60	77
126	M	26	50	79
129	M	39	62	78
136	F	22	51	81
138	M	32	63	82

Subjects completed a block of 3 Complex Coordinator trials during each test cycle. Each trial carried a base value of \$0.25, with this reward doubled if all three were passed. Again, passing the trial required satisfaction of both components of the individual's criterion.

Several minor problems occurred during Complex Coordinator testing. These included the breaking of the springs in both hand control levers and a malfunction of the time counter. In addition, several Subjects (at high BAC) stated that the task was inducing nausea. For these reasons, several testing blocks were not completed.

#### 2.2.3.2 Results

##### 2.2.3.2.1 Individual Criteria

As a first step in analysis, Complex Coordinator data were examined relative to the individual testing criteria listed previously. The results of the most promising strategies are summarized in the following table and in Figure 7:

Strategy BAC	1/3	1/2	2/3
< 0.03%	0	0	0
0.03-0.06	0	0	0
0.06-0.09	0	0	0
0.09-0.12	8.7	17.4	26.1
0.12-0.15	23.4	31.9	46.8
0.15-0.18	56.6	60.4	69.8
≥ 0.18%	83.3	83.3	94.4

(Individual Criteria)

Control data disclosed average sober rejection rates of 0%, 0%, and 0.4%, respectively, for strategies 1/3, 1/2, and 2/3. Analyses of variance applied to the data from strategy 1/2 produced the following results:

	BAC	Sex	BAC	Age	BAC	Subgroup
F value:	14.78	0.75	4.99	4.36	9.97	2.81
Significance:	P < .01	P > .05	P < .05	P > .05	P < .01	P > .05

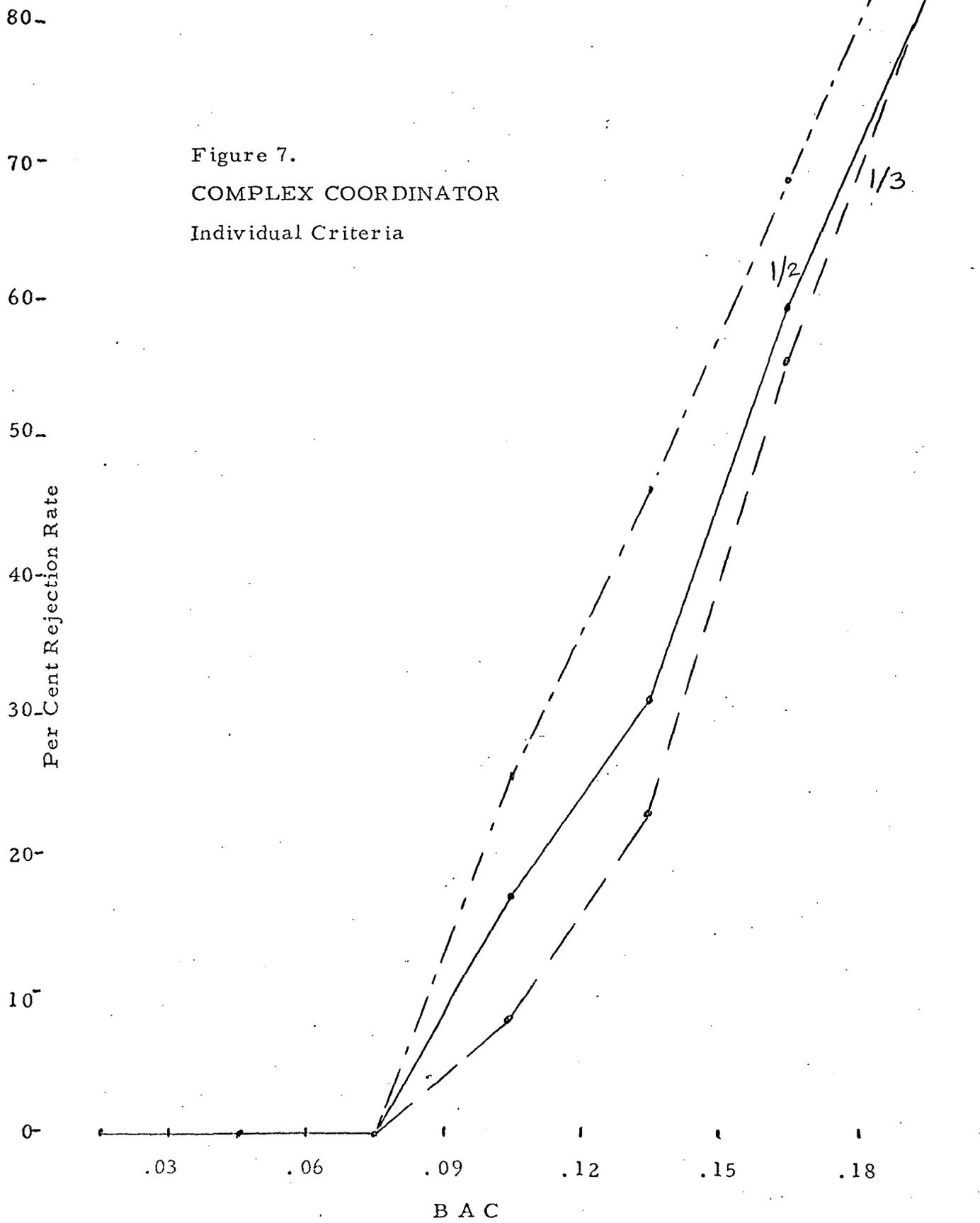
While not statistically significant in this analysis, the main effects of age and subgroup might warrant closer examination. The difference among subgroups, in particular, is of interest. Subgroup 1 produced the highest rejection rates during experimental sessions, Subgroup 2 the next highest, and Subgroup 3 the lowest. This fact supports the observation of the project staff that all Subjects seemed to improve their Complex Coordinator scores steadily throughout the testing phase, indicating that learning this task is a rather lengthy process. This may, in part, be due to the fact that the same sequence of problems is always repeated for each trial, a sequence amenable to, but possibly requiring relatively long time for, memorization. Had a different sequence been presented each time, Subject capability might have "plateaued" sooner.

#### 2.2.3.2.2

#### Universal Criterion

The next step in the analysis sought to examine the Complex Coordinator under a universal criterion. Selection of an appropriate criterion was impeded by the wide range of capability demonstrated by the sixteen Subjects. Ultimately, a criterion of 80 seconds and a coordination count of 80 was adopted. Training results indicated that this was (approximately) the most stringent criterion that could be applied without severely penalizing some of the older Subjects (notably, numbers 108-111). With respect to this criterion, only one strategy (1/3) appeared to offer some promise.

Figure 7.  
COMPLEX COORDINATOR  
Individual Criteria



The corresponding data are tabulated below and depicted in Figure 8.

BAC	Universal Criterion 1/3 Strategy
< 0.03%	0
0.03-0.06	0
0.06-0.09	0
0.09-0.12	4.4
0.12-0.15	19.2
0.15-0.18	37.0
≥ 0.18%	61.1

Analyses of variance applied to these data again disclosed no statistically significant effect for Sex, Age, or Subgroup. However, it is of interest that none of the "fails" produced by younger Subjects (age 30) resulted from exceeding the time component of this criterion, i. e., all such "fails" were caused by high coordination counts. This points up one fallacy in this analysis: had the Subjects actually been testing under this universal criterion, younger Subjects (at least) would have been able to devote more attention to their coordination counts. Even at very high BAC, their times were sufficiently low that they could have tolerated an additional 10 to 20 seconds to complete the trial; this extra time could have allowed them to more carefully control the levers to keep their coordination count within bounds. In short, the results listed above are due at least in part to the limitations of this a-posteriori analysis, and may well exaggerate the performance attainable with a universal criterion.

#### 2.2.3.2.3

#### Time-Only Criteria

In conducting the analyses described above, the project staff noted that coordination count apparently is a less sensitive measure of Subject intoxication than trial time. Specifically, if coordination count scores had been discounted, relatively few failed trials would have been transformed into passes. Attention was therefore directed to the feasibility of implementing the device under time-only criteria, a presumably less expensive design approach.

In doing so, two steps were taken. First, test data were analyzed relative to a universal time-only criterion of 80 seconds. This was identical to the time-component of the universal criterion discussed in section 2.2.3.2.2 above, and was chosen to permit quantitative assessment of the

