Investigation of the use of Video Games to Detect Alcohol-Impaired Performance

by

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Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Industrial Engineering and Operations Research

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November, 1985
Blacksburg, Virginia

ACKNOWLEDGEMENTS

The author wishes to thank Dr. Dennis L. Price for his guidance and patience during this project. Additionally, the author would like to express his deepest gratitude to his parents for encouragement and financial support provided.

Appreciation is also given to the state of Virginia and the CORE research program for the financial support provided for this study.

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INTRODUCTION

Alcohol-related problems have become a matter for national concern. Absenteeism, crime, accidents, health insurance, and most serious of all, drunk driving, are foremost among these. The massive social costs associated with the use of alcohol have come under increased public attention in recent years. These costs amount to billions of dollars as well as thousands of human lives (Berry and Bolland, 1977). Industrial losses are estimated at 25 billion dollars per year in America due to alcohol-related causes (U.S. Department of Health and Human Services, 1981) In 1981, over 25,000 Americans were killed in alcohol-related auto accidents (U.S. Department of Transportation,1982). The National Safety Council (1982) predicts that there is a fifty-fifty chance that any one citizen will become involved in an alcohol-related auto accident.

There is a wide and virtually unanimous agreement that alcohol ingestion does contribute substantially to highway crashes. However, there is considerable confusion about counter measures (Waller, 1974). Two general approaches that have been used are education and law. Education focuses on knowledge about blood alcohol concentrations (BACs), effects of alcohol on performance, and the physiological effects of alcohol. Law focuses on enforcement and legislative changes such as drinking age.

A legal problem has emerged for establishments serving beverage alcohol under the present laws. Bartenders at drinking establishments may be held liable for injury to a third party caused by a customer who left that establishment legally impaired. Drinking establishments have developed alcohol management programs to reduce this problem by training bartenders how to watch for signs of intoxication and handle significantly impaired customers. Determination of the degree of intoxication by observation can be difficult for bartenders since social behavior does not accurately indicate levels of intoxication. One solution to this problem could be to include an accurate BAC test in the alcohol management program. However, standard BAC tests such as breath-analysis devices may be perceived as offensive and therefore unacceptable to customers of drinking establishments.

An alternative to the BAC test would be a test that measures alcohol-impaired performance. One method for testing impairment currently under investigation is computer-based performance tasks in the form of commercially available video games. These tasks are being investigated for the following reasons. First, computer-based performance tasks have high face validity because they may include tasks similar to those required for driving, e.g., a tracking task. Second, the ubiquity of television, video games, and computers will influence the customers' acceptance of testing for impairment by a computer-based performance task in an establishment serving beverage alcohol. Finally, computer-driven tasks offer the flexibility of reprogramming which would offer a twofold advantage. One advantage would be that new tasks (or video games) could easily be installed without hardware changes. The second advantage in being able to reprogram the tasks would be an economic one. Video game systems, for example, are relatively inexpensive. The use of video games to determine human performance impairment due to alcohol ingestion was posed before a U.S. subcommittee hearing testimony on alcohol, drugs, and driving (Maickel,1982). Maickel (1982) suggested that the only realistic test for degree of impairment caused by alcohol is one that would measure human performance and that video games could be used as such a measure.

LITERATURE REVIEW

Studies of the effects of alcohol on human performance can be categorized into pharmacological, behavioral, or epidemiological studies. The most important pharmacological issues addressed are: absorption rates, metabolism of alcohol, tolerance, and long and short-term physiological effects. Information provided by pharmacological research in these areas has provided an improved methodological foundation for determining the performance effects caused by alcohol. Research evaluating the effect of blood alcohol concentrations on human behavior focuses primarily on the various components of behavior including sensation, cognitive processes, and psychomotor performance. Epidemiological research for alcohol-related accidents investigates why the accidents occurred and the contribution of alcohol to those accidents. The epidemiological connection of alcohol with accidents has been well established. A review of pharmacological and human performance aspects is important to the present study and is presented below.

Pharmacology

An understanding of the pharmacology of alcohol is important for any study evaluating the effects of alcohol on performance. Some pharmacological effects have been disregarded by investigators, minimizing the importance of the findings (Levine, Greenbaum, and Notken, 1973). A summary of important pharmacological principles is now presented.

Absorption, Distribution, and Elimination. Alcohol (hereafter referring to ethyl alcohol which is contained in potable liquors) is absorbed rapidly after passing into the stomach and duodenum. Factors affecting absorption rates are: the amount of food in the stomach, the concentration of alcohol, and the stomach emptying rate. Since alcohol is absorbed more rapidly in the duodenum, food has a dual effect in that it reduces both the amount absorbed in the stomach and the stomach emptying rate. The rate of absorption is important because different rates of absorption result in different levels of alcohol in the blood (Goldstein, 1983).

Distribution of alcohol occurs rapidly by simple diffusion throughout the aqueous compartments of the body. The concentration of alcohol in various tissues in the body depends on the water concentration of the tissue.

The rate of diffusion into the tissues depends on the tissue's blood supply. The brain, for example, has a high distribution rate because of its relatively high blood supply.

The amount of alcohol in the body is reported in the literature as either blood alcohol level (BAL) or blood alcohol concentration (BAC). When the amount of alcohol is reported as BAL, the researchers have tested a blood sample to calculate the level of alcohol. Alternatively, researchers who report the amount of alcohol as BAC have estimated the level of alcohol in the body indirectly, usually from a Breathalyzer test (Breen, Siler, and Pearce, 1974).

A distribution artifact, called "The Mallenby Effect", must be accounted for in performance studies on alcohol. The Mallenby Effect (see Mallenby, 1919) refers to differences in performance during rising and falling blood alcohol levels (BALs). This difference has been explained by differences in brain alcohol levels relative to BAL during rising and falling BAL.

Alcohol is eliminated either by metabolic processes or by excretion in an unchanged state. Five to ten percent is excreted in air and urine unchanged. Since the lung is an organ designed to maintain an equilibrium of volatile compounds between blood and air, any blood alcohol present in the lung's capillaries is balanced with alveolar air alcohol concentration. The dispersion factor from blood alcohol to alveolar air is 2100, i.e., there is the same amount of ethanol in one ml of blood as in 2.1 liters of alveolar air.

The remaining 90% to 95% of ingested alcohol is metabolized in two major steps. The first step is oxidation of ethanol to acetaldehyde which is carried out primarily in the liver. The liver has three enzyme systems to carry out this reaction. The second step is oxidation of acetaldehyde. Most of the acetaldehyde is converted to acetate in the liver. Acetate is a relatively harmless compound which is then converted to carbon dioxide in other tissues, particularly skeletal muscles.

Tolerance. Tolerance is defined as "a diminution of a drug effect after a period of administration of that drug" (Goldstein, 1983). There are two types of tolerance: dispositional and functional. For dispositional tolerance, less of the drug appears at the site of action. Metabolic changes are the main component to dispositional tolerance to alcohol. Functional tolerance is a change in the sensitivity of the tissue. Tolerance to alcohol was demonstrated by Goldberg (1943) using the finger-finger test. The results showed a difference in response to alcohol between heavy drinkers and abstainers by a factor of 1.5 to 2. The differences in impairment reflected the differences in BALs. Abstainers' blood alcohol levels were as much as two times that of heavy drinkers when given equivalent dosages. Some studies have not accounted for the drinking history of participants.

Effects of Alcohol on Human Performance

Three areas of human-performance studies which are relevant to evaluating the effects of alcohol on driving will be reviewed in this section. One area of performance studies are aimed at evaluating effects of alcohol on components of behavior such as reaction time, sensory sensitivity, motor effects, and intellectual functions. The second area is aimed more directly at actual driving performance by testing subjects in either driving simulators or in real vehicles on a closed driving course. Finally, video games have been suggested as potential BAC/performance correlates (Maickel, 1982). Each of these three areas will now be reviewed, followed by a discussion of the importance of the findings to the present study.

Components of Behavior. Visual acuity was found to be insensitive to the effects of alcohol-impairment at high levels. Dim light perception even slightly improved, but there is a decrease in the discrimination of different light intensities. Color perception was mildly impaired in the discrimination of red, yellow, and green (Schmidt and Bingel, 1953). Audition is also only mildly affected by alcohol effects. However, odors, tastes, and pain perception are diminished by even low doses.

Goldberg (1943) used two sensory perception tests in which there was a linear relationship to BAL when expressed as a percentage of subjects' pre-drug scores. The two sensory perception tests were the threshold intensity of a puff of air in eliciting the corneal reflex and a critical flicker fusion determination.

Levett, Karras, and Hoeft (1974), in a study evaluating two components of the visual system; accommodation and horizontal saccadic eye movement, found that alcohol reduces accommodation response by 10% to 40% and increased saccadic eye movement latencies by 26%. These workers suggest that the ability to drive safely is seriously compromised by the use of alcohol since accommodation is responsible for a clear image, and saccadic eye movement is the principle eye movement in motor vehicle operation.

Reaction time tasks are frequently used to measure the effects of alcohol on psychomotor performance. Results indicate that alcohol slows the speed of the response moderately at BALs above 0.1%, but effects are inconsistent at lower BALs (Levine, et. al., 1973). However, as the information-processing demands increase, such as in a complex discrimination task, the detrimental effect of alcohol on response speed is enhanced. Typewriting is a task which requires a high degree of motor coordination. Jellinek and McFarland (1940) found large increases in typewriting errors and a slight decrease in speed.

Goldberg (1943) tested for motor incoordination using two tests. The two tests were the standing steadiness (Romberg) test and finger-finger test. The standing steadiness test required subjects to stand with feet together and eyes closed while the body sway was recorded by a long-exposure photograph of a light attached to the subject. The area of light squiggles was proportional to BAL relative to baseline performance. The finger-finger test required subjects to bring the forefingers together with arms extended. This produced a pattern of dots on a cardboard disk attached to one finger by a painted thimble attached to the other finger. The area defined by the dots, measured with a planimeter, was found to be linearly related to blood alcohol levels relative to the pre-drug area.

Kalant, LeBlanc, and Wilson (1974) used sensorimotor tracking tasks (following a moving light in a square pattern with a photo-sensitive wand and the Romberg body sway test) to evaluate differences in intoxication potency of various alcoholic beverages. A confound in drinking histories between groups resulted in an absence of differences among the three alcoholic beverages (beer, wine, and whiskey), but the results indicated "a clear-cut and consistent effect on psychomotor performance tests". Drew, Colquhoun, and Long (1958) and Mortimer (1967) also found decrements in tracking performance at BAL as low as .03% and .02% respectively, and that errors increase progressively with higher doses.

An unstable compensatory tracking task, called the Critical Tracking Task (CTT), has been evaluated as an alcohol impairment detection device for use in automobiles (Tennant and Thompson, 1973). Subsequent tests were conducted to optimize the test strategy (Sussman and Abernethy, 1973; Oates, 1973; Oates, Preusser, and Blomberg, 1975a; and Oates, Preusser, and Blomberg, 1975b). The CTT has demonstrated greater sensitivity than pursuit or compensatory tracking tasks in discriminating intoxicated from sober subjects. At BACs greater than 0.1%, over 90% of the subjects had degraded performance (Klein and Jex, 1975).

Short and long-term memory are both affected by alcohol. Short-term memory may be affected during the original learning, its retention, or by attentiveness during either stage (Wallgren and Barry, 1970). Long-term memory studies demonstrated memory deficits of events which occurred during intoxication (Kalin, 1964; and Deithelm and Barr, 1962).

Moskowitz, (1974) conducted a study that was aimed at an estimate of the effect of alcohol on one stage of central information processing without confounding by sensory or motor processing delay using a technique of backward masking of a visual stimulus. The hypothesis that alcohol impairs the rate of information processing was supported because of the decreased number of correctly reported letters under the alcohol treatment conditions.

Driving Performance. Walls, (1970) suggests five ways to study the effects of alcohol on driving. Those five ways are: 1) by reasoning from the effects on other operations requiring attentiveness and good coordination, 2) actual cases of alcohol-impaired driving and correlating the observed behavior with BAL, 3) arranging vehicle-handling tests in safe conditions and correlating with BAL, 4) vehicle simulator performance, and 5) statistical study of the correlation between blood-alcohol levels and the incidence of accidents. Some important studies in the area of driving performance follow.

An experimental study which predicts alcohol effects on real driving situations poses serious safety problems. Therefore, two alternative experimental approaches have been employed. One approach is to use driving simulators. The other approach is to use automobiles in a closed driving course. The findings from both of these types of studies is compromised. Driving-simulator studies are compromised because subjects are not exposed to real traffic hazards. The disadvantages of using a closed driving course are that the environment must be restricted to provide safety, and replication of stimuli is more difficult than with driving simulators. Simulators have generally been chosen over the closed driving course (Moskowitz, 1974).