80-

70-

60-

50-

40-

30-

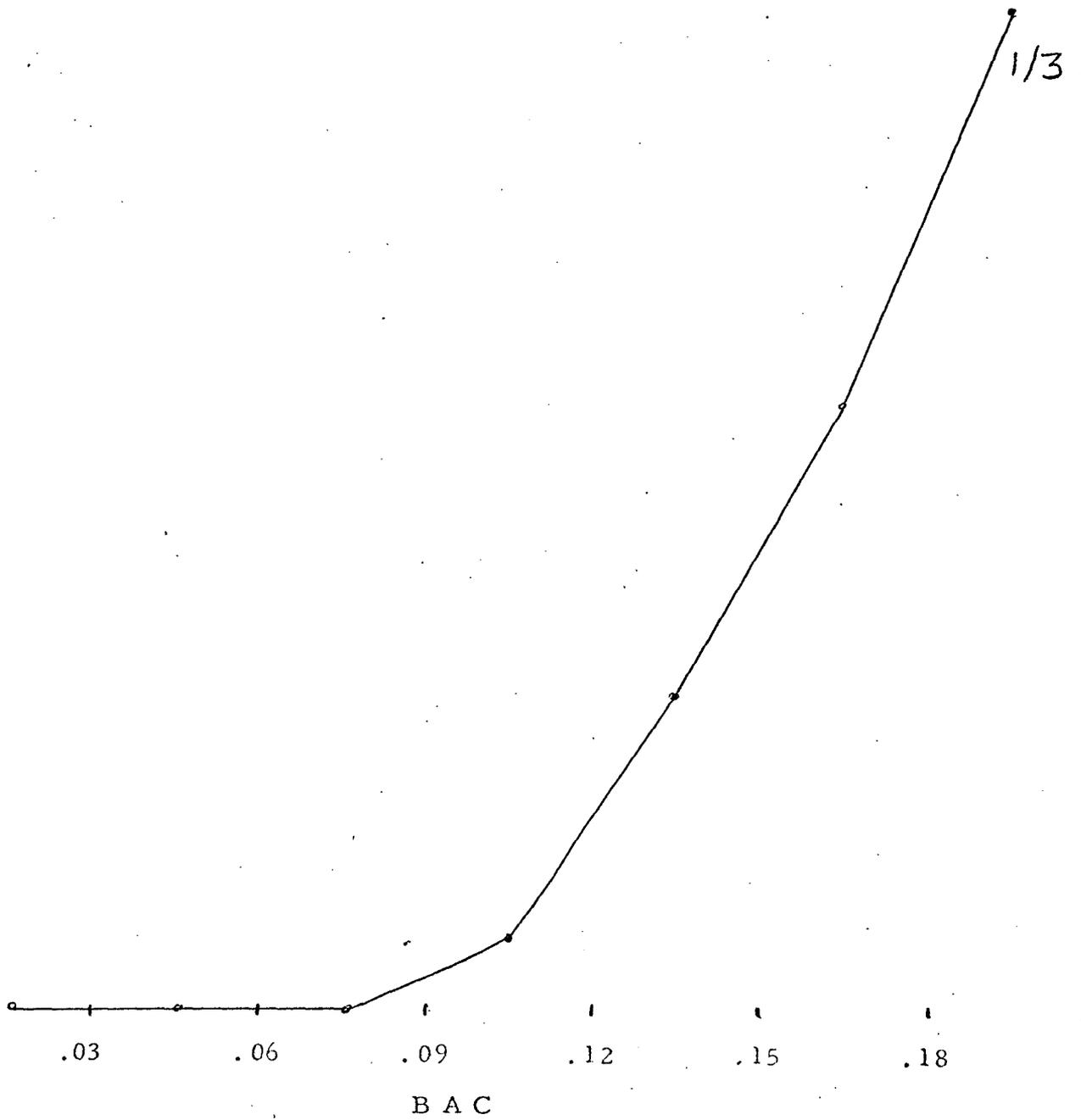
20-

10-

0-

Figure 8.  
COMPLEX COORDINATOR  
Universal Criterion: 80/80

Per Cent Rejection Rate



effects of time and coordination count on the observed failure rates. Second, a set of individual criteria were selected. For each Subject, this criterion was 5 seconds less than the time-component of his previous individual criterion (discussed in section 2.2.3.2.1).

Analysis relative to these individual time-only criteria indicates that the 1/3 strategy would produce performance comparable to that observed for the combined time/coordination count case. However, it is of interest to note that, in the time-only case, failure rate as a function of BAC is more nearly uniform across the two age groups. This fact could be taken to support a preference for time-only criteria over the combined score approach. The universal criterion analysis, however, seems to indicate that a time-only Complex Coordinator might be restricted to individual criteria implementations. Specifically, no young Subject ever failed a trial....regardless of BAC....relative to the 80 seconds criterion, while appreciable percentages of older individuals did so at BACs above 0.09%.

Thus, while time-only criteria appear comparable to (or, perhaps, a slight improvement over) the combined approach in the individual case, their applicability for universal employment is highly suspect.

#### 2.2.3.3 Discussion

Two questions arise concerning the Complex Coordinator's merits as an ASIS. The first concerns the apparently long duration of learning. This could increase implementation costs by necessitating lengthy training of those drivers required to have the system installed in their vehicles. Moreover, it admits the possibility that the drivers' capability may subsequently increase to the point where their pass/fail criteria are too lenient, thus degrading operational performance. The second question extends beyond this particular instrument and concerns the feasibility of any ASIS that relies on individual criteria. Specific disadvantages of such systems are discussed in the final section of this report. Here, it suffices to comment that the laboratory-derived performance of an individual criterion device may be an optimistic estimate of that which is achievable in the real world.

Two specific design parameters of this system warrant closer attention. First, the trial durations (35-85 seconds) observed during the program may be intolerably long for operational applications.\* Second, the use of a fixed sequence of problems not only may contribute to lengthening

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\* Trial duration is a function of both the number of problems constituting the trial and the specific match duration time. Thus, trials could be shortened by employing fewer problems, a shorter match time, or both. The appropriate approach to reducing trial time must involve trade-offs between these two parameters and suggests the need for further testing.

the learning curve as suggested earlier, but also may admit less degradation due to alcohol than would a random sequence. It is therefore suggested that future tests of this device employ trials consisting of shorter, random sequences of problems.

#### 2.2.4 Divided Attention Test

The Divided Attention Test (DAT), developed by DOT-TSC, has, as the name implies, two task components. One component is a pursuit tracking task, the display for which includes projected images of a target and tracking symbol. The target symbol undergoes unpredictable horizontal oscillations, driven by two sinusoidal forcing functions. The Subject attempts to constantly align the tracking symbol with the target symbol by appropriately turning a steering wheel. The steering response is compatible, i. e., turning the wheel to the left causes the tracking symbol to move to the left, etc. The other task component is a test of reaction time in the peripheral vision field. Sixteen indicator lights, subtending  $0.5^{\circ}$  visual angle and mounted every  $11^{\circ}$  from the center of the Subject's view on a semi-circular screen,\* illuminate at varying intervals of time in an unpredictable sequence. When the Subject detects a light, he depresses the pushbutton on either the left or right side of the steering wheel, in accordance with whether the illuminated indicator is on the left or right side of the screen. Indicator lights remain illuminated until the Subject correctly responds, or for a maximum of 1.4 seconds.

The measure, or "score," corresponding to the DAT tracking task was the tracking error, expressed in volts (dc). For the peripheral vision task, the Subject's reaction time for each indicator illuminating during the course of a trial was recorded. Trial duration was set at two minutes; this typically allowed sufficient time for some 50 indicators to illuminate.

Throughout the program, the DAT was examined with respect to five (5) trial conditions. These are listed below:

- Condition A: Tracking task operating, peripheral task off.
- Condition B: Tracking task off, peripheral task operating.
- Condition C: Both tasks operating, Subject instructed to perform only the tracking task.
- Condition D: Both tasks operating, Subject instructed to perform only the peripheral task.

---

\*The tracking task display is located immediately above the center of this screen. The screen radius is roughly 28 inches.

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---

\*The tracking task display is located immediately above the center of this screen. The screen radius is roughly 28 inches.

Condition E: Both tasks operating, Subject instructed to perform both.

Only condition E conformed fully to the DAT design described above. Conditions A through D served as control conditions, permitting assessment of the effects of alcohol upon each task component separately and isolation of the source of any effects upon the joint task.

#### 2.2.4.1 Procedures

DAT training consisted of six blocks of two trials on each of the three training sessions. Of the total 36 trials, 12 were taken under condition E and 6 under each of the other four conditions. All Subjects took their training trials in the following sequence of conditions:

	<u>Training Trials</u>		
<u>Block No.</u>	<u>1st Session</u>	<u>2nd Session</u>	<u>3rd Session</u>
1	A, B	D, B	E, A
2	C, D	E, E	B, E
3	E, E	C, A	E, C
4	A, E	E, B	D, E
5	C, E	E, D	B, C
6	B, D	A, C	A, D

Separate criteria for training reward were developed for the two task components. For the peripheral vision task, Subjects earned \$0.50 if they produced at least 25 reaction times not exceeding 500 milliseconds in the course of a trial. A \$0.50 reward was also offered for the tracking task, with the criterion depending upon the condition in question. For conditions A and C, the criterion was a tracking error not exceeding 4.0; for condition E, 5.0 was employed. Thus, a maximum award of \$1.00 could be earned for condition E trials, and \$0.50 for each of the other conditions.

During the testing phase, Subjects completed a block of three DAT trials on each test cycle. Precisely one of these was always condition E. The sixteen Subjects were partitioned into three sets (each containing at least one member of every subgroup) in accordance with the condition sequence of their trials. These sets and sequences are listed below.

SET 1

Members: Subjects 102, 111, 115, 123, 129

<u>Block No.</u>	<u>First (Experimental/ Control) Session</u>	<u>Second (Experimental/ Control) Session</u>
1	A, B, E	C, D, E
2	A, C, E	B, D, E
3	B, C, E	A, D, E
4	C, D, E	A, B, E
5	B, D, E	A, C, E
6	A, D, E	B, C, E
7	D, C, E	B, A, E
8	D, B, E	C, A, E

SET 2

Members: Subjects 103, 107, 108, 117, 126, 136

<u>Block No.</u>	<u>First (Experimental/ Control) Session</u>	<u>Second (Experimental/ Control) Session</u>
1	C, E, D	B, E, A
2	D, E, B	A, E, C
3	A, E, D	C, E, B
4	B, E, A	C, E, D
5	A, E, C	D, E, B
6	C, E, B	A, E, D
7	B, E, A	C, E, D
8	A, E, C	D, E, B

SET 3

Members: Subjects 105, 110, 120, 125, 138

<u>Block No.</u>	<u>First (Experimental/ Control) Session</u>	<u>Second (Experimental/ Control) Session</u>
1	E, A, D	E, B, C
2	E, C, B	E, A, D
3	E, B, D	E, C, A
4	E, D, A	E, C, B
5	E, B, C	E, D, A
6	E, D, B	E, A, C
7	E, D, A	E, C, B
8	E, B, C	E, D, A

Thus, each Subject encountered precisely the same sequence of trial conditions on experimental and control sessions, with condition E occurring twice as often as any other condition. Criteria for testing reward were the same as had been employed during the training phase.

Shortly after commencement of the training phase, the digital timer used to record peripheral task scores malfunctioned. During the several hours that elapsed before a replacement could be found, the affected Subjects were able to take only tracking task trials (Conditions A and C); however, most of the "missed" trials were made up before the end of training. During testing, several Subjects complained this device (like the Complex Coordinator) tended to make them nauseous. Thus, a number of testing trials were skipped at high BACs.

#### 2.2.4.2            Results

Detailed analysis of DAT data is being conducted by TSC. Because this device is in a much earlier stage of development than are the other three instruments, the objective of this analysis is to obtain basic information concerning the effect of alcohol upon the two task components, jointly and individually. Test procedures applied to the DAT were geared to this objective; as a result, data were not collected in a manner permitting assessment of a variety of implementation strategies.\* Thus, it is inappropriate to discuss the performance of the DAT in the same context that applies to the other devices.

In order to provide some preliminary indication of the instrument's sensitivity to alcohol, the mean scores produced during experimental sessions are tabulated below as a function of BAC class interval. In this table, the tracking scores represent the mean pursuit tracking error, while the peripheral scores are the mean numbers of reaction times not exceeding 500 milliseconds.

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\* In effect, the DAT, as tested in this program, represented five separate instruments, corresponding to the various trial conditions. Since no more than one trial was taken under any given condition at any one time, there is no basis for computing performance relative to any strategy other than 1/1. Thus, no tabulations of DAT results are given in the Appendix to this report.

Condition BAC	Tracking Task			Peripheral Task		
	A	C	E	B	D	E
< 0.03%	2.466	2.469	3.007	31.2	34.8	29.1
0.03-0.06	2.402	2.302	2.814	29.8	30.2	27.3
0.06-0.09	2.741	2.540	3.332	26.0	34.2	22.9
0.09-0.12	2.797	2.929	3.747	26.6	24.4	17.1
0.12-0.15	3.431	3.778	4.478	21.5	21.4	13.7
0.15-0.18	4.041	3.857	5.105	14.5	15.3	9.3
≥ 0.18%	4.733	4.618	5.875	9.0	6.4	4.2

Analyses of variance (BAC versus Condition) applied to these data produced the following results:

	Tracking Task		Peripheral Task	
	Condition	BAC	Condition	BAC
F value:	43.40	75.02	14.48	48.71
Significance:	P<.01	P<.01	P<.01	P<.01

Thus, both BAC and trial condition have statistically significant effects upon the tracking and peripheral task scores. An instrument (such as the DAT) based on either or both of these tasks therefore is at least feasible as a candidate ASIS.

As a rough estimate of the performance that might be produced by the DAT, the results of condition E trials are tabulated below relative to the (rather arbitrary) criterion employed during testing (tracking score not exceeding 5.0, peripheral score of at least 25). To provide some range for comparison, these trials are also tabulated for a more lenient criterion (tracking score not exceeding 5.5, peripheral score of at least 15). Since only one such trial was taken during each testing cycle, these data reflect a 1/1 strategy.

BAC	Criterion	
	<u>Track <math>\leq</math> 5.0, per. <math>\geq</math> 25</u>	<u>Track <math>\leq</math> 5.5, per. <math>\geq</math> 15</u>
< 0.03%	20.0	3.1
0.03-0.06	30.5	8.6
0.06-0.09	44.4	16.6
0.09-0.12	75.0	29.2
0.12-0.15	89.4	67.5
0.15-0.18	92.5	81.1
$\geq$ 0.18%	100.0	100.0

It is evident from the high sober rejection rate that the original testing criterion might not suffice for operational applications. However, the second criterion, coupled with a strategy that leaves some margin for error (e.g., 1/3 or 1/2), might well produce acceptable performance.

The data listed above are shown graphically in Figure 9.

#### 2.2.4.3

#### Discussion

It would be premature at this time to draw conclusions concerning the merits of the DAT as an ASIS. Nevertheless, it has been shown that scores on the constituent tasks are significantly degraded by alcohol. In addition, there is some evidence that reasonable criteria and strategies can be identified that will result in meaningful performance. However, it is clear that further development and testing is required before this instrument can be fully evaluated.

As one area for further development, it is suggested that attempts be made to improve the "face validity" of the DAT. As configured for this program, the device suffered in this regard in two ways:

- The trail duration (2 minutes) was clearly much too long to be practical, especially if multiple-trial strategies are to be considered. It is recognized that this fact was known prior to the program, and that the lengthy trial time was necessary for the collection of adequate data. However, the time is now ripe to examine more reasonable durations (e.g., 20 seconds or less).

100-

90-

80-

70-

60-

50-

40-

30-

20-

10-

0-

Figure 9.  
DIVIDED ATTENTION TASK  
1/1 STRATEGY

Criteria:  
Tracking  $\leq 5.0$   
Peripheral  $\geq 25$

Criteria:  
Tracking  $\leq 5.5$   
Peripheral  $\geq 15$

Per Cent Rejection Rate

B A C .03

.06

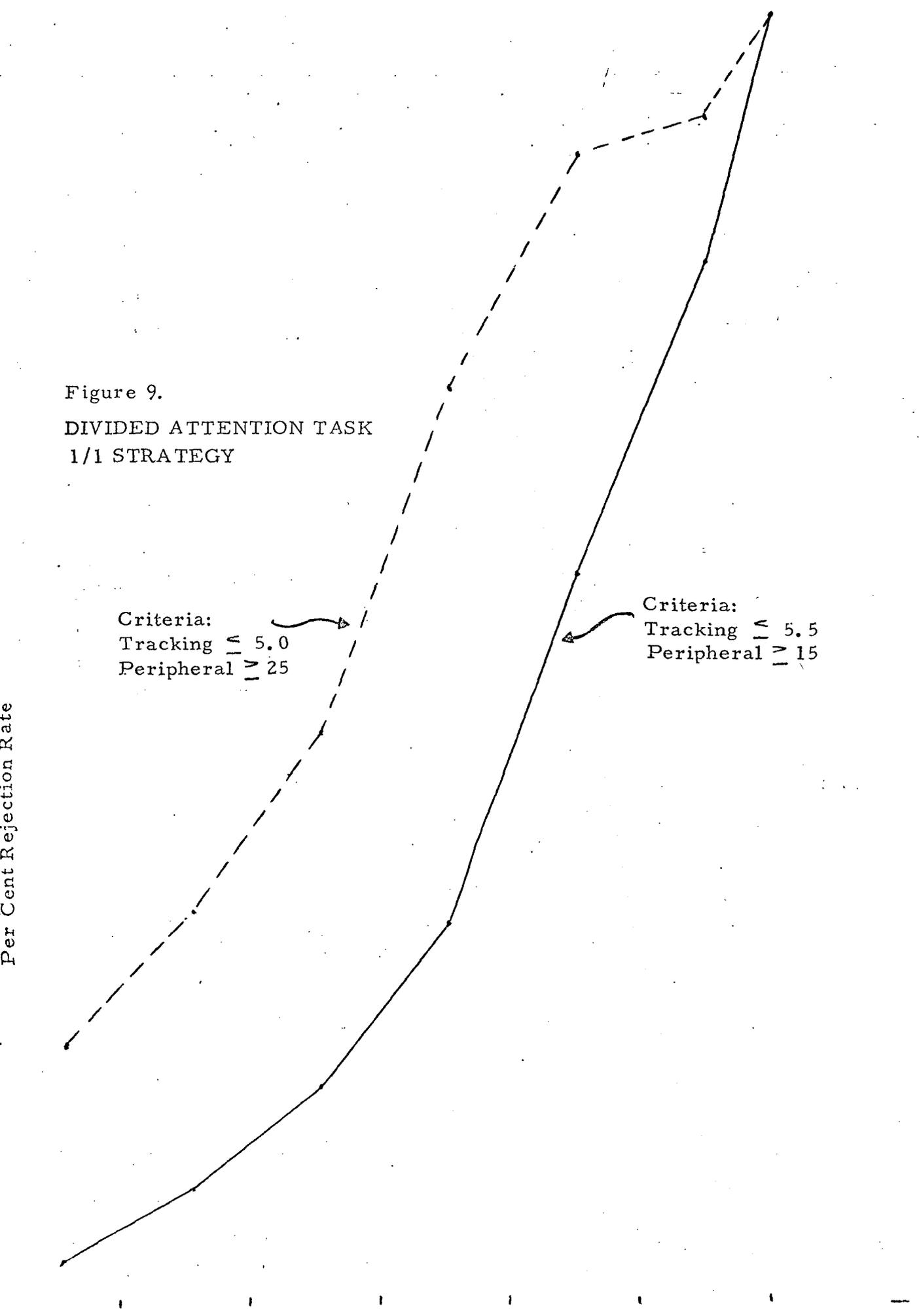
.09

.12

.15

.18

-40-



- The peripheral vision task was inherently biased against Subjects wearing eyeglasses. These individuals were essentially blind to indicators located on the extremes of the semicircular screen, and as a result only rarely achieved peripheral rewards. Again, this is not to suggest that this outcome was not anticipated prior to testing; however, now that this has been shown conclusively to be a problem, future configurations of the instrument should incorporate fewer peripheral indicators.