Evaluation of driving performance is difficult because all of the behavioral demands of driving cannot be confidently enumerated. McKnight and Adams (1970) identified 1700 behavioral items believed important for a wide range of fairly common driving experiences. Simulators do sample a subset of those behaviors. Therefore, researchers are in a position to generalize to potential alcohol effects on that behavioral subset in actual driving conditions only to the extent that they can specify that subset (Moskowitz, 1974).

There is considerable agreement among simulator studies that the most common effect is impairment of the capacity for information processing, in which time sharing of several concurrent tasks is required (Newman and Fletcher, 1940; Asknes, 1984; Von Wright and Mikkonen, 1970).

Detection of impairment due to alcohol, drowsiness, and the combined effects of alcohol and drowsiness on driving simulator performance was recently investigated by Dingus, Hardee, and Wierwille (1985) using several performance measures. Results indicated that for alcohol, certain lane deviation measures increased. The authors concluded that lane-related performance measures should be capable of detecting alcohol impairment at high BAC levels (near 0.1%).

A closed-course experiment was conducted by Bjerver and Goldberg (1950) to investigate the time required to perform driving tasks. Subjects were required to perform relatively simple driving tasks under either drinking (experimental) or non-drinking (control) conditions. The authors concluded that performance was impaired by 25% to 30% at BAC levels between 0.04% and 0.05%. Coldwell, Penner, Smith, Lucas, Rodgers, and Darrock, 1958; and Taylor and Stephens (1962) also found significant driving skill impairment using vehicles on a closed course.

An alternative approach for studying the effects of alcohol on driving performance is the correlation of BACs with the incidence of accidents. The most extensive study of this type was conducted by Borkenstein, Growther, Shumate, Zeil, and Zylam (1964). The primary purpose of this study was to compare drinkers and non-drinkers to determine whether there was any significant difference in the incidence of accidents and to compare the proportions of drinkers in the accident group and the no-accident group. The results indicated that the effect of alcohol on the incidence of accidents became significantly detectable at blood-alcohol levels above 0.08% The results also indicated that the proportion of drinkers in the accident group was statistically different from the proportion of drinkers in the no-accident group at levels above 0.08%. Walls (1970) points out that this increase in liability to accidents appears to be approximately exponential.

Loomis and West (1958) used a dummy model car to test stopping and starting at traffic lights and steering performance by keeping the model car on a moving black strip. They found that performance fell off exponentially with increasing blood alcohol. Drew, et. al. (1959) also used an auto simulator and tested subjects along several parameters (speed, errors, control movement). Impairment was detectable at concentrations as low as 0.02% to 0.03% BAC and at 0.08% BAC, there was a 12% deterioration in performance.

In a study evaluating effects of alcohol on steering performance, Mortimer and Sturgis (1974) isolated the cue structure drivers use for controlling the path of a vehicle in an effort to define the effects of alcohol on the steering task more clearly. The results indicated that drivers reduced their responsiveness at 0.07% BAC based on reductions in steering wheel displacement which meant that the drivers steering maneuvers were more coarse, and similar to drivers just learning how to drive. The "beginner-like" behavior was also shown by the decrease in the mean yaw rate frequency bandwidths. Since lateral position errors were not significantly affected by alcohol, it was suggested that alcohol affected the cue structure used by drivers. The general conclusion from this study was that the effect of alcohol on steering performance is to reduce the overall competence to a level more similar to that of novice drivers.

Two behavioral aspects affected by alcohol intoxication that are a potential hazard to driving are judgement and risk-taking. First, subjects are often unable to judge their own level of intoxication (Goldberg, 1943). Second, in a study designed to measure directly the recognition of the hazard by intoxicated drivers, findings revealed that alcohol degraded performance while increasing the driver's estimate of his ability (Cohen, Dearnaley, and Hansel, 1958). Allen, Schwartz, Hogge, and Stein, (1978) studied these problems in experiments designed to investigate the effects of alcohol on driver decision-making. An analysis of subjects' decision-making indicated "that the increased risk-taking was caused by degraded perceptual and psychomotor capabilities, not increased acceptance of risk".

A demographic finding that is relevant to investigations of the effects of alcohol on driving performance is the apparently disproportionate number of males involved in alcohol-related traffic accidents. According to the National Highway Traffic Safety Administration (1981), 85% of the drivers with alcohol involvement in accidents are males, and 89% of all drivers arrested for driving while intoxicated are males. Males were selected as subjects in this initial investigation of the use of video games to detect alcohol-impaired performance in view of these statistics. However, this is not to say that the problem of drunk driving is limited to males, and follow-up research efforts should be expanded to include investigations of population differences.

Video Game Performance. The attributes of commercially available video games have been investigated to assess those factors which influence video-game performance. Bobko, Bobko, and Davis (1984) employed a multi-dimensional scaling technique to determine perceptual differences among video games. Three underlying dimensions were revealed which accounted for 30% of the variance. Those three dimensions were: destructiveness, dimensionality, and graphic quality. Researchers have suggested that video games contain attributes relevant to military applications (Jones, Kennedy, and Bittner, 1981; Kelly, Greitzer, and Hershman, 1981; Kennedy, Bittner, Harbeson, and Jones, 1982; Shannon, Krause, and Irons, 1982). Shannon, Krause, and Irons (1982) employed a structured job analytic tool, the Position Analysis Questionnaire (PAQ), to isolate attributes of one video game, Phantoms Five. The purpose of the research was to study a flight simulation task and Phantoms Five was selected for its bombing and air combat maneuvering features. Shannon, Krause, and Irons (1982) concluded that form perception, perceptual speed, closure, and spatial visualization were the most critical attributes in explaining variance among scores.

Researchers have demonstrated the effects of alcohol on performance using psychophysical tasks and tasks related to driving performance such as driving simulators. The importance of these findings to the present study is that video games may also demonstrate impaired performance caused by alcohol since video games contain many of the skills and attributes known to be affected by alcohol. For example, the complexity of video games varies across and often within video games, and increasing task complexity has been shown to enhance the detrimental effect of alcohol (Carpenter, 1959; Chiles and Jennings, 1970). Therefore, a complex video game may demonstrate impairment due to alcohol. Another relevant video game attribute is task realism. For example, many video game tasks are similar to those used in driving an automobile, and some actually simulate automobile driving. Finally, video games have demonstrated high test-retest reliability (Jones, et.al., 1981). These researchers noted that when a task is administered on repeated occasions, it may or may not become stabilized with practice. The video game tested in this study became differentially stabilized after six days of practice with only 10 trials per day. It should be obvious that the variance caused by a non-stabilized task would contribute to the error-term and would compromise a repeated-measure design. In conclusion, varied complexity, task realism, and high test-retest reliability are three factors which suggest that video games are potential candidates for detection of alcohol-impaired performance.

OBJECTIVE OF THE RESEARCH

The intent of the study proposed here was to provide information about two types of performance tasks for detecting alcohol impairment. The tasks evaluated in the present study were a commercially available video game and a tracking task that has previously been investigated in alcohol research (e.g., Chiles and Jennings, 1970).

The influence of alcohol on driving performance is well established epidemiologically. This influence has been implied using several lab tasks such as driving simulators, critical tracking task, and other psychophysical tasks which contain a subset of the actual tasks required for driving. The basis for the implication from the laboratory tasks is that if alcohol affects a subset of required driving tasks then it will also affect that subset of tasks during actual driving conditions. The converse is not assumed to be true, i.e., that if alcohol does not affect a subset of driving tasks in a laboratory situation, then that subset will be unaffected by alcohol in actual driving conditions. Therefore, the effect of alcohol on performance, as studied here, will not be used to establish "safe" driving conditions.

Alcohol management programs have been developed by establishments serving beverage alcohol for the purpose of customer safety and legal protection. The goal of these programs is to determine which customers may be attempting to drive while intoxicated upon leaving that establishment, and then to intervene by suggesting that the customer take a cab or ride with a driver not under the influence. This intervention is intended to save lives and reduce the liability of drinking establishments. The present method for determining a customer's level of intoxication used by alcohol management programs is by observing social behavior. As previously stated, this method may be difficult for bartenders since social behavior does not accurately indicate levels of intoxication. A performance task which indicates impaired performance and is customer-acceptable would be an important addition to existing alcohol management programs.

HYPOTHESES

The results of this study would be expected to support the following hypotheses:

1. Level of difficulty for the pursuit tracking task will differ in comparison to two levels of video game difficulty as determined by subjects' selected revolutions per minute (RPM).

2. Time on target will be greater at a lower RPM than at a higher RPM for the pursuit tracking task.

3. Performance scores will be greater at the lower level of difficulty compared to the higher level of difficulty.

4. As BAC increases, the detrimental effect of alcohol on task performance will increase.

5. There will be a greater decrement to performance of the video game task than of the pursuit tracking task.

6. There will be a significant relationship of BAC to task scores.

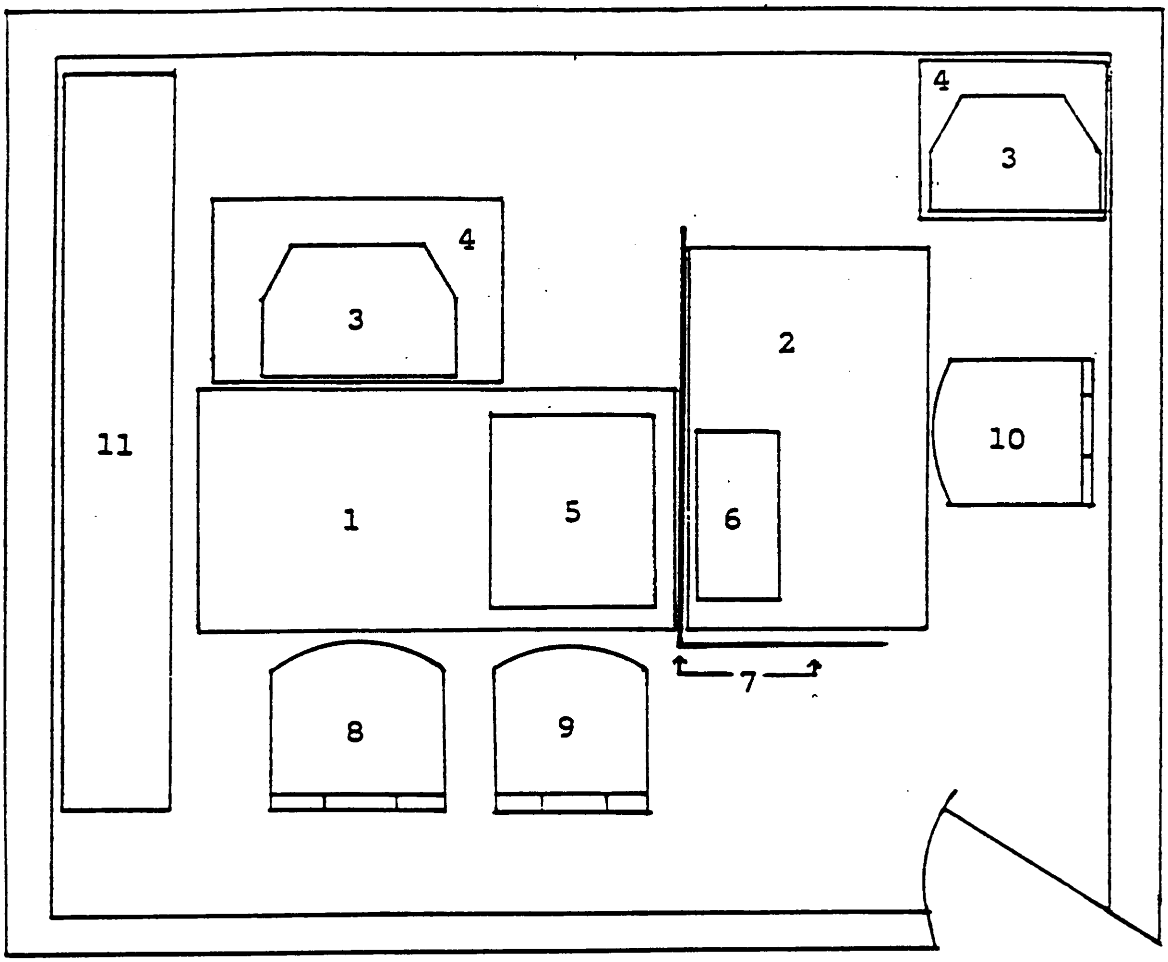
EXPERIMENTAL METHOD AND DESIGN

Subjects

Twelve males of at least 21 years of age were drawn from the Virginia Tech community to serve as volunteer subjects. Recruitment of subjects was initiated by placing two types of advertisements around the Virginia Tech campus. The purpose of one of the advertisements was to recruit subjects for Phase I of the experiment only. The purpose of the other advertisement was to recruit subjects for both phases of the experiment. Four subjects participated in Phase I only, and the remaining eight subjects participated in both phases of the experiment. The two advertisements are provided in Appendix A. Subjects who participated in both phases of the experiment were required to participate in a screening session prior to participation in any of the experimental sessions. The screening procedure is described in the "Experimental Procedures" subsection of this chapter. Subjects were also required to read and sign an informed consent form prior to participation. The consent form is included in this document (Appendix B). Subjects were paid $3.00/hr for their participation.