By attending to these items during the next stage of development, the estimates of DAT performance obtained from future tests will be less open to question.

### 3. General Discussion and Conclusions

The major conclusion to be drawn from this program is that...with the exception of the Reaction Analyzer...the instruments offer better\* performance than the devices tested during the 1972 program, and thus may aptly be termed "second generation" ASIS.

Performance, however, is not the only issue to consider in formulating decisions concerning the applicability of these instruments. Several other factors may also have a significant impact. While the program was not designed to examine these in a formal, systematic manner, it is possible to offer some observations and comments that at least suggest some of the major areas of concern. These are discussed below.

#### 3.1 Universal versus Individual Criterion

In previous sections of this report, mention was made repeatedly of the different advantages and disadvantages of two distinct classes of ASIS devices. The first class, i. e., those that apply a universal pass/fail criterion to all drivers, in effect ignore individual differences in capability. Thus, they admit the possibility that some drivers might succeed in passing the test even while markedly impaired while others may be prevented from operating their vehicles at least occasionally when (relatively) "sober." However, such devices are relatively easy to implement, in that there is no need to design for varying criteria. The second class, i. e., those that issue a unique criterion to each driver, promise more nearly uniform performance across all individuals. Properly selected, such criteria can help to insure that all drivers will face roughly equal probability of rejection at a given degree of impairment.\*\* However, an individual criterion device must be designed to permit the driver to insert or select his own criterion,\*\*\* thus requiring more sophistication, and presumably higher cost, than instruments of the universal class. More importantly, it seems likely that devices employing individual criteria could easily be "cheated." This could be accomplished in one or both of the following ways:

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\* In this context, "better" implies lower sober, and higher intoxicated, rejection rates. This is admittedly a subjective assessment, since quantitative standards against which ASIS effectiveness can be measured are yet to be specified.

\*\* Although not necessarily at a given level of BAC. Ample evidence exists to show that BAC is not a uniform measure of impairment.

\*\*\* A constraint arising from the fact that many (if not most) vehicles routinely are operated by more than one driver.

- . First, once the device is installed in his vehicle, the driver might simply select a criterion more lenient than his own.
- . Second, during the pre-installation training from which his criterion would be derived, the driver might purposely misrepresent his true capability and thus acquire an artificially lenient criterion. During the 1972 program an experiment was conducted to assess the effectiveness of this form of cheating for an individual criterion device (Quickey). The participating Subjects acquired criteria that, while not noticeably different from those issued to many non-cheating volunteers, were sufficient to allow them to pass the test nearly all the time, even at maximum BAC ( $> 0.18\%$ ).

While it is undoubtedly true that countermeasures might be developed to combat these approaches, it is likely that they would prove costly to implement and less than completely effective. The laboratory-derived performance of an individual criterion ASIS thus probably exaggerates its "real world" impact.

In view of these considerations, it may be concluded that, if a device is amenable to either universal or individual criterion implementation, the former is the more desirable approach. This is especially clear for the Critical Tracking Tester, since the performance offered by the two schemes do not differ appreciably. It must also be observed that the feasibility of instruments for which no suitable universal criterion can be established is open to serious doubt. The Complex Coordinator may belong to this class (although, as stated in Section 2.2.3 the test design precluded proper assessment of its merits relative to a universal criterion). If this is actually the case, the very attractive performance it demonstrated may represent an unattainable ideal.

### 3.2 Public Acceptability

If any ASIS is to prove useful it must be deemed at least tolerable by a sizable majority of the driving public. Operational application will almost certainly require passage of enabling legislation or standards. Enactment of such measures could be thwarted if most drivers... or even a fair sized vocal minority... oppose the concept. In addition, if a device meets with substantial disfavor, there likely will be a high incidence of tampering, removal, destruction, and employment of any and all overt or covert means of circumventing its purpose. The feasibility of any given device is thus tied directly to its acceptability.

In order to provide some data concerning this factor, the Subjects were requested at the beginning of their last session to list the four instruments in their own order of preference and to provide some rationale for their choices. Fourteen Subjects complied with this request. By assigning a value of 1 to a "first place" vote, 4 to "last place," etc., numeric scores of relative preference were derived. Summing across all respondents produced the following results:

Device	Total Score	Number Choosing			
		1st Place	2nd Place	3rd Place	4th Place
Critical Tracking Tester	27	6	3	5	0
Complex Coordinator	27	5	5	4	0
Divided Attention Test	35	3	5	2	4
Reaction Analyzer	51	0	1	3	10

The written comments associated with these choices are summarized below:

#### Critical Tracking Tester

Viewed as highly practical by nearly all Subjects (this may be due, in part, to the incorporation of an actual automobile interior into this device). Two Subjects (107 and 129), however, suggested that repeated testing might damage the steering mechanism. Subject 120 stated that the device could easily be passed while intoxicated; all others expressed precisely the opposite view. In addition, all who chose to comment on the relative nuisance of the instruments felt this device would suffer least in that regard.

#### Complex Coordinator

Nearly all Subjects stated that this instrument was "fun" to operate. However, 7 of the 14 explicitly remarked that it would be impractical for automobile installation. Several also observed that they were continually improving their scores throughout testing, and asserted that they would eventually be able to pass at high levels of intoxication.

### Divided Attention Test

Complete agreement among all Subjects that trial duration was too long. Partly because of this, and also owing to the large physical dimensions of the peripheral task screen, nearly all questioned its practicality. Subjects wearing eyeglasses (as well as a few others) stated they could not see lights on the extremes of the screen.

### Reaction Analyzer

A nearly uniform lack of trust in this device was evident, with many Subjects specifically mentioning the high probability of sober failure. Others reported that they felt they had actually performed better on certain failed trials than on others resulting in passes. Only 2 of the 14 felt it would be practical for real world application.

Based upon the preceding, it appears that the Critical Tracking Tester would be the most acceptable of the four devices. While the Complex Coordinator was viewed with numerically equal favor, this seemed to arise more from its interesting, or amusing, characteristics in the laboratory setting than from any perceived real world practicality. The Divided Attention Test, on the other hand, proved less acceptable largely because of design characteristics that were an artifact of testing. If the design modifications suggested in Section 2.2.4 are adopted, its acceptability might be considerably enhanced. The disfavor with which the Subjects viewed the Reaction Analyzer is perhaps more serious, since it seemed to stem from the instrument's performance, especially the high sober rejection rate. Only further development and testing, as suggested in Section 2.2.2 will determine whether this problem can be solved.

-----

This report concludes with a brief summary of the test results pertaining to each of the four instruments.

#### (1) Critical Tracking Tester

This device has been shown to have the potential to prevent 65 to 80% of grossly intoxicated motorists (BAC  $\geq$  0.18%) from operating their vehicles without penalizing sober drivers. Moreover, the corresponding criteria may be applied universally, thus reducing implementation costs and limitations. Finally, the device seems well designed from the standpoint of acceptability.

The above remarks notwithstanding, there clearly remains room for improvement. The next stage of development should therefore concentrate on optimizing certain parameters to maximize performance. In particular, it would be desirable to increase rejection rate at BACs in the neighborhood of the statutory limit (0.10% in most states).

## (2) Complex Coordinator

Although this instrument may share the limitations common to individual criterion devices, its performance is sufficiently promising to justify continued consideration. It, too, would reject substantial proportions of intoxicated drivers (up to roughly 90% at high BAC) without inconvenience to sober motorists. However, task duration should be decreased to enhance the acceptability of the device. Also, each trial should incorporate a random sequence of problems. This may both increase task difficulty (particularly, it is hoped, when the driver is intoxicated) and reduce the currently lengthy learning time.

Further development of the Complex Coordinator should focus on two major issues:

- . the feasibility of selecting a suitable universal criterion;
- . design and configuration requirements associated with installation in automobiles.

With regard to the first issue, tests should be conducted using relatively large samples of Subjects to determine the range of capability demonstrated by representatives of the entire driving population. It is recommended that these tests examine both time-only and time-plus-coordination criteria. If this effort discloses that a substantial proportion of the public is compatible with a single criterion, the impact of the limitations of an individual criterion scheme might be softened. If this is not the case, attention should be turned to the feasibility of resolving those limitations.

## (3) Divided Attention Test

It has been shown that this device is based on a concept that possesses face validity for ASIS applications, and some indications exist that suitable criteria may be selected to produce attractive performance. Much, however, remains to be done. Specifically, the design must be extensively modified if the instrument is to prove acceptable and amenable to vehicular installation. At the very least, though, this instrument shows ample promise to warrant further development.

(4) Reaction Analyzer

Less can be concluded concerning this instrument than for the previous three. The performance produced relative to the single (arbitrary) criterion examined during testing appears at most marginally suitable for operational applications. However, there is no basis for estimating the extent to which alternate criteria would affect this performance.

Clearly, if future tests of this device are to be conducted, it must be modified to produce more meaningful data than could be obtained in this program.

APPENDIX

SUMMARY ASIS PERFORMANCE DATA

## Critical Tracking Tester Results

The following tables present the performance of the CTT relative to four universal criteria (4.40, 4.20, 4.00, and 3.80) and two individual criteria (5th percentile and 10th percentile). In each case, the results are given for strategies 1/1, 1/2, 2/2, 1/3, 2/3, and 3/3, and are presented separately for various categories of Subjects. Both experimental and control session data are presented.