Apparatus

Video Game Task. A video game called "Gorf" was selected as the video game task from among several video games (see Appendix C). Gorf was selected because it was relatively easy to learn and was not primarily a "strategy" game. The video game was presented by an Atari home computer (model 800XL) with a floppy disk drive (model 1050) on a 19 inch RCA color television. The television was located at a maximum viewing distance of 102 cm. resulting in a subtended angle of 16.7 degrees, at a height of 120 cm. to the top of the screen. The smallest object presented by the video game subtended 6.7 minutes of arc, which is within the detection ability of subjects with 20/25 vision. (Van Cott and Kinkade, 1972). A standard Atari game joystick was used as a control device for the video game. The joystick was configured on a 74 cm. high table top in front of the subjects so as to provide support for the base of the joystick, and for support of subjects' forearms. A second television, connected into the Atari system, was placed out of subjects' view and provided the experimenter with a method of recording game scores without interfering with subjects' performance. A diagram of the laboratory lay-out is presented in Figure 1.



Scale: 1/2 inch = 1 foot

1. Table
2. Experimenter's desk
3. Television
4. Television stand
5. Pursuit Tracker and PC (see Fig. 2)
6. Atari computer
7. Barrier
8. Subject chair
9. Subject stool (see Fig. 2)
10. Experimenter's chair
11. Bookshelf

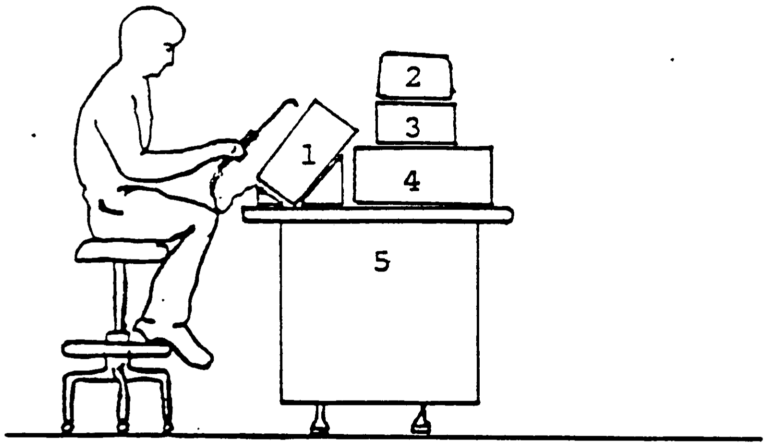
Figure 1. Block diagram of laboratory.

Pursuit Tracking Task. The Pursuit Tracking Task was presented by a Lafayette Rotary Pursuit Tracker, model 30013, with a 12 inch diameter circular overlay. The Pursuit Tracker (PT) was connected to the standard parallel printer port of an IBM PC computer to record the Time-On-Target (TOT) for each trial. A BASIC program controlled the sampling of the parallel port for computation of TOT. The PC display was positioned behind the PT as shown in Figure 2. The display provided feedback in the form of seconds on target for each one minute trial. Each trial was initiated by two 0.5 second tones elicited by the IBM PC, whereas the termination of each trial was indicated by a single, 1.0 second tone.

Blood Alcohol Content. A Smith and Wesson Model 900A Breathalyzer was used to assess blood alcohol content.

Experimental Design

The primary objective of this study was to determine the effect of four levels of BAC on the performance of two types of tasks at two levels of difficulty. The research was conducted in two phases. The purpose of the first phase (Phase I) was twofold: First, to compare and adjust the difficulty of the two tasks based on subjective evaluations. Second, to provide practice of the tasks for the second



Scale: 1/2 inch = 1 foot

1. Rotary Pursuit Tracker
2. PC display
3. Display stand
4. IBM PC
5. Table

Figure 2. Diagram of pursuit tracker and display.

phase of the research (Phase II). The purpose of the second phase was to collect performance data under four levels of BAC. The experimental designs for both phases of the research are described in the following two subsections.

<u>Phase I</u>: <u>Task Difficulty</u>. A one factor, two level design was used to collect data on subjects' estimation of the PT difficulty in comparison to two levels of VG difficulty. Task performance data were also collected during this estimation procedure. Each subject was assigned to one of two possible orders of two blocks. A block of four trials at one level of difficulty was followed by a block of four trials at the other level of difficulty.

Each trial began with the performance of the video game task followed by performance and adjustment of the tracking task. It was necessary to present the tasks to the subjects in this order since subjects were adjusting the pursuit tracking task difficulty level based on the assessed difficulty of the VG task which they had performed just prior to the PT task.

<u>Phase II</u>: <u>Task Performance</u>. Task performance data were collected under a three-way, within-subjects factorial design. The three factors were: BAC, Task Difficulty, and

Task Type. The BAC factor had four target levels: 0.00%, 0.05%, 0.07%, and 0.09%. Task Difficulty and Task Type consisted of two levels each. Levels of difficulty were accomplished by changes in RPM for the PT and by changes in the speed of objects for the VG. The two RPM levels were derived by calculating the mean RPM selected by subjects in Phase I. Task-Type levels were accomplished by presenting a simple, psychomotor task as one type, and a more complex task in the form of a video game as the other type.

The task-performance period was separated into two blocks, one for performing the video game task, and one for performing the pursuit tracking task. It was necessary to organize the performance of the two tasks into blocks of trials because of time constraints and the impracticality of having subjects move from task to task as well as prepare for the next trial. Subjects were assigned to one of two possible orders of blocks, VG followed by PT or PT followed by VG ,to counterbalance for order effects. The order of the target BAC levels was counterbalanced to reduce order effects according to a Latin Square design. Difficulty levels within the blocks was counterbalanced and combined with the BAC levels such that at each level of BAC there were 2 low-high orders and 2 high-low orders. The terms "low" and "high" are used in in this context to describe the levels of difficulty relatively and not as a means of describing the levels of difficulty quantitatively. These orders are presented in Table 1.

Experimental Procedures

The present study was carried out in two experimental phases. Phase I consisted of a one hour session. Phase II required four sessions ranging from two to five hours each. Prior to the two experimental phases, a screening session was conducted to obtain information for evaluating potential subject's qualifications for participation. The procedures for the screening sessions as well as the experimental sessions are described in respective subsections below.

Screening. Subjects who had signed-up for this experiment were first contacted, then brought in for a screening session lasting approximately 15 minutes. The following information was obtained:

1) Subjects were asked to sign a consent form for clinical record evaluation. The consent form of each potential subject was given to the Virginia Tech Health Service to determine if any medical condition would preclude participation in an experiment involving ethanol consumption. The clinical record evaluation consent form is provided in Appendix D.

TABLE 1

Counterbalance Design for presentation of Task Difficulty and BAC

Difficulty# and BAC order
for combination with both task orders:

	Subject	1	2	3	4
Session 1	BAC	0.09	0.07	0.05	0.00
	Difficulty	H-L	H-L	L-H	L-H
Session 2	BAC	0.00	0.09	0.07	0.05
	Difficulty	H-L	H-L	L-H	L-H
Session 3	BAC	0.05	0.00	0.09	0.07
	Difficulty	H-L	H-L	L-H	L-H
Session 4	BAC	0.07	0.05	0.00	0.09
	Difficulty	H-L	H-L	L-H	L-H

L = Low, H = High

2) Subjects were asked to present a valid driver's license to qualify for the age requirement (21 years of age).

3) Subjects were tested for visual acuity using an Orthorater. A visual acuity of 20/25 corrected or uncorrected vision was required.

4) Subjects were tested for color blindness using Dvorine color plates. Since the video game presented objects of different colors, color-blind subjects were to be eliminated. However, no subject that was screened demonstrated color-blindness.

5) Each subject's weight was recorded from a calibrated bathroom-type scale for calculating BAC's in Phase II of the experiment.

6) Subjects provided information regarding their drug and alcohol consumption using the form presented in Appendix E. The purpose of collecting this information was to control for the effect of tolerance due to different levels of consumption. Subjects who were not normally abstainers from alcohol consumption nor heavy drinkers, and who were not presently taking prescription drugs, qualified for the experiment.

7) Subjects also provided information about their previous experience with the video game and pursuit tracker

used in this experiment. This information was not used as a criterion for screening, but simply for data gathering purposes.

Phase I. One hour was required for phase I of the experiment on one occasion. This phase provided information about the comparison of difficulty between the two tasks. It also provided practice of the tasks prior to the second phase of the research. The procedure was as follows:

1) Subjects were asked to read and sign a consent form (see Appendix B).

2) Subjects were randomly assigned to one of the two order conditions.

3) Subjects were presented with written instructions regarding the experiment (see Appendix F). Subjects' questions about the procedure were answered after the instructions had been read. A demonstration of each of the two tasks was then given by the experimenter. The joystick control and firing button were demonstrated for the Video Game Task. Placement of the PT wand in the hand and positioning of the wand over the target were both demonstrated. Also, the control of the Revolutions Per Minute (RPM) was demonstrated for the PT Task.

4) Subjects practiced both tasks three times.

5) Subjects performed both tasks eight times for a total of 16 trials. Each video-game trial lasted one minute, during which the subject was instructed to assess the difficulty of the task. Each video-game trial was then followed by a PT trial which consisted of performing the pursuit tracking task for a one minute period and adjusting the difficulty to match that of the previous video-game trial by rotating the RPM selection knob during the first 5 to 10 seconds of the period. Video game score, TOT, and selected RPM were collected at the end of each trial.

6) Subjects were debriefed. Debriefing consisted of a verbal explanation of matching difficulty between the two tasks and of practice provided by this session for subsequent sessions.

Phase II. The Breathalyzer was calibrated according to instructions provided with the calibration instrument (Smith and Wesson, model no. MK-2). Next, subjects were contacted for the scheduling of four evening sessions lasting from 2 to 5 hours. Subjects were told that waiting periods would occur, and to bring something to do to occupy the waiting periods. The scheduled arrival times were staggered by 20 minutes since only one subject could be tested at a time. The procedure was as follows:

1) Subjects were presented with instructions at the beginning of each session (see Appendix G).

2) Subjects practiced both tasks three times to regain familiarity and to reduce practice effects.

3) Subjects ingested the vodka/orange juice mixture over a 20 minute period. The vodka and orange juice had been combined earlier that same day according to the calculations provided in Appendix H. The instructions specified that the entire 20 minute period should be used to drink the mixture at a constant rate. This instruction was also issued verbally prior to each ingestion period.

4) Subjects waited 20 minutes to allow the alcohol to be absorbed. Magazines were provided as an activity to "pass the time". Some of the subjects also brought personal reading and study material for this period.

5) A Breathalyzer test was administered for the purpose of obtaining subject's BAC prior to task performance. Subjects who had not approached the target BAC for that session were instructed to wait an additional 10 minutes after which another breath test was administered. This occurred on three occasions. On all three occasions, the BAC had risen after the additional 10 minute period, and the session schedule was resumed.

6) Subjects performed both tasks six times (three at each level of difficulty). The performance period for each task was one minute. There was a 10 second delay between trials. During this period, the experimenter informed the subject as to which task would be presented next. The experimenter also recorded video-game scores during those periods which followed performance of the Video Game Task.

7) A second Breathalyzer test was administered. The pre-performance BAC was combined with the post-performance BAC to provide an average for the task-performance period.

8) Subjects were escorted to a classroom next to the testing area for a detoxification period. Many subjects chose to read or study course material during this period.

9) Subjects were tested for BAC. When all subjects' BAC registered below 0.03 g/Kg they were driven home by the Experimenter.

10) At the end of the detoxification period of the final session, subjects were debriefed by the experimenter. The purpose of the experiment was explained during this debriefing. Also, target BACs for each session and for each subject were explained. Any questions regarding the experiment were answered at this time. As a follow-up to this debriefing, a brief description of the results was mailed to all subjects (see Appendix I).

RESULTS

The data were analyzed following each of the two phases of the experiment. Phase I data consisted of Subjects' RPM settings as well as TOT for the tracking task. The data for Phase II were analyzed to test for BAC, Difficulty, and Task effects. This analysis consisted of an analysis of variance (ANOVA) to test for main effects and interactions, and regression analysis to determine the degree of the relationship without using subjects as their own control.

Phase I: RPM selection

There were two objectives to the analysis of Phase I data. The first objective was to determine differences in RPM selection for two levels of difficulty in comparison to the video game task, and the second was to determine the effect of the selected RPM on the performance of the task (measured in TOT).

The data used to compare difficulty were the RPM's selected by subjects under two difficulty-level conditions. A nonparametric test, the Sign Test, was performed since the assumption of an interval scale, which is necessary for a parametric test, is not applicable. "It is difficult and bad practice to assume an interval scale when asking subjects to rate things because they don't have that scale psychologically" (Snyder, 1983). Results indicated that the RPM's selected for the two levels of difficulty were significantly different ($p < .001$, one-tailed). The selected RPM's for the two levels of difficulty are contained in Table 2.

The second analysis for Phase I tested the effect of the RPM's selected on performance. The task performance data used in this analysis was the TOT for a one minute period at the RPM selected by each subject (see Table 3). The purpose of this analysis was to establish whether or not the RPM selected by subjects for the two levels of difficulty resulted in differences in performance. A Correlated t-Test indicated a significant difference in performance for the two levels of difficulty ($t\ (11) = 3.51$, $p < 0.005$, one-tailed).

Phase II: Task performance

The analysis for Phase II had two primary objectives: 1) to determine the effect of four levels of Target BAC on performance for two types of tasks with two levels of difficulty, and 2) to investigate the linear relationship of

TABLE 2

Selected RPM for two levels of difficulty

	In comparison with:	
Subject	Cadet	Avenger
1	29	41
2	31	41
3	33	45
4	39	48
5	13	24
6	17	29
7	20	38
8	29	41
9	20	43
10	12	29
11	19	35
12	24	31

TABLE 3

TOT at selected RPM for two levels of difficulty

	TOT for selected RPM in comparison with:	
Subject	Cadet	Avenger
1	54.6	48.9
2	55.0	46.7
3	41.6	39.8
4	47.0	28.7
5	55.3	53.9
6	55.9	54.7
7	53.0	39.2
8	53.7	46.3
9	56.4	48.4
10	57.2	55.3
11	54.9	49.9
12	55.7	51.9

levels of actual BAC to task performance. The data used to evaluate the effect of BAC on task performance was game score for the VG task and TOT for the PT task. Game scores reflected the number of targets destroyed during a one-minute period for each video game trial, and pursuit tracking scores reflected TOT during a one-minute period for each pursuit tracking trial. Since the performance data for the two tasks was not measured on the same scale, the data from both tasks was standardized to the same mean and standard deviation. The standardized data were then submitted to a Hartley Test in order to determine if the two tasks met the assumption of homogeneity of variance, and could therefore be analyzed by ANOVA. The test did not reject the hypothesis of homogeneity of variance. Therefore, an ANOVA was performed using Target BAC, Task Difficulty, and Task Type as factors. The ANOVA demonstrated significant main effects for both BAC, F (3,21) = 6.80, $p < 0.01$, and Difficulty, F (1,7) = 35.97, $p < 0.001$. No interaction was significant at alpha = 0.05. The ANOVA Summary Table is provided in Table 4.

Separate ANOVAs were then performed on each task. Results of the Video-Game analysis indicated significant main effects for BAC, F (3,21) = 8.06, $p < 0.001$, and for Difficulty, F (1,7) = 25.67, $p < 0.005$. The BAC by

TABLE 4

ANOVA Summary Table for the Analysis of Video Game and Pursuit Tracking Performance

Source	df	SS	F	p
Between-Subjects				
Subjects (S)	7	2107.68		
Within-Subjects				
BAC (B)	3	733.82	6.80	0.0022
Difficulty (D)	1	2695.53	35.97	0.0005
Task (T)	1	0.00		
S x B	21	755.35		
S x D	7	524.54		
S x T	7	3572.39		
B x D	3	32.21	0.60	0.6244
B x T	3	49.78	0.77	0.5217
D x T	1	273.11	3.66	0.0975
S x B x D	21	378.10		
S x D x T	7	522.94		
S x B x T	21	450.40		
B x D x T	3	16.10	0.23	0.8738
S x B x D x T	21	488.04		
Total	127			

Difficulty interaction was not significant. The ANOVA Summary Table for the video game analysis is provided in Table 5, and a graphical representation of the data is presented in Figure 3. A Newman-Keuls Test was then performed on the four BAC means to isolate the contribution to the BAC Main Effect, the results of which are presented in Table 6.

The analysis of the pursuit tracking task performance indicated a significant main effect for Difficulty, $\underline{F}$ (1,7) = 18.70, $\underline{p}$ < 0.005. No significance was found for the BAC main effect or the BAC by Difficulty interaction. Table 7 contains the ANOVA Summary Table for the pursuit tracking task analysis, and a graphical representation of the data is presented in Figure 4.

The data used to meet the second objective were the actual BAC and video-game performance scores. A linear regression of game score on actual BAC was performed for each level of difficulty to determine the degree of the relationship of game score to BAC. The video game was selected for this analysis since the ANOVA indicated a significant BAC effect. The R-Square values were 0.08 for the Cadet level of the video game, and 0.08 for the Avenger level. The regression equation lines were Y = 2310.49 - 4217.85(X), and Y = 1996.63 - 4842.91(X), respectively. The

TABLE 5

ANOVA Summary Table for Video Game Analysis

Source	df	SS	F	p
Between-Subjects				
Subjects (S)	7	12858319.66		
Within-Subjects				
BAC (B)	3	1524909.87	8.06	0.0009
Difficulty (D)	1	1913484.31	25.67	0.0015
S x B	21	1323886.68		
S x D	7	521846.67		
B x D	3	6277.16	0.04	0.9890
S x B x D	21	1098886.33		
Total	63			

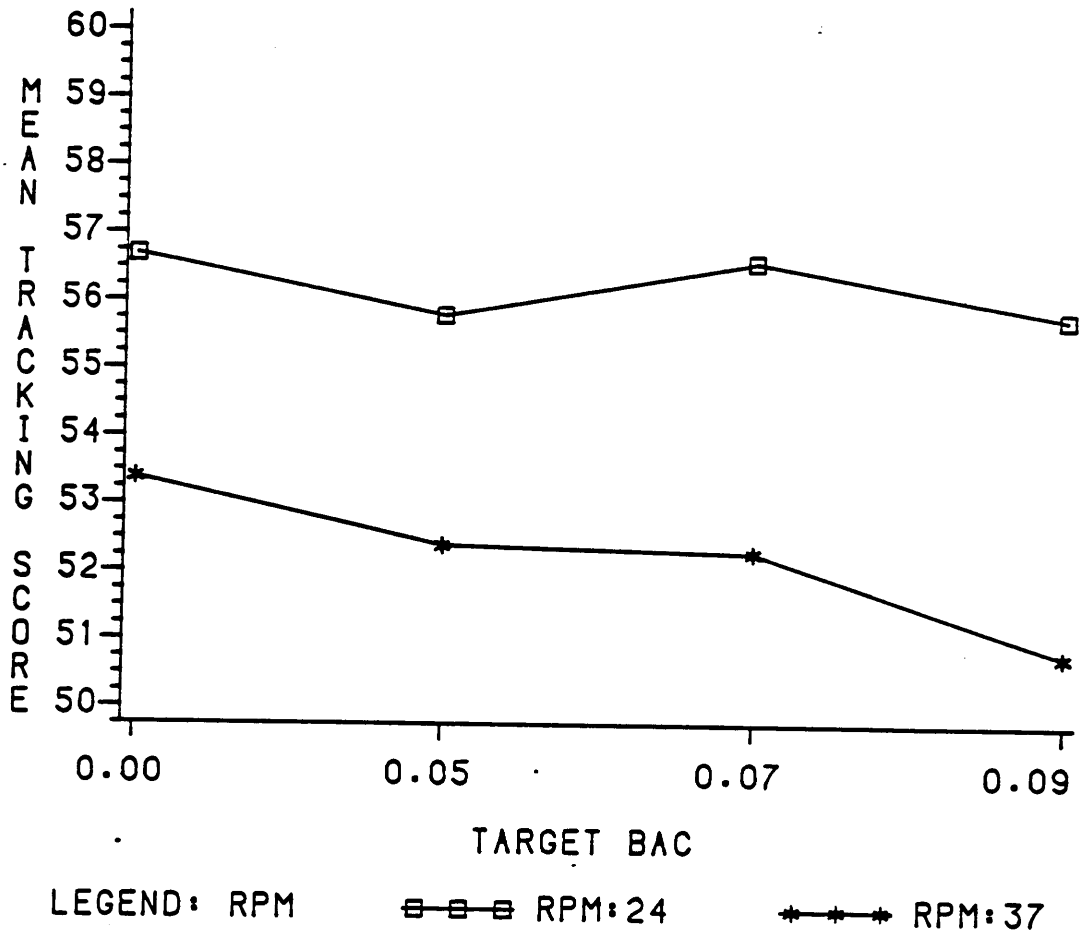


Figure 3. Mean tracking score at two levels of difficulty.

TABLE 6

Results of Newman-Keuls Test for the video game BAC Main Effect

Alpha level = 0.05 df = 21 MS = 63042.2 n = 16

Mean#	Target BAC		
2132.31	.00	A	
1977.08	.05	A	B
1868.75	.07	C	B
1709.38	.09	C	

Means with the same letter are not significantly different

TABLE 7

ANOVA Summary Table for the Pursuit Tracking Task

Source	df	SS	F	p
Between-Subjects				
Subjects (S)	7	175.66		
Within-Subjects				
BAC (B)	3	33.96	2.58	0.0809
Difficulty (D)	1	279.64	18.70	0.0035
S x B	21	92.22		
S x D	7	104.67		
B x D	3	5.52	0.64	0.5981
S x B x D	21	60.46		
Total	63			

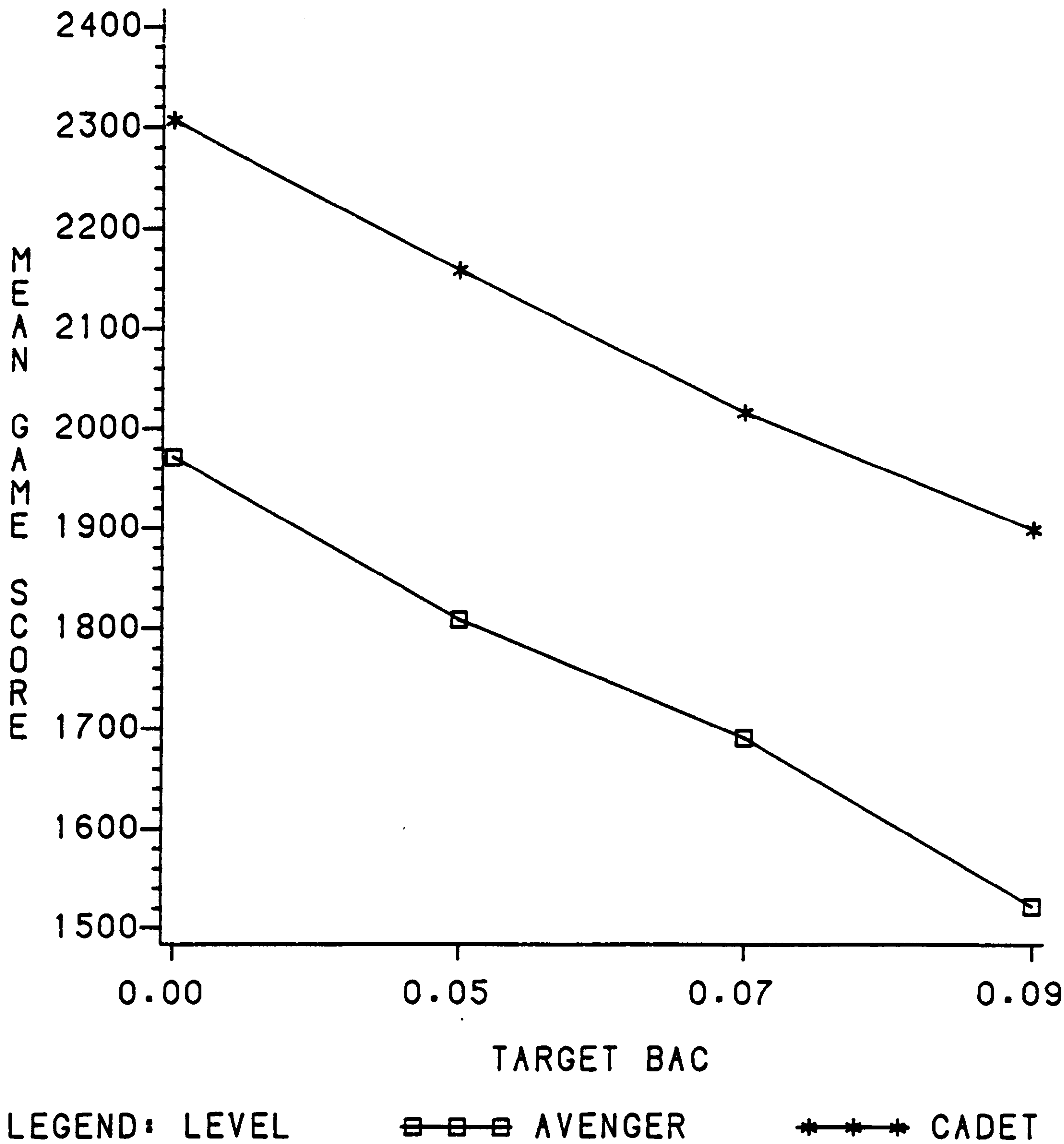


Figure 4. Mean game score at two levels of difficulty.

formula for the least squares method used to calculate regression equations in the present study is provided in Appendix J. Next, the regression analysis was performed on each subject's data. The results are presented in Tables 8 and 9.