CTT- 440 EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
<i>SGRP 1</i>								
<i>S</i>	<.03	11.11	4.76	23.81	0.00	9.52	23.81	21
<i>G</i>	.03-.06	14.81	0.00	22.22	0.00	11.11	33.33	9
<i>R</i>	.06-.09	33.33	20.00	40.00	20.00	20.00	60.00	5
<i>P</i>	.09-.12	59.26	22.22	77.78	22.22	77.78	77.78	9
	.12-.15	59.65	52.63	78.95	36.84	57.89	84.21	19
	.15-.18	90.91	81.82	90.91	81.82	90.91	100.00	11
	≥.18	100.00	100.00	100.00	100.00	100.00	100.00	4
<i>SGRP 2</i>								
<i>S</i>	<.03	13.89	4.17	25.00	4.17	8.33	29.17	24
<i>G</i>	.03-.06	16.67	0.00	33.33	0.00	0.00	50.00	6
<i>R</i>	.06-.09	40.74	33.33	55.56	0.00	44.44	77.78	9
<i>P</i>	.09-.12	42.86	42.86	71.43	0.00	57.14	71.43	7
	.12-.15	80.70	63.16	89.47	57.89	89.47	94.74	19
	.15-.18	77.78	76.19	85.71	66.67	80.95	85.71	21
	≥.18	87.50	87.50	87.50	75.00	87.50	100.00	8
<i>SGRP 3</i>								
<i>S</i>	<.03	6.67	0.00	5.00	0.00	5.00	15.00	20
<i>G</i>	.03-.06	12.50	12.50	12.50	12.50	12.50	12.50	8
<i>R</i>	.06-.09	16.67	0.00	25.00	0.00	25.00	25.00	4
<i>P</i>	.09-.12	42.86	28.57	57.14	28.57	42.86	57.14	7
	.12-.15	54.55	36.36	72.73	18.18	63.64	81.82	11
	.15-.18	83.33	75.00	87.50	70.83	83.33	95.83	24
	≥.18	77.78	66.67	66.67	66.67	66.67	100.00	6







CTT- 420 EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
<i>SGRP 1</i>								
<i>S</i>	<.03	9.52	4.76	19.05	0.00	9.52	19.05	21
<i>G</i>	.03-.06	11.11	0.00	11.11	0.00	11.11	22.22	9
<i>R</i>	.06-.09	13.33	0.00	20.00	0.00	20.00	20.00	5
<i>P</i>	.09-.12	44.44	22.22	55.56	11.11	55.56	66.67	9
	.12-.15	42.11	26.32	68.42	15.79	42.11	68.42	19
	.15-.18	90.91	81.82	90.91	81.82	90.91	100.00	11
	≥.18	100.00	100.00	100.00	100.00	100.00	100.00	4
<i>SGRP 2</i>								
<i>S</i>	<.03	9.72	0.00	20.83	0.00	4.17	25.00	24
<i>G</i>	.03-.06	11.11	0.00	16.67	0.00	0.00	33.33	6
<i>R</i>	.06-.09	22.22	11.11	33.33	0.00	11.11	55.56	9
<i>P</i>	.09-.12	28.57	28.57	42.86	0.00	42.86	42.86	7
	.12-.15	59.65	31.58	68.42	26.32	63.16	89.47	19
	.15-.18	69.84	57.14	80.95	52.38	76.19	80.95	21
	≥.18	83.33	87.50	87.50	75.00	87.50	87.50	8
<i>SGRP 3</i>								
<i>S</i>	<.03	5.00	0.00	0.00	0.00	0.00	15.00	20
<i>G</i>	.03-.06	8.33	0.00	12.50	0.00	12.50	12.50	8
<i>R</i>	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	4
<i>P</i>	.09-.12	33.33	28.57	42.86	28.57	28.57	42.86	7
	.12-.15	39.39	18.18	54.55	9.09	27.27	81.82	11
	.15-.18	68.06	54.17	70.83	50.00	66.67	87.50	24
	≥.18	77.78	66.67	66.67	66.67	66.67	100.00	6





PRINT 3

RESULTS: CTT- 400  
EXPERIMENTAL DATA  
PERFORMANCE VS BAC

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
A	<.03	2.56	0.00	6.15	0.00	0.00	7.69	65
L	.03-.06	7.25	0.00	8.70	0.00	8.70	13.04	23
L	.06-.09	9.26	5.56	22.22	0.00	5.56	22.22	18
	.09-.12	21.74	4.35	34.78	4.35	17.39	43.48	23
	.12-.15	31.29	10.20	53.06	8.16	18.37	67.35	49
	.15-.18	61.90	48.21	67.86	41.07	66.07	78.57	56
	≥.18	77.78	66.67	83.33	61.11	77.78	94.44	18
M	<.03	3.57	0.00	10.71	0.00	0.00	10.71	28
A	.03-.06	5.13	0.00	7.69	0.00	7.69	7.69	13
L	.06-.09	9.52	0.00	28.57	0.00	0.00	28.57	7
E	.09-.12	30.30	9.09	36.36	9.09	36.36	45.45	11
S	.12-.15	24.07	5.56	50.00	5.56	16.67	50.00	18
	.15-.18	52.78	41.67	54.17	37.50	54.17	66.67	24
	≥.18	75.76	63.64	81.82	63.64	72.73	90.91	11
F	<.03	1.80	0.00	2.70	0.00	0.00	5.41	37
E	.03-.06	10.00	0.00	10.00	0.00	10.00	20.00	10
M	.06-.09	9.09	9.09	18.18	0.00	9.09	18.18	11
A	.09-.12	13.89	0.00	33.33	0.00	0.00	41.67	12
L	.12-.15	35.48	12.90	54.84	9.68	19.35	77.42	31
E	.15-.18	68.75	53.13	78.13	43.75	75.00	87.50	32
S	≥.18	80.95	71.43	85.71	57.14	85.71	100.00	7
Y	<.03	0.00	0.00	0.00	0.00	0.00	0.00	29
O	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	9
U	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	7
N	.09-.12	0.00	0.00	0.00	0.00	0.00	0.00	9
G	.12-.15	25.33	8.00	40.00	4.00	16.00	56.00	25
	.15-.18	38.67	20.00	44.00	16.00	40.00	60.00	25
	≥.18	52.38	42.86	57.14	28.57	42.86	85.71	7
O	<.03	4.63	0.00	11.11	0.00	0.00	13.89	36
L	.03-.06	11.90	0.00	14.29	0.00	14.29	21.43	14
D	.06-.09	15.15	9.09	36.36	0.00	9.09	36.36	11
	.09-.12	35.71	7.14	57.14	7.14	28.57	71.43	14
	.12-.15	37.50	12.50	66.67	12.50	20.83	79.17	24
	.15-.18	80.65	70.97	87.10	61.29	87.10	93.55	31
	≥.18	93.94	81.82	100.00	81.82	100.00	100.00	11

CTT- 400 EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
SGRP 1								
S	<.03	6.35	0.00	19.05	0.00	0.00	19.05	21
G	.03-.06	7.41	0.00	11.11	0.00	11.11	11.11	9
R	.06-.09	6.67	0.00	20.00	0.00	0.00	20.00	5
P	.09-.12	33.33	11.11	44.44	11.11	33.33	55.56	9
	.12-.15	26.32	5.26	57.89	5.26	15.79	57.89	19
	.15-.18	81.82	72.73	90.91	54.55	90.91	100.00	11
	≥.18	91.67	75.00	100.00	75.00	100.00	100.00	4
SGRP 2								
S	<.03	0.00	0.00	0.00	0.00	0.00	0.00	24
G	.03-.06	5.56	0.00	0.00	0.00	0.00	16.67	6
R	.06-.09	14.81	11.11	33.33	0.00	11.11	33.33	9
P	.09-.12	14.29	0.00	28.57	0.00	14.29	28.57	7
	.12-.15	42.11	21.05	63.16	15.79	31.58	78.95	19
	.15-.18	60.32	47.62	71.43	38.10	66.67	76.19	21
	≥.18	75.00	75.00	87.50	62.50	75.00	87.50	8
SGRP 3								
S	<.03	1.67	0.00	0.00	0.00	0.00	5.00	20
G	.03-.06	8.33	0.00	12.50	0.00	12.50	12.50	8
R	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	4
P	.09-.12	14.29	0.00	28.57	0.00	0.00	42.86	7
	.12-.15	21.21	0.00	27.27	0.00	0.00	63.64	11
	.15-.18	54.17	37.50	54.17	37.50	54.17	70.83	24
	≥.18	72.22	50.00	66.67	50.00	66.67	100.00	6