TABLE 8

Results of the regression analysis for individual subject data at the Cadet level of difficulty

Subject	Regression Line	R-square	p
1.	Y = 2686.5 - 7881.6(X)	0.86	0.07
2.	Y = 2368.6 + 201.8(X)	0.03	0.83
3.	Y = 2683.6 - 2265.8(X)	0.52	0.28
4.	Y = 2720.1 - 3195.5(X)	0.47	0.31
5.	Y = 1782.6 - 7997.3(X)	0.86	0.07
6.	Y = 1754.6 - 4770.9(X)	0.79	0.11
7.	Y = 2665.3 - 7627.9(X)	0.99	0.0045
8.	Y = 1868.3 - 1477.6(X)	0.56	0.25

TABLE 9

Results of the regression analysis for individual subject data at the Avenger level of difficulty

Subject	Regression Line	R-square	p
1.	Y = 2410.7 - 9758.3(X)	0.94	0.03
2.	Y = 1352.0 + 9133.1(X)	0.51	0.28
3.	Y = 2512.5 - 2501.4(X)	0.39	0.38
4.	Y = 2689.1 - 9992.3(X)	0.53	0.27
5.	Y = 1394.7 - 6863.9(X)	0.97	0.01
6.	Y = 1238.2 - 6123.5(X)	0.79	0.11
7.	Y = 2163.8 - 5292.7(X)	0.81	0.10
8.	Y = 2230.2 - 8131.1(X)	0.86	0.07

DISCUSSION AND CONCLUSIONS

The objective of the present study was to investigate the use of a video game task in comparison to a pursuit tracking task for the purpose of detecting alcohol impairment. To carry out this objective, the two tasks used in this study were compared for difficulty in Phase I. The conclusions from Phase I are: 1) that subjects selected higher RPM's to represent a higher level of difficulty, and 2) that the higher RPM's selected resulted in decreased performance compared to lower RPM's. Performance on the two tasks under various levels of BAC was then measured in Phase II. The general conclusions from Phase II are: 1) that performance of both tasks was significantly affected by BAC and Difficulty, and 2) that a greater decrement in performance due to BAC was observed for the video game task than for the pursuit tacking task. The results and implications of the two phases of research will be discussed further in the following two subsections.

Phase I: Task Difficulty

Two analyses provided information about the levels of difficulty that were evaluated by subjects. First, the RPM selected by subjects to reflect two levels of difficulty, and second, performance at those two levels. Results of the selected RPM for two levels of difficulty clearly indicated that subjects selected a higher RPM to represent a higher level of difficulty. This finding was not surprising, and most likely could be predicted. However, it was a necessary step in producing two levels of difficulty for the pursuit tracking task that would be of similar difficulty compared to the two levels of the video game task.

Tracking scores for the PT task, measured in Time On Target (TOT), were also analyzed. The purpose of this analysis was to establish whether or not the levels selected by subjects resulted in differences in performance. Results indicated a highly significant difference in performance for two selected levels of difficulty.

Phase II: Task Performance

An overall ANOVA indicated highly significant BAC and Difficulty main effects. No significant interaction was found between these two variables, which suggests that the BAC effect did not increase or decrease depending on level of difficulty. The BAC and Task variables did not appear to have a significant interaction effect either. However, in separate ANOVAs, the BAC effect was significant for the video game task, but was not significant for the pursuit tracking task. This finding suggests that the video game task is affected to a greater degree than the pursuit tracking task, and is apparent from the plotted results in Figures 3 and 4. A comparison of percent decrement in performance between the two tasks also supports this conclusion. Mean percent decrement in performance between the placebo and 0.09% BAC conditions for the pursuit tracking task was 3.6%, whereas mean percent decrement for the video game task was 22.8%. These findings suggest that the complexity of a psychomotor task is a more important factor in detecting alcohol-impaired performance than the difficulty level selected for a particular task.

The relationship of BAC to video-game performance was further analyzed by performing a regression of game score on actual BAC. The analysis of variance performed above provided information pertaining to the likelihood of the differences observed among the independent variables, but not the specific relationship of the independent variables to the dependent variable. The purpose of the regression analysis was to provide information about the prediction of one variable from knowledge of another variable.

Results indicated that only a small proportion of the variance in game score was accounted for by the BAC variable. Interpretation of this finding is straightforward; inter-subject variability was too high to assess the game score/BAC relationship in an overall regression analysis. Inter-subject variability for each level of VG difficulty is graphically illustrated in Figures 5 and 6. The ramification of this finding to an applied research setting is that the relationship of game scores to BAC would need to be established on an individual basis. This relationship could then be used to estimate BAC. As an example of this estimation, one subject's regression equation of game score on BAC was plotted (see Fig. 7) with 95% confidence interval curves, that is, the mean value of scores is expected to fall within these lines with 95% confidence for a given BAC value. These confidence limits provide information about expected game scores at various levels of BAC. However, the objective of a video-game test would be to estimate BAC from various game scores. The procedure for carrying out this objective is to establish upper (X_U) and lower (X_L) limits, called fiducial limits, for the BAC variable at a particular game score by performing inverse regression (Draper and Smith, 1981). The equation provided by Draper and Smith (1981) for calculating the fiducial limits is contained in Appendix K. The procedure recommended by Draper and Smith (1981) for estimating the fiducial limits is to: 1) Draw the fitted regression line and confidence interval curves, 2) draw a horizontal line parallel to the X axis at a height of an obtained Y value, 3) Where this straight line cuts the confidence interval curves, drop perpendiculars onto the X-axis to give lower and upper "fiducial limits". These limits, as shown in Figure 7, can then be used to establish a "zone of intoxication" for the subject. For example, if the subject scored a three-trial mean of 2100, then the estimated "zone of intoxication" would be from 0.065% BAC to 0.090% BAC. This performance, observed in an applied setting, would indicate that the subject (customer) was approaching the legal limit of intoxication, and that counter-measures may need to be taken to prevent additional alcohol consumption.

Draper and Smith (1981) point out that estimation by inverse regression is not of much practical value unless the regression is well established, that is, statistically significant. Only two of the 16 regressions performed on individual subject data resulted in statistical significance ($p < 0.05$) in the present study (see Tables 9 and 10). Therefore, the regression needs to be improved over what has

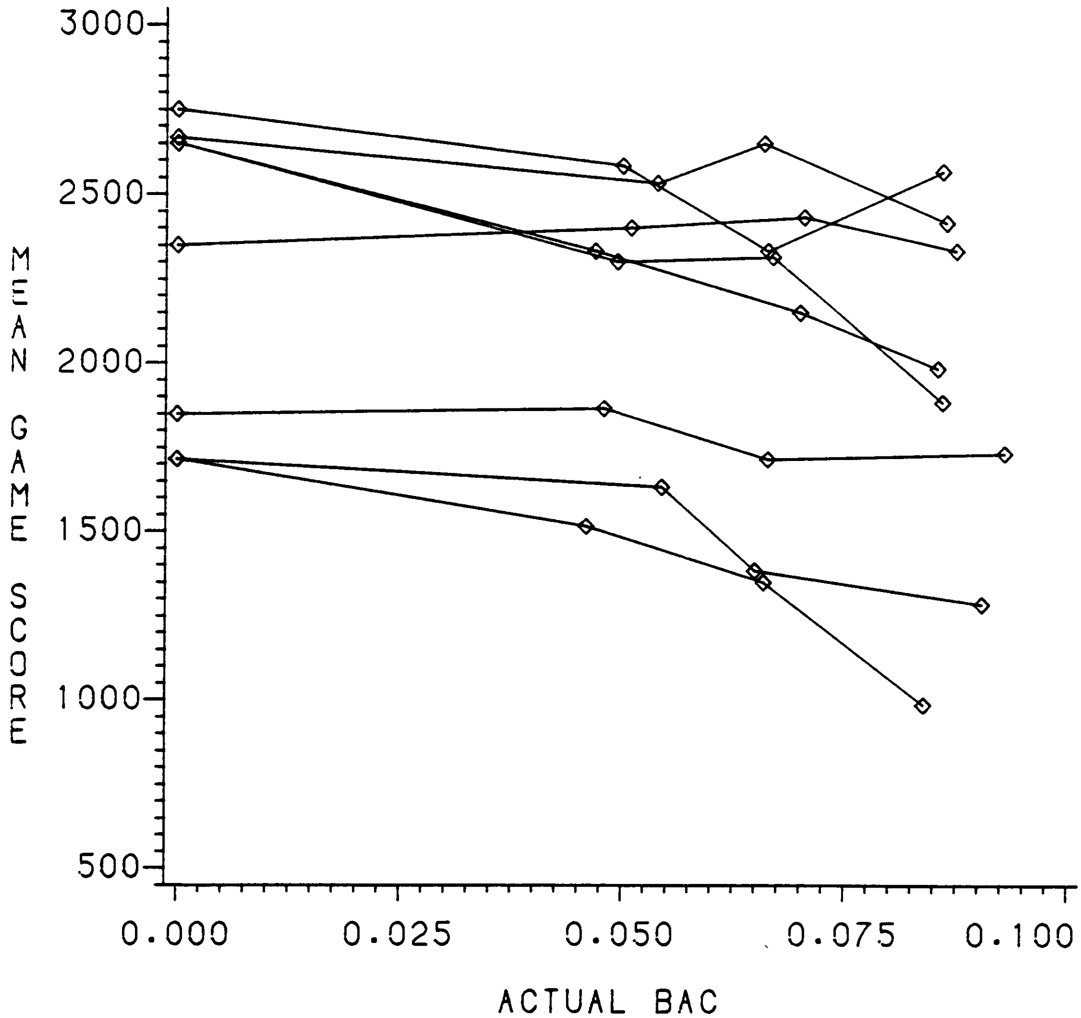


Figure 5. Subject's three-trial mean game scores at the Cadet level of difficulty.

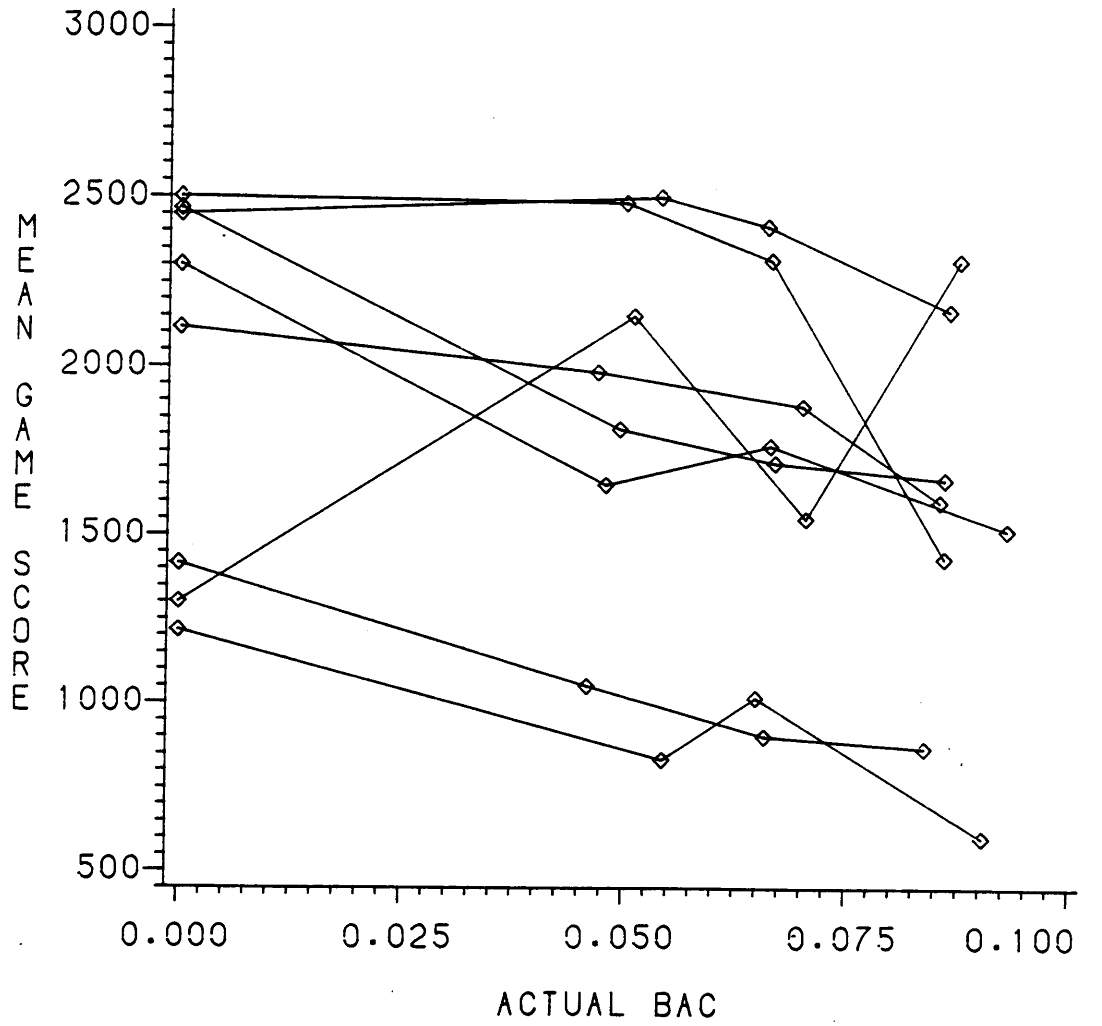


Figure 6. Subject's three-trial mean game scores at the Avenger level of difficulty.

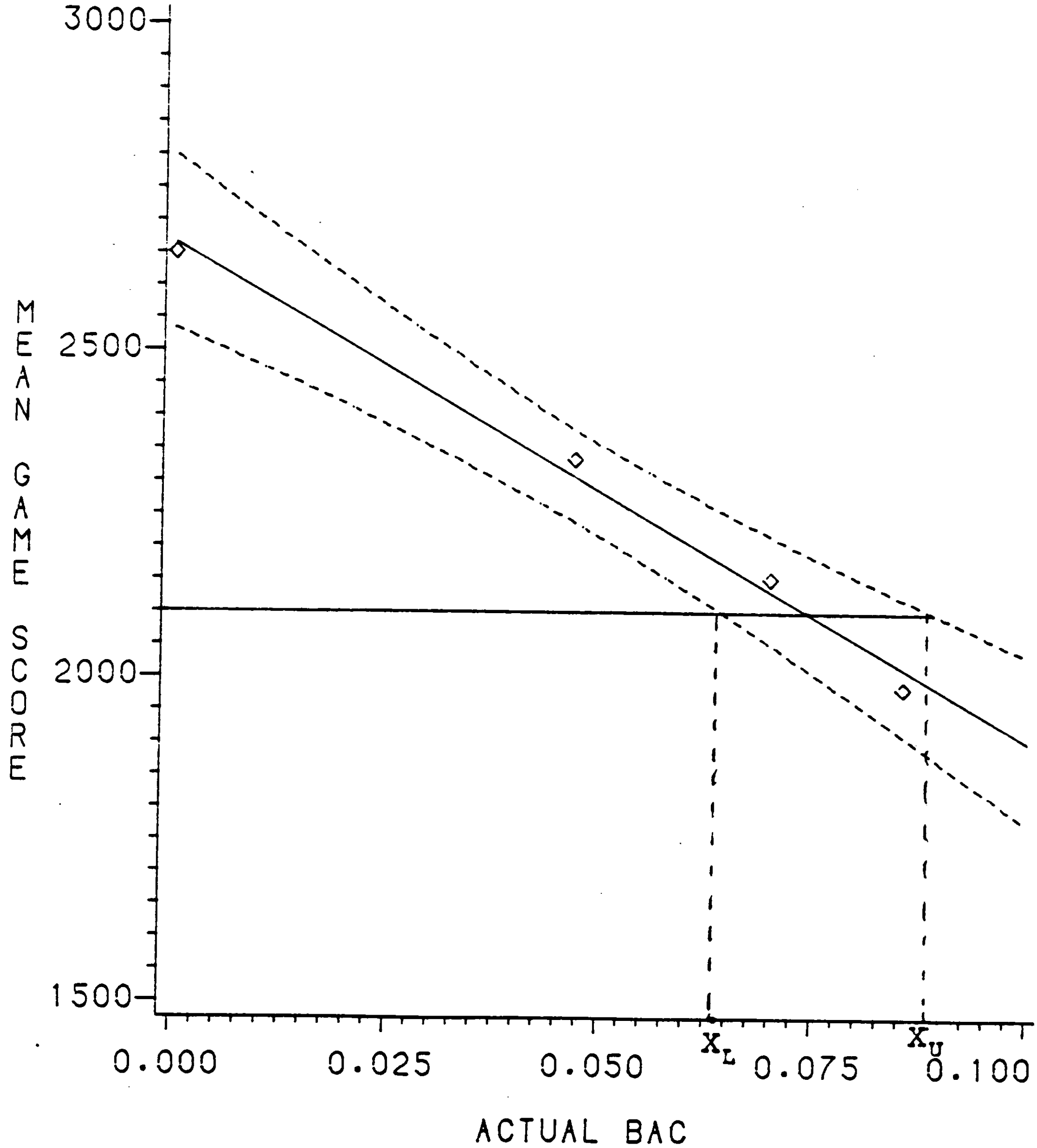


Figure 7. Example of inverse regression for one subject with 95% confidence interval curves.

been observed in the present study to reliably estimate BAC from video game score. Allen, Stein, and Jex (1981) recommend increasing the number of trials to improve the reliability of a psychomotor screening test. In statistical hypothesis testing, reliability is improved by an increase in the number of trials (increased sample size) because the probability of a "Type II" error is decreased. A "Type II" error is the probability that there is a performance decrement when the test concludes that there is none.

An increase in the number of trials necessary to estimate BAC introduces a practical consideration for the present investigation. More trials would require a greater amount of time to both administer and take the video-game test. The amount of time required to estimate BAC with a video game test would be an important consideration for customers as well as drinking establishment personnel.

The results of this study suggest that a commercially available video game could be an important addition to a drinking establishment's alcohol management program for detecting legally impaired customers if a reference score, under a no-alcohol condition, could be established for each individual. Also, multiple trials would need to be administered to increase the test's ability to detect alcohol-impaired performance. Further development of the video game as an alcohol impairment detection test is recommended, and specific areas of further research are described in the next chapter.

RECOMMENDATIONS

The following are suggested recommendations for further studies on the use of video games to detect alcohol-impaired performance:

1) Expand the research to include other commercially-available video games. The video game used in this study clearly demonstrated alcohol-impaired performance. Investigation of other video games would be necessary to determine whether or not this finding will generalize to other video games.

2) Research which would investigate the effects of higher dosages of BAC on the performance of video games. Data from such studies would aid in developing a strategy for determining those customers who are above the legally-impaired level.

3) Field (drinking establishment) studies which would investigate the feasibility of including a video game as a performance test in an alcohol management program.

4) A duplicated research involving women as participants. Performance comparison between men and women would be appropriate.

5) Details relating to the methods used for manipulating BAC in any study using BAC as an independent variable would provide information which would help to achieve predicted BAC's. In the present study, actual BAC's were close to the predicted values using the formula provided in Appendix G. This formula was derived from data provided by Greenblatt and Schuckit (1976). The mean BACs obtained in this study were 0.000%, 0.050%, 0.067%, and 0.087% with standard deviations of 0.000, 0.003, 0.002, and 0.003 respectively (see Fig. 8). Although these means are close to the predicted targets of 0.00%, 0.05%, 0.07%, and 0.09%, the formula used in this study for calculating BAC should be questioned for the following reasons: 1) The database was small (two subjects), and 2) the equation contains a cubed factor that will cause the predicted BAC to decrease at some point as alcohol dosage increases. This is counter-theoretic as well as counter-intuitive. However, the BACs obtained in this study do indicate that this formula was fairly accurate under the low levels of alcohol and conditions described in this study.

The most important aspect in calculating the alcohol necessary to achieve a target BAC is not whether the researcher has found the "proper" formula, but whether the researcher has replicated the conditions under which a particular formula was developed. Many factors are known to influence the resulting BAC such as absorption rate, tolerance, and percent of body fat, but an integration and detailed description of all of the factors' influences has not been developed. Hence, researchers should report the details of their method for administering alcohol and data relating to those factors known to influence BAC. This information will contribute to the development of a data base that will be used for better calculation of the amount of alcohol necessary to achieve target BACs, and general knowledge about how the human body absorbs, distributes, and eliminates alcohol.

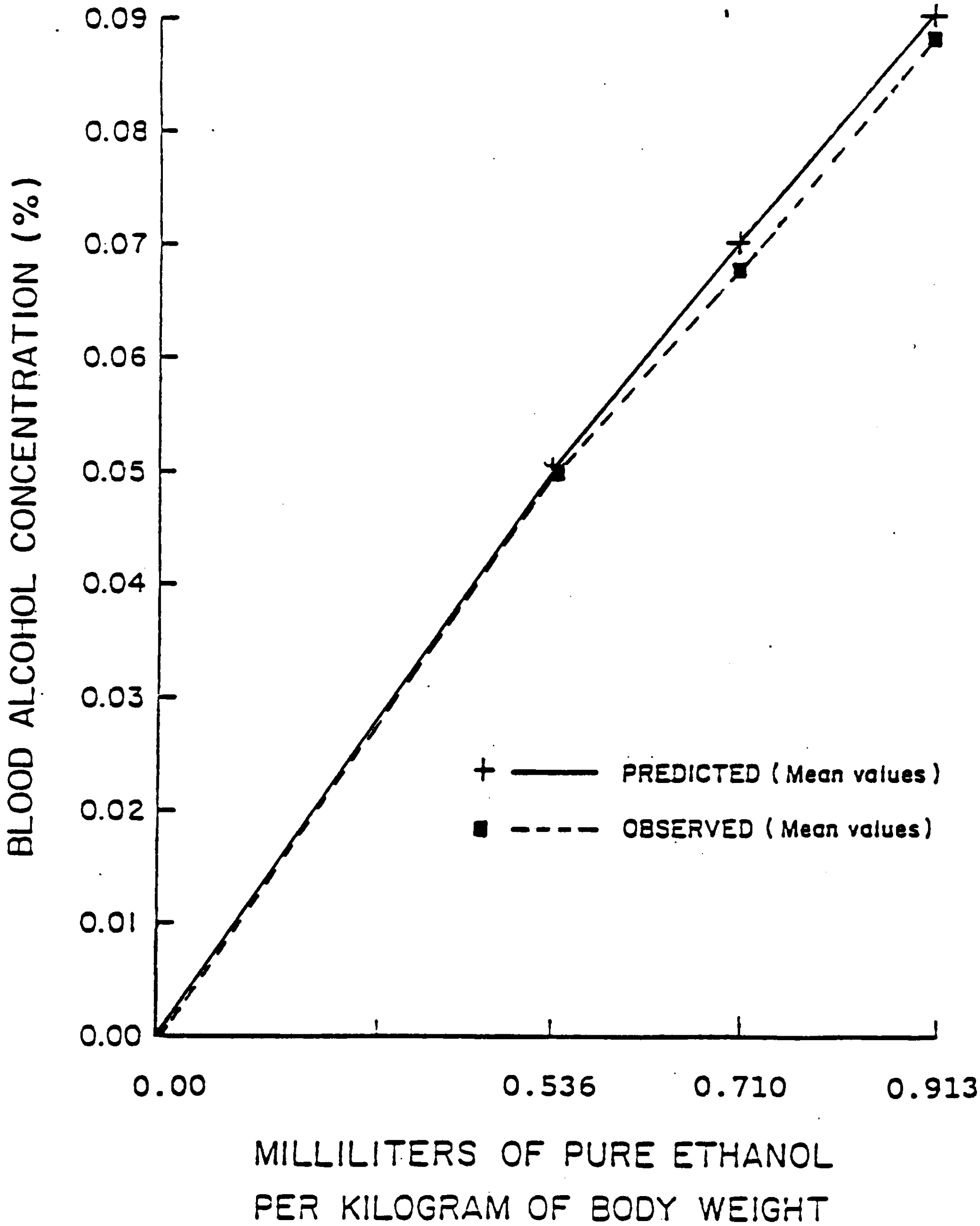


Figure 8. Predicted versus observed alcohol mean values.