PRINT 4

RESULTS: CTT- 380  
EXPERIMENTAL DATA  
PERFORMANCE VS BAC

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
A	<.03	2.05	0.00	4.62	0.00	0.00	6.15	65
L	.03-.06	4.35	0.00	4.35	0.00	4.35	8.70	23
L	.06-.09	5.56	5.56	11.11	0.00	5.56	11.11	18
	.09-.12	14.49	4.35	30.43	0.00	4.35	39.13	23
	.12-.15	16.33	4.08	26.53	4.08	10.20	34.69	49
	.15-.18	47.62	26.79	58.93	23.21	50.00	69.64	56
	≥.18	68.52	61.11	72.22	50.00	72.22	83.33	18
M	<.03	2.38	0.00	7.14	0.00	0.00	7.14	28
A	.03-.06	5.13	0.00	7.69	0.00	7.69	7.69	13
L	.06-.09	4.76	0.00	14.29	0.00	0.00	14.29	7
E	.09-.12	18.18	9.09	27.27	0.00	9.09	45.45	11
S	.12-.15	12.96	5.56	27.78	5.56	5.56	27.78	18
	.15-.18	38.89	20.83	45.83	16.67	41.67	58.33	24
	≥.18	63.64	54.55	63.64	45.45	63.64	81.82	11
F	<.03	1.80	0.00	2.70	0.00	0.00	5.41	37
E	.03-.06	3.33	0.00	0.00	0.00	0.00	10.00	10
M	.06-.09	6.06	9.09	9.09	0.00	9.09	9.09	11
A	.09-.12	11.11	0.00	33.33	0.00	0.00	33.33	12
L	.12-.15	18.28	3.23	25.81	3.23	12.90	38.71	31
E	.15-.18	54.17	31.25	68.75	28.13	56.25	78.13	32
S	≥.18	76.19	71.43	85.71	57.14	85.71	85.71	7
Y	<.03	0.00	0.00	0.00	0.00	0.00	0.00	29
O	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	9
U	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	7
N	.09-.12	0.00	0.00	0.00	0.00	0.00	0.00	9
G	.12-.15	12.00	0.00	20.00	0.00	8.00	28.00	25
	.15-.18	22.67	8.00	28.00	8.00	16.00	44.00	25
	≥.18	28.57	28.57	28.57	0.00	28.57	57.14	7
O	<.03	3.70	0.00	8.33	0.00	0.00	11.11	36
L	.03-.06	7.14	0.00	7.14	0.00	7.14	14.29	14
D	.06-.09	9.09	9.09	18.18	0.00	9.09	18.18	11
	.09-.12	23.81	7.14	50.00	0.00	7.14	64.29	14
	.12-.15	20.83	8.33	33.33	8.33	12.50	41.67	24
	.15-.18	67.74	41.94	83.87	35.48	77.42	90.32	31
	≥.18	93.94	81.82	100.00	81.82	100.00	100.00	11

CTT- 380 EXPERIMENTAL CONTINUED

BAC CLASS	STRATEGY						NO. OF BLOCKS	
	INTERVAL	1/1	1/2	2/2	1/3	2/3		3/3
SGRP 1								
S	<.03	4.76	0.00	14.29	0.00	0.00	14.29	21
G	.03-.06	7.41	0.00	11.11	0.00	11.11	11.11	9
R	.06-.09	6.67	0.00	20.00	0.00	0.00	20.00	5
P	.09-.12	22.22	11.11	33.33	0.00	11.11	55.56	9
	.12-.15	10.53	5.26	21.05	5.26	5.26	21.05	19
	.15-.18	54.55	27.27	63.64	18.18	54.55	90.91	11
	≥.18	83.33	75.00	100.00	50.00	100.00	100.00	4
SGRP 2								
S	<.03	0.00	0.00	0.00	0.00	0.00	0.00	24
G	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	6
R	.06-.09	7.41	11.11	11.11	0.00	11.11	11.11	9
P	.09-.12	9.52	0.00	28.57	0.00	0.00	28.57	7
	.12-.15	28.07	5.26	36.84	5.26	21.05	57.89	19
	.15-.18	47.62	28.57	66.67	23.81	47.62	71.43	21
	≥.18	62.50	62.50	62.50	50.00	62.50	75.00	8
SGRP 3								
S	<.03	1.67	0.00	0.00	0.00	0.00	5.00	20
G	.03-.06	4.17	0.00	0.00	0.00	0.00	12.50	8
R	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	4
P	.09-.12	9.52	0.00	28.57	0.00	0.00	28.57	7
	.12-.15	6.06	0.00	18.18	0.00	0.00	18.18	11
	.15-.18	44.44	25.00	50.00	25.00	50.00	58.33	24
	≥.18	66.67	50.00	66.67	50.00	66.67	83.33	6





PRINT 1

RESULTS: CTT- 5TH  
EXPERIMENTAL DATA  
PERFORMANCE VS BAC

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
A	<.03	1.54	0.00	3.08	0.00	0.00	4.62	65
L	.03-.06	1.45	0.00	4.35	0.00	0.00	4.35	23
L	.06-.09	5.56	5.56	11.11	0.00	5.56	11.11	18
	.09-.12	18.84	4.35	34.78	4.35	13.04	39.13	23
	.12-.15	25.85	16.33	36.73	12.24	22.45	42.86	49
	.15-.18	56.36	38.18	69.09	30.91	61.82	76.36	55
	≥.18	79.63	72.22	83.33	66.67	83.33	88.89	18
M	<.03	2.38	0.00	3.57	0.00	0.00	7.14	28
A	.03-.06	2.56	0.00	7.69	0.00	0.00	7.69	13
L	.06-.09	4.76	0.00	14.29	0.00	0.00	14.29	7
F	.09-.12	27.27	9.09	45.45	9.09	18.18	54.55	11
S	.12-.15	35.19	27.78	38.89	22.22	33.33	50.00	18
	.15-.18	73.91	56.52	86.96	47.83	82.61	91.30	23
	≥.18	90.91	81.82	90.91	81.82	90.91	100.00	11
F	<.03	0.90	0.00	2.70	0.00	0.00	2.70	37
E	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	10
M	.06-.09	6.06	9.09	9.09	0.00	9.09	9.09	11
A	.09-.12	11.11	0.00	25.00	0.00	8.33	25.00	12
L	.12-.15	20.43	9.68	35.48	6.45	16.13	38.71	31
E	.15-.18	43.75	25.00	56.25	18.75	46.88	65.63	32
S	≥.18	61.90	57.14	71.43	42.86	71.43	71.43	7
Y	<.03	2.30	0.00	3.45	0.00	0.00	6.90	29
O	.03-.06	3.70	0.00	11.11	0.00	0.00	11.11	9
U	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	7
N	.09-.12	22.22	0.00	33.33	0.00	22.22	44.44	9
G	.12-.15	33.33	28.00	44.00	20.00	32.00	48.00	25
	.15-.18	53.33	36.00	64.00	28.00	60.00	72.00	25
	≥.18	71.43	71.43	71.43	57.14	71.43	85.71	7
O	<.03	0.93	0.00	2.78	0.00	0.00	2.78	36
L	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	14
D	.06-.09	9.09	9.09	18.18	0.00	9.09	18.18	11
	.09-.12	16.67	7.14	35.71	7.14	7.14	35.71	14
	.12-.15	18.06	4.17	29.17	4.17	12.50	37.50	24
	.15-.18	58.89	40.00	73.33	33.33	63.33	80.00	30
	≥.18	84.85	72.73	90.91	72.73	90.91	90.91	11

CTT- 5TH EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
SGRP 1								
S	<.03	4.76	0.00	9.52	0.00	0.00	14.29	21
G	.03-.06	3.70	0.00	11.11	0.00	0.00	11.11	9
R	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	5
P	.09-.12	25.93	0.00	55.56	0.00	22.22	55.56	9
	.12-.15	42.11	31.58	52.63	26.32	36.84	63.16	19
	.15-.18	81.82	63.64	100.00	54.55	90.91	100.00	11
	≥.18	91.67	75.00	100.00	75.00	100.00	100.00	4
SGRP 2								
S	<.03	0.00	0.00	0.00	0.00	0.00	0.00	24
G	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	6
R	.06-.09	7.41	11.11	11.11	0.00	11.11	11.11	9
P	.09-.12	14.29	0.00	28.57	0.00	0.00	42.86	7
	.12-.15	14.04	5.26	26.32	0.00	10.53	31.58	19
	.15-.18	58.33	35.00	75.00	25.00	65.00	85.00	20
	≥.18	95.83	100.00	100.00	87.50	100.00	100.00	8
SGRP 3								
S	<.03	0.00	0.00	0.00	0.00	0.00	0.00	20
G	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	8
R	.06-.09	8.33	0.00	25.00	0.00	0.00	25.00	4
P	.09-.12	14.29	14.29	14.29	14.29	14.29	14.29	7
	.12-.15	18.18	9.09	27.27	9.09	18.18	27.27	11
	.15-.18	43.06	29.17	50.00	25.00	45.83	58.33	24
	≥.18	50.00	33.33	50.00	33.33	50.00	66.67	6





PRINT 4

RESULTS: CTT-10TH  
EXPERIMENTAL DATA  
PERFORMANCE VS BAC

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
A	<.03	4.10	0.00	9.23	0.00	0.00	12.31	65
L	.03-.06	2.90	0.00	4.35	0.00	0.00	8.70	23
L	.06-.09	9.26	5.56	16.67	0.00	5.56	22.22	18
	.09-.12	27.54	13.04	43.48	4.35	26.09	52.17	23
	.12-.15	37.41	28.57	48.98	22.45	32.65	57.14	49
	.15-.18	65.48	48.21	75.00	39.29	69.64	87.50	56
	≥.18	90.74	83.33	88.89	83.33	88.89	100.00	18
M	<.03	4.76	0.00	7.14	0.00	0.00	14.29	28
A	.03-.06	5.13	0.00	7.69	0.00	0.00	15.38	13
L	.06-.09	9.52	0.00	28.57	0.00	0.00	28.57	7
E	.09-.12	33.33	9.09	45.45	9.09	27.27	63.64	11
S	.12-.15	44.44	38.89	55.56	33.33	44.44	55.56	18
	.15-.18	81.94	66.67	91.67	54.17	91.67	100.00	24
	≥.18	96.97	90.91	100.00	90.91	100.00	100.00	11
F	<.03	3.60	0.00	10.81	0.00	0.00	10.81	37
E	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	10
M	.06-.09	9.09	9.09	9.09	0.00	9.09	18.18	11
A	.09-.12	22.22	16.67	41.67	0.00	25.00	41.67	12
L	.12-.15	33.33	22.58	45.16	16.13	25.21	58.06	31
E	.15-.18	53.13	34.38	62.50	28.13	53.13	78.13	32
S	≥.18	80.95	71.43	71.43	71.43	71.43	100.00	7
Y	<.03	3.45	0.00	6.90	0.00	0.00	10.34	29
O	.03-.06	7.41	0.00	11.11	0.00	0.00	22.22	9
U	.06-.09	4.76	0.00	0.00	0.00	0.00	14.29	7
N	.09-.12	33.33	11.11	55.56	0.00	33.33	66.67	9
G	.12-.15	45.33	36.00	52.00	28.00	44.00	64.00	25
	.15-.18	64.00	44.00	68.00	36.00	68.00	88.00	25
	≥.18	90.48	85.71	85.71	85.71	85.71	100.00	7
O	<.03	4.63	0.00	11.11	0.00	0.00	13.89	36
L	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	14
D	.06-.09	12.12	9.09	27.27	0.00	9.09	27.27	11
	.09-.12	23.81	14.29	35.71	7.14	21.43	42.86	14
	.12-.15	29.17	20.83	45.83	16.67	20.83	50.00	24
	.15-.18	66.67	51.61	80.65	41.94	70.97	87.10	31
	≥.18	90.91	81.82	90.91	81.82	90.91	100.00	11