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Appendix A

SUBJECT RECRUITMENT ADVERTISEMENTS

RECRUITING ADVERTISEMENT: PHASE I SUBJECTS

(reduced in size by 64%)

SUBJECTS WANTED!

(MALES ONLY)

PARTICIPATE IN A

VIDEO GAME EXPERIMENT

TIME REQUIRED: 1 HOUR

PARTICIPANT REQUIREMENT: MUST HAVE CORRECTED OR UNCORRECTED VISION OF 20/25 OR BETTER

TO SIGN UP: GO TO WHITTEMORE 167 BETWEEN 8 A.M. AND 3 P.M. MONDAY THROUGH FRIDAY

NO EXPERIENCE NECESSARY

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.
VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.
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VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.
VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

RECRUITING ADVERTISEMENT: PHASE II SUBJECTS

(reduced in size by 64%)

SUBJECTS WANTED!

(MALES ONLY)

PARTICIPATE IN A

ALCOHOL/VIDEO GAME EXPERIMENT

TIME REQUIRED: 4 nights, about 4 hours per night plus a 1 hour training session

PAYMENT: $12 for each evening session plus $3 for the training session

REQUIREMENTS FOR PARTICIPANTS: (1) must be 21 years of age; (2) must have current records at student health; (3) must have corrected or uncorrected vision of 20/25 or better;

TO SIGN UP: go to Whittemore 167 between 8am and 3pm Monday through Friday; you will be contacted for a 15 minute initial screening;

NO EXPERIENCE NECESSARY

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

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VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

VIDEO GAME EXPERIMENT
WHIT. 167 8A.M.-3P.M.

Appendix B

FORMS FOR INFORMED CONSENT

FORM FOR INFORMED CONSENT (5-Session Study)

The purpose of the current study is to look at the effects of alcohol on task performance. Mr. Kidd will meet with you on four additional occasions for about five hours each time. On each meeting he will ask you to drink a mixture of vodka and orange juice and will give you a breath test like the one used by many police departments. You will then be asked to spend about 15 minutes performing two tasks. These tasks will be a video game and a rotary pursuit tracking task. Following this 15 minute period, you will rest in the laboratory until your body has used up almost all the alcohol you were given. During the time you spend resting, Mr. Kidd will answer any questions you may have regarding the experiment except those those that may influence your performance during remaining sessions.

If you agree to participate in this experiment you have certain rights and obligations. The purpose of this document is to make you aware of these rights and obligations, and to obtain your consent to participate.

1. Being in an experiment can make some people nervous even when they know that there are no good or bad scores. If you find yourself getting nervous, or you want to stop being in the experiment for any other reason, you have the right to stop the experiment in which you are participating at any time.

Should you terminate the experiment, you will receive pay only for the proportion of time you participated, including all time your presence is required. If you should terminate your participation, you will be required to remain on the premises until your blood alcohol content reaches a level of 0.03% or less. Further, if you should terminate your participation, your legal rights, regarding negligence and the liability of the institution and its agents are not waived.

2. You have the right to see your data and to withdraw it from the experiment if you feel that you should. In general, data are processed after all runs are completed. In this experiment, we can provide you with some quantitative information immediately after the entire experiment. Subsequently, all data will be treated with anonymity. Therefore, if you wish to withdraw your data, you must do so immediately after your participation is completed. If you do not exercise your right to withdraw your data, any information collected about you during the project can be used for educational and/or scientific purposes either at the Virginia Polytechnic Institute and State University or at other scientific or educational institutions. If any information about the alcohol project is shown to other people, your name will not appear on it anywhere.

3. You have the right to be informed of the results of the overall experiment. If you wish to receive information on the results, please include your address (3 months hence) with your signature in the space provided. A summary will be sent to you. If you would like further information, please contact the Human Factors Laboratory, 961-5635, and a full report will be made available to you.

4. You will be required to refrain from eating any foods or drinking any liquids (including alcohol) for at least four (4) hours prior to the experimental session.

5. You will be required to abstain from drinking any alcohol or taking any drugs for at least twenty-four (24) hours prior to the experimental session.

6. You will be required to remain under observation until your blood alcohol content, indicated by Breathalyzer tests, is reduced to 0.03% or less.

7. After each experimental session you will be transported home by a driver who has not ingested any alcohol. Under no circumstance will you be allowed to drive yourself home.

8. During each session you spend in the laboratory, you may or may not be in an intoxicated condition. You might experience blurred vision, dizziness, nausea, loss of balance, and difficulty with speech.

9. It is your responsibility as a participant to advise Mr. Kidd of any medical problems that arise in the course of the experiment. Should you for some reason suffer injury, we will not offer care or compensation other than first aid.

Should you have any additional questions or problems, contact Dr. Dennis L. Price, Professor, IEOR Department, at 961-5635, or Mr. Charles D. Waring, Chairman, Institutional Review Board for Research involving Human Subjects, at 961-5284.

Your assistance in this experiment is intended to be an interesting experience for you, and the people involved greatly appreciate your contribution as a participant.

YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE READ YOUR ABOVE STATED RIGHTS AND OBLIGATIONS AS A PARTICIPANT, AND THAT YOU CONSENT TO PARTICIPATE. If you include your name <u>and</u> address printed below, a summary of the experimental results will be sent to you.

____

Signature

____

Printed Name

____

Address

____

City, State, Zip

FORM FOR INFORMED CONSENT (1-Session Study)

The purpose of the current study is to compare the levels of difficulty between two types of tasks. You will be asked to spend about 15 minutes learning to perform the two tasks. Following this 15 minute period, you will be asked to match the levels of difficulty between the two types of tasks by adjusting the difficulty of one of the tasks. Mr Kidd will answer any questions you may have regarding the experiment except those that may influence your performance during the remainder of the session.

If you agree to participate in this experiment you have certain rights and obligations. The purpose of this document is to make you aware of these rights and obligations, and to obtain your consent to participate.

1. Being in an experiment can make some people nervous even when they know that there are no good or bad scores. If you find yourself getting nervous, or you want to stop being in the experiment for any other reason, you have the right to stop the experiment in which you are participating at any time.

Should you terminate the experiment, you will receive pay only for the proportion of time you participated, including all time your presence is required. If you should terminate your participation, your legal rights, regarding negligence and the liability of the institution and its agents are not waived.

2. You have the right to see your data and to withdraw it from the experiment if you feel that you should. In general, data are processed after all runs are completed. In this experiment, we can provide you with some quantitative information immediately after the entire experiment. Subsequently, all data will be treated with anonymity. Therefore, if you wish to withdraw your data, you must do so immediately after your participation is completed. If you do not exercise your right to withdraw your data, any information collected about you during the project can be used for educational and/or scientific purposes either at the Virginia Polytechnic Institute and State University or at other scientific or educational institutions. If any information about the video game project is shown to other people, your name will not appear on it anywhere.

3. You have the right to be informed of the results of the overall experiment. If you wish to receive information on the results, please include your address (3 months hence) with your signature in the space provided. A summary will be sent to you. If you would like further information, please contact the Human Factors Laboratory,

961-5635, and a full report will be made available to you.

4. It is your responsibility as a participant to advise Mr. Kidd of any medical problems that arise in the course of the experiment. Should you for some reason suffer injury, we will not offer care or compensation other than first aid.

Should you have any additional questions or problems, contact Dr. Dennis L. Price, Professor, IEOR Department, at 961-5635, or Mr. Charles D. Waring, Chairman, Institutional Review Board for Research involving Human Subjects, at 961-5284.

Your assistance in this experiment is intended to be an interesting experience for you, and the people involved greatly appreciate your contribution as a participant.

YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE READ YOUR ABOVE STATED RIGHTS AND OBLIGATIONS AS A PARTICIPANT, AND THAT YOU CONSENT TO PARTICIPATE. If you include your name <u>and</u> address printed below, a summary of the experimental results will be sent to you.

____

Signature

____

Printed Name

____

Address

____

City, State, Zip

Appendix C

LIST OF CANDIDATE VIDEO GAMES

<u>List of Candidate Video Games</u>

1. Air Combat Maneuvering
2. Asteroids
3. Baseball
4. BC Quest For Tires
5. Canyon Climber
6. Claim Jumper
7. Crossfire
8. Cubes
9. Galactic Chase
10. Gorf
11. Match Racer
12. Mule
13. Preppie
14. Raster Blaster
15. Salmon Run
16. Track Attack
17. Wizard of Wor

Appendix D

CLINICAL RECORD EVALUATION FORM

<u>CLINICAL RECORD EVALUATION</u>

I,________________________ authorize C. W. Schiffert, M.d.,
Print Name

Director of the Virginia Tech Health Service, to release requested information about my health to the: <u>Alcohol Experiment</u>.

Signed______________________________
Signature of Student

I have reviewed the Virginia Tech Clinical record of ____________________ and find a/no medical condition or physical impairment that precludes his participation in the following activity: <u>Alcohol Experiment</u>.

____
Director of Student Health Service

Appendix E

SCREENING QUESIONNAIRE

SCREENING QUESTIONNAIRE

Name: ____

Address: ____

Phone Number: _______________________________________

ID Number (SS#): _____________________________________

TO BE FILLED IN BY EXPERIMENTER:

Visual Acuity: _______________________________________

Weight: ____

Color Blindness: _____________________________________

The following questions are intended to give the experimenters information regarding the general levels of alcohol and caffeine consumption to which your body is accustomed and information regarding any previous experience with video games. You may ignore any questions which are offensive to you. 1. How much of the following do you consume per week?

a) Beer (number of cans, bottles, glasses) _______per week

b) Wine (table wine, i.e., white, red, rose) ______glasses per week

c) Fortified Wine (port or sherry) _______glasses per week

d) Hard (distilled) liquor (whiskey, gin, etc.) ____ounces per week

2. During the course of a week, on which days do you usually consume alcoholic beverages? (Circle all days that apply)

Monday Tuesday Wednesday Thursday Friday Saturday Sunday

3. Indicate the percentage of your alcohol consumption associated with each of the days you may have circled in question 2; writing the correct percentage values in the spaces provided for morning, afternoon, and evening. (Remember that the total of these percentages should equal 100 for the entire week.)

	M	T	W	H	F	S	S
Morning	___	___	___	___	___	___	___
Afternoon	___	___	___	___	___	___	___
Evening	___	___	___	___	___	___	___

4. How much coffee do you drink?

   a) Morning ____________ cups per day

   b) Afternoon __________ cups per day

   c) Evening ____________ cups per day

5. Are you presently taking any prescribed drugs? If so, list the type of drug and when taken.

   yes / no ____

   ____

6. Are you presently using legal non-prescribed drugs? (cold capsules, vitamins, etc.) If so, please list the type of drug and when taken.

   yes / no ____

   ____

7. During the period when you played the most video games, how often did you play video games? Please indicate the average number of games you played per week.

   Approximately ___________ games per week.

8. How well do you play video games? Please rate your video-game skill level?

____ Beginner

____ Intermediate

____ Advanced

____ Expert

9. Have you ever played a video game called "Gorf"?

___ yes

___ no

10. Have you ever performed a task called a Rotary Pursuit Tracking Task?

___ yes

___ no

Appendix F

SUBJECT INSTRUCTIONS - PHASE I

INSTRUCTIONS

The purpose of this session is to compare and adjust the levels of difficulty between two types of tasks. One type of task will be a video game called "Gorf". In order to perform this task you will need to use the joystick located on the table in front of you. The task will be displayed on the television that is also located in front of you. The second type of task is a tracking task called a Rotary Pursuit Tracking Task. The tracking task will be performed using the apparatus located to your right. At this time, please indicate that you are ready to receive further instructions from the experimenter by saying, "ready".

During this session, you will be adjusting the difficulty of the Tracking Task to match the difficulty of the Video Game Task. In order to adjust the difficulty of the Tracking Task, rotate the dial marked "RPM", which is located on the left side of the tracking apparatus. Attempt to make your adjustment during the first 5 to 10 seconds of the one minute period. At the end of each one minute session, record the RPM you selected on the following page (round off to the nearest whole number). After you have entered the RPM for that trial, turn the RPM dial back to 0 and let the experimenter know that you are ready for the next Video Game trail by saying, "Ready". Continue to compare and adjust the level of difficulty each time you perform the Tracking Task. Now that you have read these instructions, the experimenter will review this procedure with you. Please indicate that you are ready for a review of the procedure now by saying, "Ready".

Video Game Difficulty Level	Tracker RPM Selection

Appendix G

SUBJECT INSTRUCTIONS - PHASE II

Instructions

Procedure

1. Practice tasks - 10 minutes
2. Drink - 20 minutes
   - please try to drink the entire mixture over the 20 minute period at a constant rate
3. Wait - 20 minutes
   - this will allow the mixture to be absorbed
4. Breathalyzer test - approx. 2 minutes
5. Perform tasks - 15 minutes
6. Breathalyzer test - approx. 2 minutes
7. Wait - until approximately 9:30 p.m.

Notes:

1. You will be driven home by the experimenter only after all participants have reached a blood alcohol concentration of 0.03 percent or below. If being driven home presents a problem, please inform the experimenter now.

2. The estimated time of completion is 9:30

3. Please feel free to make use of the time you are required to wait by studying, ordering pizza, etc.

Thanks again for your participation!

Appendix H

ALCOHOL DOSAGE CALCULATION

ALCOHOL DOSAGE CALCULATION

The four target BAC levels used in the study (0.00%, 0.05%, 0.07%, 0.09%) were achieved by administering a dosage of vodka based on the subject's body weight (measured in kilograms). Specifically, for 0.05, 0.07, and 0.09 per cent BAC to be attained, 0.5363, 0.7102, and 0.913 milliliters of pure ethanol per kilogram was required, as demonstrated in previous research (e.g., Barbre and Price, 1982). This follows from the formula:

$$\%BAC = 0.031841d + 0.16522d^2 - 0.09782d^3$$

where d is equal to milliliters of pure ethanol per kilogram of body weight. The vodka was 80 proof, that is, 40 per cent pure ethanol. The required dosage of vodka was mixed with cold orange juice such that the total drink volume was held constant with respect to body weight.

The total drink volume in ounces was determined by taking the participant's body weight in pounds, dividing that by 50, and multiplying the quotient by four, this gives four ounces of liquid per 50 lbs of body weight. When this figure was divided by .03381, it yielded the drink volume in milliliters.

For the placebo condition of 0.00 per cent BAC, the full amount of orange juice was administered with a few drops of vodka floated on top for taste. For the actual dosage levels, the milliliters per kilogram required for a certain BAC was multiplied by body weight (in kilograms), then this product was divided by 0.4 to yield the amount of vodka needed for each BAC. The amount of orange juice needed was the difference between the required amount of vodka and the total drink volume.

Appendix I

DEBRIEFING LETTER

Safety Projects Office

167 Whittemore Hall

Virginia Polytechnic Institute

Dear Participant:

Here are the results of the experiment you participated in earlier this quarter...

The average video game scores for all participants at four levels of Blood Alcohol Concentration (BAC) are presented in Figure 1. Figure 2 represents the performance on the pursuit-tracker. (Please note that Fig. 1 and 2 demonstrate averages, and that your performance may have been different than this average.)

The purpose of the experiment was to investigate two types of tasks at two levels of difficulty to determine their effectiveness in detecting alcohol-impaired customers at drinking establishments. The results of this experiment suggest that a video game may have potential in achieving this purpose.

If you have any further questions, please do not hesitate to contact Stan Kidd at 961-5635.

Again, thanks for taking part in this research and have a good summer.

Sincerely,

Stan Kidd

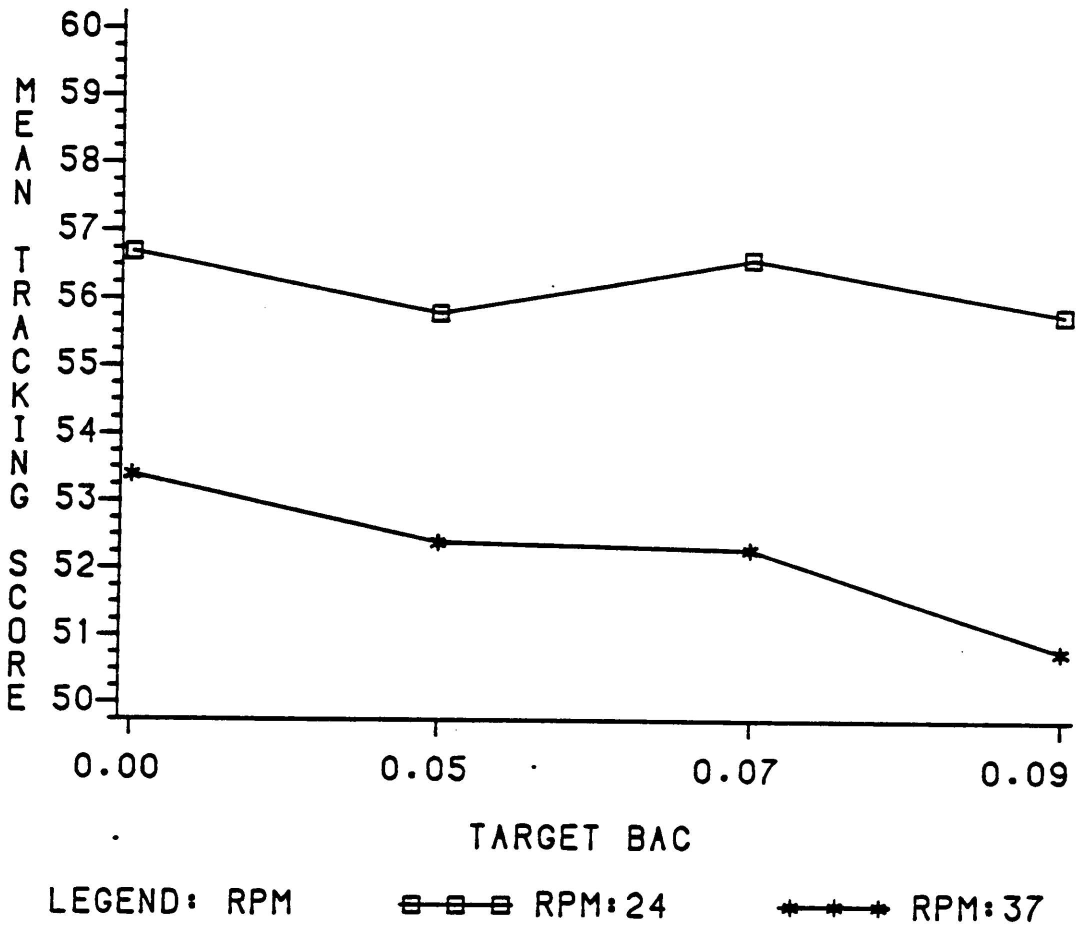

Figure 1. Mean tracking score at two levles of difficulty.

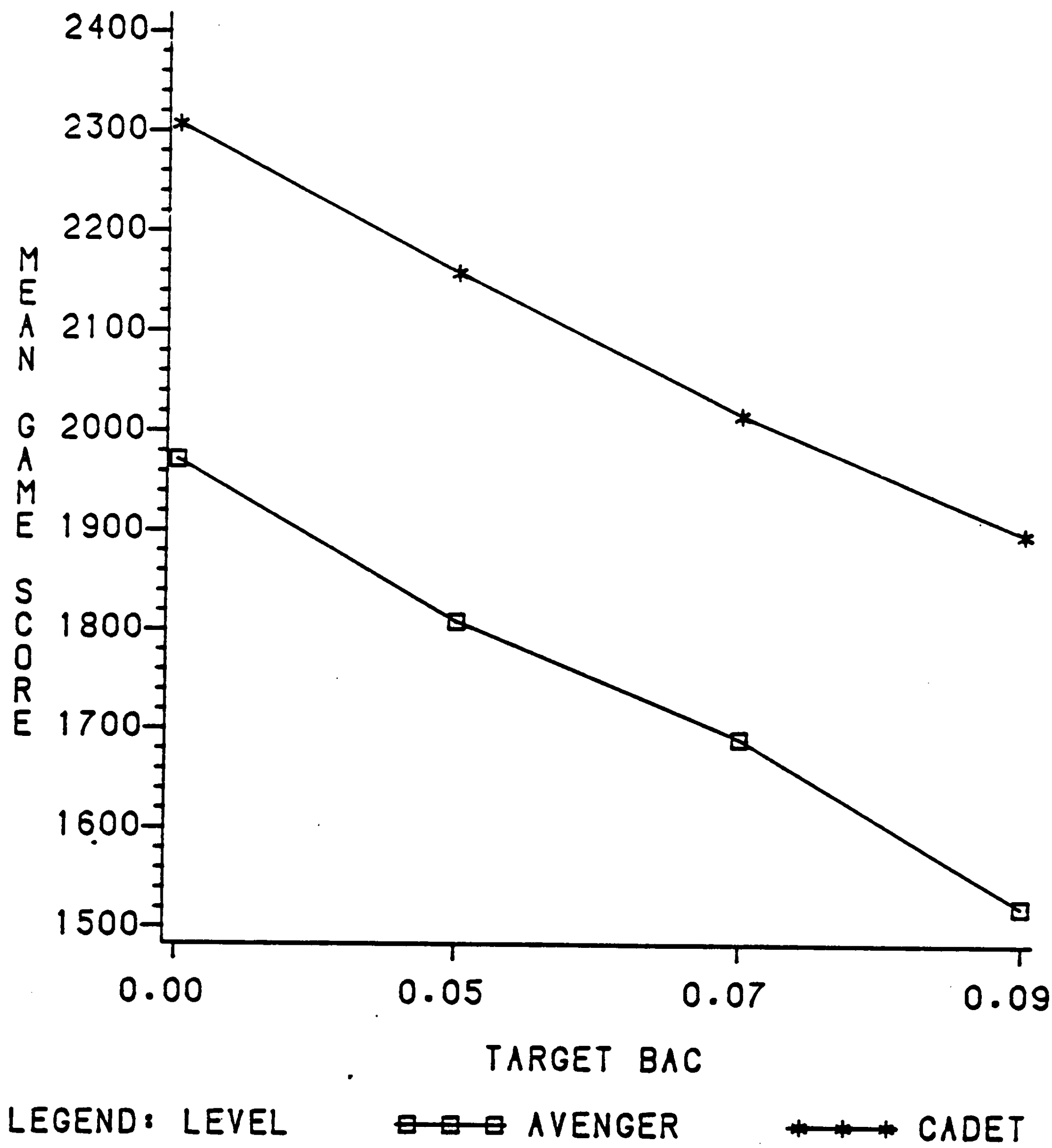

Figure 2. Mean game score at two levels of difficulty.

Appendix J

CALCULATION OF THE REGRESSION OF Y ON X

FORMULA: METHOD OF LEAST SQUARES FOR

CALCULATING THE REGRESSION OF Y ON X

The equation of the regression line of Y on X is

$$Y' = a + bX$$

where

$$b = \frac{\Sigma XY - (\Sigma X)(\Sigma Y)/n}{\Sigma X^2 - (\Sigma X)^2/n}$$

and

$$a = \overline{Y} - b\overline{X}$$

Note: n = the number of pairs of X and Y values.

Appendix K

FIDUCIAL LIMIT CALCULATION

FIDUCIAL LIMIT CALCULATION

The equation provided by Draper and Smith (1981) for calculating the fiducial limits is

$$\left.\begin{matrix} X_U \\ X_L \end{matrix}\right\} = \bar{X} + \frac{b_1(Y_0 - \bar{Y}) \pm ts\{[(Y_0 - \bar{Y})^2/S_{xx}] + (b_1{}^2/n) - (t^2s^2/nS_{xx})\}^{1/2}}{b_1{}^2 - (t^2s^2/S_{xx})}$$

where

$$S_{xx} = \sum (X_i - \bar{X})^2$$

$t = t(\nu, 1 - \alpha/2)$ is the usual t percentage point, and ν is the number of degrees of freedom of s^2

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ABSTRACT

INVESTIGATION OF THE USE OF VIDEO GAMES
TO DETECT ALCOHOL-IMPAIRED PERFORMANCE

by

Stan Kidd

Twelve male subjects participated in Phase One and eight male subjects participated in Phase Two of a two-part experiment evaluating the effects of various levels alcohol on the performance of two tasks with two levels of difficulty. One task required performance of a commercially available video game, and the other task required rotary pursuit tracking performance. Two levels of pursuit tracking task difficulty were developed in comparison to two levels of video game difficulty in Phase One. Results indicated a significant difference in performance at the two levels of pursuit tracking task difficulty that were developed. Performance on both tasks was then evaluated in Phase Two under four target levels of blood alcohol concentration (0.0%, 0.05%, 0.07%, and 0.09%). Results

indicated significant alcohol and difficulty effects, and video game performance was degraded to a greater extent by the alcohol dosages used than rotary pursuit tracking performance.