CTT-10TH EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
<i>SGRP 1</i>								
S	<.03	7.94	0.00	19.05	0.00	0.00	23.81	21
G	.03-.06	3.70	0.00	11.11	0.00	0.00	11.11	9
R	.06-.09	6.67	0.00	0.00	0.00	0.00	20.00	5
P	.09-.12	33.33	11.11	55.56	0.00	33.33	66.67	9
	.12-.15	52.63	42.11	73.68	31.58	52.63	73.68	19
	.15-.18	84.85	72.73	100.00	54.55	100.00	100.00	11
	≥.18	91.67	75.00	100.00	75.00	100.00	100.00	4
<i>SGRP 2</i>								
S	<.03	2.78	0.00	8.33	0.00	0.00	8.33	24
G	.03-.06	5.56	0.00	0.00	0.00	0.00	16.67	6
R	.06-.09	11.11	11.11	22.22	0.00	11.11	22.22	9
P	.09-.12	33.33	14.29	57.14	0.00	28.57	71.43	7
	.12-.15	28.07	21.05	36.84	15.79	21.05	47.37	19
	.15-.18	66.67	47.62	76.19	38.10	71.43	90.48	21
	≥.18	100.00	100.00	100.00	100.00	100.00	100.00	8
<i>SGRP 3</i>								
S	<.03	1.67	0.00	0.00	0.00	0.00	5.00	20
G	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	8
R	.06-.09	8.33	0.00	25.00	0.00	0.00	25.00	4
P	.09-.12	14.29	14.29	14.29	14.29	14.29	14.29	7
	.12-.15	27.27	18.18	27.27	18.18	18.18	45.45	11
	.15-.18	55.56	37.50	62.50	33.33	54.17	79.17	24
	≥.18	77.78	66.67	66.67	66.67	66.67	100.00	6





## Reaction Analyzer Results

The following table presents the performance of the Reaction Analyzer relative to criterion M. These results reflect all implementation strategies (1/1, 1/2, 2/2, 1/3, 2/3, and 3/3), and are given separately for each category of Subjects. Both experimental and control session data are shown.

PRINT 2

RESULTS: REACANAL  
EXPERIMENTAL DATA  
PERFORMANCE VS BAC

BAC CLASS INTERVAL	STRATEGY						NO. OF BLOCKS
	1/1	1/2	2/2	1/3	2/3	3/3	
<.03	14.58	6.25	20.31	3.13	10.94	29.69	64
.03-.06	11.59	4.35	13.04	0.00	13.04	21.74	23
.06-.09	33.33	16.67	55.56	5.56	33.33	61.11	18
.09-.12	31.88	17.39	52.17	4.35	26.09	65.22	23
.12-.15	42.86	26.53	63.27	12.24	46.94	69.39	49
.15-.18	62.50	42.86	75.00	33.93	64.29	89.29	56
≥.18	68.52	50.00	83.33	50.00	66.67	88.89	18
<.03	8.33	3.57	10.71	3.57	3.57	17.86	28
.03-.06	7.69	0.00	7.69	0.00	7.69	15.38	13
.06-.09	38.10	14.29	57.14	14.29	28.57	71.43	7
.09-.12	33.33	18.18	54.55	9.09	27.27	63.64	11
.12-.15	27.78	11.11	50.00	5.56	22.22	55.56	18
.15-.18	52.78	25.00	70.83	20.83	50.00	87.50	24
≥.18	54.55	27.27	72.73	27.27	54.55	81.82	11
<.03	19.44	8.33	27.78	2.78	16.67	38.89	36
.03-.06	16.67	10.00	20.00	0.00	20.00	30.00	10
.06-.09	30.30	18.18	54.55	0.00	36.36	54.55	11
.09-.12	30.56	16.67	50.00	0.00	25.00	66.67	12
.12-.15	51.61	35.48	70.97	16.13	61.29	77.42	31
.15-.18	69.79	56.25	78.13	43.75	75.00	90.63	32
≥.18	90.48	85.71	100.00	85.71	85.71	100.00	7
<.03	9.20	0.00	10.34	0.00	10.34	17.24	29
.03-.06	14.81	11.11	22.22	0.00	22.22	22.22	9
.06-.09	28.57	14.29	57.14	0.00	28.57	57.14	7
.09-.12	11.11	0.00	11.11	0.00	0.00	33.33	9
.12-.15	29.33	16.00	48.00	8.00	28.00	52.00	25
.15-.18	53.33	36.00	72.00	20.00	52.00	88.00	25
≥.18	42.86	14.29	71.43	14.29	28.57	85.71	7
<.03	19.05	11.43	28.57	5.71	11.43	40.00	35
.03-.06	9.52	0.00	7.14	0.00	7.14	21.43	14
.06-.09	36.36	18.18	54.55	9.09	36.36	63.64	11
.09-.12	45.24	28.57	78.57	7.14	42.86	85.71	14
.12-.15	56.94	37.50	79.17	16.67	66.67	87.50	24
.15-.18	69.89	48.39	77.42	45.16	74.19	90.32	31
≥.18	84.85	72.73	90.91	72.73	90.91	90.91	11

REACANAL EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATFGY						NO. OF BLOCKS
		1/1	1/2	2/2	1/3	2/3	3/3	
SGRP 1								
S	<.03	9.52	4.76	9.52	4.76	4.76	19.05	21
G	.03-.06	7.41	0.00	11.11	0.00	11.11	11.11	9
R	.06-.09	26.67	20.00	40.00	20.00	20.00	40.00	5
P	.09-.12	37.04	22.22	66.67	11.11	33.33	66.67	9
	.12-.15	45.61	26.32	68.42	21.05	42.11	73.68	19
	.15-.18	69.70	63.64	72.73	63.64	72.73	72.73	11
	≥.18	50.00	25.00	75.00	25.00	50.00	75.00	4
SGRP 2								
S	<.03	13.04	4.35	21.74	0.00	8.70	30.43	23
G	.03-.06	16.67	16.67	16.67	0.00	16.67	33.33	6
R	.06-.09	33.33	22.22	55.56	0.00	33.33	66.67	9
P	.09-.12	33.33	14.29	28.57	0.00	28.57	71.43	7
	.12-.15	45.61	26.32	63.16	5.26	57.89	73.68	19
	.15-.18	66.67	42.86	90.48	33.33	71.43	95.24	21
	≥.18	70.83	62.50	75.00	62.50	62.50	87.50	8
SGRP 3								
S	<.03	21.67	10.00	30.00	5.00	20.00	40.00	20
G	.03-.06	12.50	0.00	12.50	0.00	12.50	25.00	8
R	.06-.09	41.67	0.00	75.00	0.00	50.00	75.00	4
P	.09-.12	23.81	14.29	57.14	0.00	14.29	57.14	7
	.12-.15	33.33	27.27	54.55	9.09	36.36	54.55	11
	.15-.18	55.56	33.33	62.50	20.83	54.17	91.67	24
	≥.18	77.78	50.00	100.00	50.00	83.33	100.00	6





## Complex Coordinator Results

The following tables present the performance of the Complex Coordinator relative to:

1. Individually-assigned criteria based upon both time and coordination count (COMCOR-I).
2. Universally-applied criterion of 80 seconds, 80 coordination count (COMCOR-U).
3. Individual time-only criteria (CC-TIM/I). For each Subject, this criterion is 5 seconds less than the time component of the criterion used in case 1 above.
4. A universal time-only criterion of 80 seconds (CC-TIM/U).

In all cases, results are given for six strategies (1/1, 1/2, 2/2, 1/3, 2/3, 3/3) and each category of Subjects. Both experimental and control data are presented.



COMCOR-I EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
<i>SGRP 1</i>								
S	<.03	3.17	0.00	4.76	0.00	0.00	9.52	21
G	.03-.06	3.70	0.00	11.11	0.00	0.00	11.11	9
R	.06-.09	6.67	0.00	0.00	0.00	0.00	20.00	5
P	.09-.12	33.33	11.11	44.44	11.11	33.33	55.56	9
	.12-.15	61.40	52.63	73.68	36.84	63.16	84.21	19
	.15-.18	95.83	100.00	100.00	87.50	100.00	100.00	8
	≥.18	100.00	100.00	100.00	100.00	100.00	100.00	4
<i>SGRP 2</i>								
S	<.03	2.78	0.00	8.33	0.00	0.00	8.33	24
G	.03-.06	5.56	0.00	16.67	0.00	0.00	16.67	6
R	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	9
P	.09-.12	23.81	14.29	57.14	0.00	14.29	57.14	7
	.12-.15	45.10	17.65	64.71	17.65	47.06	70.59	17
	.15-.18	68.25	57.14	80.95	57.14	66.67	80.95	21
	≥.18	95.83	87.50	100.00	87.50	100.00	100.00	8
<i>SGRP 3</i>								
S	<.03	3.33	0.00	5.00	0.00	0.00	10.00	20
G	.03-.06	4.17	0.00	12.50	0.00	0.00	12.50	8
R	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	4
P	.09-.12	33.33	28.57	42.86	14.29	28.57	57.14	7
	.12-.15	21.21	18.18	27.27	9.09	18.18	36.36	11
	.15-.18	59.72	50.00	70.83	45.83	62.50	70.83	24
	≥.18	77.78	66.67	83.33	66.67	83.33	83.33	6







COMCOR-U EXPERIMENTAL CONTINUED

	RAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
<i>SGRP 1</i>								
<i>S</i>	<.03	4.76	0.00	14.29	0.00	0.00	14.29	21
<i>G</i>	.03-.06	3.70	0.00	11.11	0.00	0.00	11.11	9
<i>R</i>	.06-.09	20.00	20.00	20.00	0.00	20.00	40.00	5
<i>P</i>	.09-.12	29.63	11.11	44.44	0.00	33.33	55.56	9
	.12-.15	40.35	31.58	68.42	15.79	36.84	68.42	19
	.15-.18	77.78	77.78	88.89	66.67	77.78	88.89	9
	≥.18	91.67	75.00	100.00	75.00	100.00	100.00	4
<i>SGRP 2</i>								
<i>S</i>	<.03	8.33	4.17	20.83	0.00	4.17	20.83	24
<i>G</i>	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	6
<i>R</i>	.06-.09	18.52	11.11	33.33	0.00	22.22	33.33	9
<i>P</i>	.09-.12	38.10	42.86	57.14	14.29	42.86	57.14	7
	.12-.15	50.98	41.18	70.59	35.29	47.06	70.59	17
	.15-.18	60.32	57.14	71.43	42.86	61.90	76.19	21
	≥.18	75.00	75.00	75.00	62.50	75.00	87.50	8
<i>SGRP 3</i>								
<i>S</i>	<.03	0.00	0.00	0.00	0.00	0.00	0.00	20
<i>G</i>	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	8
<i>R</i>	.06-.09	8.33	0.00	25.00	0.00	0.00	25.00	4
<i>P</i>	.09-.12	9.52	14.29	14.29	0.00	14.29	14.29	7
	.12-.15	12.12	0.00	27.27	0.00	0.00	36.36	11
	.15-.18	45.83	25.00	66.67	20.83	45.83	70.83	24
	≥.18	66.67	50.00	83.33	50.00	66.67	83.33	6







CC-TIM/I EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY						NO. OF BLOCKS
		1/1	1/2	2/2	1/3	2/3	3/3	
<i>SGRP 1</i>								
<i>S</i>	<.03	9.52	4.76	19.05	0.00	9.52	19.05	21
<i>G</i>	.03-.06	18.52	11.11	44.44	0.00	11.11	44.44	9
<i>R</i>	.06-.09	26.67	20.00	40.00	20.00	20.00	40.00	5
<i>P</i>	.09-.12	75.00	50.00	87.50	50.00	75.00	100.00	8
	.12-.15	85.96	84.21	89.47	73.68	89.47	94.74	19
	.15-.18	100.00	100.00	100.00	100.00	100.00	100.00	9
	≥.18	80.00	80.00	80.00	80.00	80.00	80.00	5
<i>SGRP 2</i>								
<i>S</i>	<.03	2.78	0.00	4.17	0.00	0.00	8.33	24
<i>G</i>	.03-.06	5.56	0.00	16.67	0.00	0.00	16.67	6
<i>R</i>	.06-.09	22.22	11.11	33.33	0.00	11.11	55.56	9
<i>P</i>	.09-.12	38.10	28.57	57.14	14.29	42.86	57.14	7
	.12-.15	47.06	23.53	64.71	23.53	41.18	76.47	17
	.15-.18	85.71	80.95	85.71	80.95	85.71	90.48	21
	≥.18	100.00	100.00	100.00	100.00	100.00	100.00	8
<i>SGRP 3</i>								
<i>S</i>	<.03	5.00	0.00	10.00	0.00	0.00	15.00	20
<i>G</i>	.03-.06	20.83	12.50	25.00	12.50	12.50	37.50	8
<i>R</i>	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	4
<i>P</i>	.09-.12	52.38	57.14	57.14	42.86	57.14	57.14	7
	.12-.15	36.36	27.27	36.36	27.27	27.27	54.55	11
	.15-.18	66.67	62.50	70.83	58.33	66.67	75.00	24
	≥.18	94.44	100.00	100.00	83.33	100.00	100.00	6





RESULTS: CC-TIM/U  
 EXPERIMENTAL DATA  
 PERFORMANCE VS BAC

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
A	<.03	0.00	0.00	0.00	0.00	0.00	0.00	65
L	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	23
L	.06-.09	3.70	5.56	5.56	0.00	5.56	5.56	18
	.09-.12	4.35	4.35	4.35	4.35	4.35	4.35	23
	.12-.15	5.67	4.26	8.51	4.26	4.26	8.51	47
	.15-.18	22.01	18.87	26.42	13.21	22.64	30.19	53
	≥.18	38.89	27.78	50.00	27.78	38.89	50.00	18
M	<.03	0.00	0.00	0.00	0.00	0.00	0.00	28
A	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	13
L	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	7
E	.09-.12	0.00	0.00	0.00	0.00	0.00	0.00	11
S	.12-.15	0.00	0.00	0.00	0.00	0.00	0.00	17
	.15-.18	10.61	9.09	13.64	0.00	13.64	18.18	22
	≥.18	33.33	18.18	45.45	18.18	36.36	45.45	11
F	<.03	0.00	0.00	0.00	0.00	0.00	0.00	37
E	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	10
M	.06-.09	6.06	9.09	9.09	0.00	9.09	9.09	11
A	.09-.12	8.33	8.33	8.33	8.33	8.33	8.33	12
L	.12-.15	8.89	6.67	13.33	6.67	6.67	13.33	30
E	.15-.18	30.11	25.81	35.48	22.58	29.03	38.71	31
S	≥.18	47.62	42.86	57.14	42.86	42.86	57.14	7
Y	<.03	0.00	0.00	0.00	0.00	0.00	0.00	29
O	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	9
U	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	7
N	.09-.12	0.00	0.00	0.00	0.00	0.00	0.00	9
G	.12-.15	0.00	0.00	0.00	0.00	0.00	0.00	25
	.15-.18	0.00	0.00	0.00	0.00	0.00	0.00	22
	≥.18	0.00	0.00	0.00	0.00	0.00	0.00	7
O	<.03	0.00	0.00	0.00	0.00	0.00	0.00	36
L	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	14
D	.06-.09	6.06	9.09	9.09	0.00	9.09	9.09	11
	.09-.12	7.14	7.14	7.14	7.14	7.14	7.14	14
	.12-.15	12.12	9.09	18.18	9.09	9.09	18.18	22
	.15-.18	37.63	32.26	45.16	22.58	38.71	51.61	31
	≥.18	63.64	45.45	81.82	45.45	63.64	81.82	11

CC-TIM/U EXPERIMENTAL CONTINUED

	BAC CLASS INTERVAL	STRATEGY					NO. OF BLOCKS	
		1/1	1/2	2/2	1/3	2/3		3/3
<i>SGRP 1</i>								
<i>S</i>	<.03	0.00	0.00	0.00	0.00	0.00	0.00	21
<i>G</i>	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	9
<i>R</i>	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	5
<i>P</i>	.09-.12	0.00	0.00	0.00	0.00	0.00	0.00	9
	.12-.15	3.51	0.00	10.53	0.00	0.00	10.53	19
	.15-.18	58.33	50.00	62.50	37.50	62.50	75.00	8
	≥.18	58.33	50.00	75.00	50.00	50.00	75.00	4
<i>SGRP 2</i>								
<i>S</i>	<.03	0.00	0.00	0.00	0.00	0.00	0.00	24
<i>G</i>	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	6
<i>R</i>	.06-.09	7.41	11.11	11.11	0.00	11.11	11.11	9
<i>P</i>	.09-.12	14.29	14.29	14.29	14.29	14.29	14.29	7
	.12-.15	11.76	11.76	11.76	11.76	11.76	11.76	17
	.15-.18	14.29	14.29	19.05	9.52	14.29	19.05	21
	≥.18	33.33	25.00	37.50	25.00	37.50	37.50	8
<i>SGRP 3</i>								
<i>S</i>	<.03	0.00	0.00	0.00	0.00	0.00	0.00	20
<i>G</i>	.03-.06	0.00	0.00	0.00	0.00	0.00	0.00	8
<i>R</i>	.06-.09	0.00	0.00	0.00	0.00	0.00	0.00	4
<i>P</i>	.09-.12	0.00	0.00	0.00	0.00	0.00	0.00	7
	.12-.15	0.00	0.00	0.00	0.00	0.00	0.00	11
	.15-.18	16.67	12.50	20.83	8.33	16.67	25.00	24
	≥.18	33.33	16.67	50.00	16.67	33.33	50.00	6





