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INVESTIGATION OF THE EFFECTS OF SECOBARBITAL ON COGNITIVE AND PSYCHOMOTOR SKILLS RELATED TO DRIVING AN AUTOMOBILE

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INVESTIGATION OF THE EFFECTS OF SECOBARBITAL ON COGNITIVE AND PSYCHOMOTOR SKILLS RELATED TO DRIVING AN AUTOMOBILE

BY

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EFFECTS OF SECOBARB ON DRIVING SKILLS

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OF

ROBERT ARTHUR MILLER

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ABSTRACT

The effects of a 100 mg. dose of secobarbital was measured on a cognitive and psychomotor test of human behavior presumably related to driving an automobile. Eight healthy subjects, six female and two male, ranging in age from 25 to 40 years were tested by means of a simple math test and a pursuit rotor. Each subject underwent three separate drug experiments and during each was tested at one hour and at three hours after secobarbital administration. Blood samples were taken immediately before the one and three hour testing sessions in each drug trial. Quantitation of the secobarbital was accomplished by gas chromatography using a 2.5% SE-30 column.

Secobarbital was found to significantly impair both the cognitive and psychomotor functions of behavior as measured by the math and pursuit rotor tests respectively at the one hour time interval after secobarbital ingestion. Only in the second drug trial did a psychomotor impairment persist at the three hour time period. Blood levels of secobarbital showed a correlation with percent change in psychomotor performance at one hour with the pursuit rotor test results and with the combined one and three hour pursuit rotor test results. Rank-order correlation was also shown. Math test results did not show correlation with blood levels of secobarbital.

The time since secobarbital ingestion appeared to be

an important consideration when trying to determine drug induced impairment of function. Impairment in both the cognitive and psychomotor functions was noted at the one hour time period but not at the three hour time period even though secobarbital blood levels remained in the therapeutic range.

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I. INTRODUCTION

With respect to the Implied Consent Law of the Motor Vehicle Code Act of Rhode Island as amended and effective September 1, 1973, it is "unlawful and punishable for any person who is a habitual user of or under the influence of any intoxicating liquor, narcotic drug, barbiturate, toluene, or any central nervous system stimulant to drive an automobile."

Alcohol, unlike drugs in general, is one substance which has been thoroughly studied by many researchers to determine its effects on psychomotor skills as they relate to driving an automobile. There are well standardized tests which can identify and measure quantities of alcohol within a person's blood stream and entire body. Correlation between the amount of alcohol in a person's blood stream and the psychomotor effects caused by it has progressed to the extent that legislators have been able to enact laws to govern its abuse in automobile traffic circumstances. Definite amounts of alcohol in a person's blood stream, i.e., 0.10% by weight, have been shown to definitely cause impairment of psychomotor performance.

Similar information with regard to drugs and their effects on psychomotor performance does not exist. Due to the difficulty in predicting the effects of drugs, under uncontrolled circumstances, on psychomotor skills, one cannot show with certainty if a drug when detected in the blood stream in therapeutic amounts is actually causing a psychomotor impairment. The inability to prove the correlation between blood levels of drugs and spychomotor impairment is

due in part to lack of sufficient research done in this area. Research that has been done has correlated a given dose of drug with an impairment of human performance, but has not attempted to correlate blood levels of drugs and the psychomotor impairment caused by them.

To this end a study is proposed that will attempt to determine if a correlation exists between blood levels of secobarbital and impairment of a psychomotor and cognitive skill used to drive an automobile. The study will involve eight young, healthy, adults who will be given 100 mgs. of secobarbital sodium and at pre-determined intervals undergo two tests that relate to some of the skills needed to operate a motor vehicle. Just prior to the tests, a blood sample will be taken and the level of secobarbital present in the blood stream determined. Evaluation of the psychomotor tests in the light of the secobarbital blood levels will be made.

Secobarbital, as a representative of the barbiturate class of drugs, was selected as the test drug for this investigation because of its popularity and availability on both the licit and illicit markets. Barbiturates are among the most frequently prescribed sedative-hypnotic drugs and secobarbital is one of the most popular fast acting barbiturates. The adult average dose of secobarbital is 50-200 mgs. daily for sedation and 100 mgs. at bedtime for sleep induction. (Swinyard and Harvey, 1970).

II. LITERATURE REVIEW

Driving an automobile is a highly complex psychomotor and perceptual task which is therefore subject to impairment by any factor which significantly alters the physiological and/or psychological state of an individual.

With the passage by the State Legislature of the Implied Consent Law previously referred to, an attempt has been made to remove from the highways of Rhode Island those people who either knowingly or unknowingly drive an automobile while under the influence of drugs. The use of mind altering drugs other than alcohol presents a serious contemporary problem. The exact proportion of the population of the United States using mind altering drugs is not known and to even a lesser extent the proportion of those who use drugs and drive an automobile. However, the fact that alcohol and drugs, alone or in combination, are associated with over 50% of highway fatalities is a well known and documented observation. (Milner, 1972).

Studies of the incidence of drug use in the general population indicate that drugs have become an important factor in the automobile driving population. An editorial in Traffic Laws Commentary (1965) presents general figures prepared by Smith, Kline, and French in 1963. It states that at any time, 10 to 20% of the driving population is using a prescribed drug.

According to a California survey (Manheiner et al, 1968), 12% of men and 22% of women reported that they legally used prescription or non-prescription stimulants, sedatives, or tranquilizers frequently. Four percent of men and 8% of women reported using sedatives, 6% of

men and 14% of women used tranquilizers, and 5% of men and 8% of women used stimulants.

The results of two independent surveys reported by Parry (1968) indicate that "about one-fourth of the U. S. adult population currently use one or another of the legal psychotropic drugs--sedatives, tranquilizers, and stimulants." "Currently" is interpreted to mean within twelve months prior to the survey questionnaire. Forty-eight percent of those surveyed had taken psychotropic drugs at some time preceding the survey questionnaire.

Studies to determine the frequency with which drugs are involved in either fatal or non-fatal automobile accidents are limited; however, some information is available to indicate the impact of drugs on driving in the United States. In a study conducted by the State of California Highway Patrol (1965), it was found that drugs were detected in approximately 12% of the fatal single car accidents. The procedures for drug detection used in this survey did not cover all drugs, but due to circumstances, were limited.

A survey conducted by Finkle et al. (1968), reported the frequency of occurrences of drugs in 3,409 routine drinking driver investigations in Santa Clara County, California, during 1966. Seven-hundred and five or 21% of the cases involved 713 drug occurrences. There were 107 different drugs which fell into 20 different categories which included prescribed and over-the-counter compounds.

A study conducted by Woodhouse (1972) of the Midwest Research Institute sponsored by the U. S. Department of Transportation determined the incidence of drugs in fatally injured drivers. One-hundred and ninety-one biological samples were obtained from special Alcohol Safety Action Project areas throughout the United States. Samples were sent

in by coroners and medical examiners. It was determined that 24% of the specimens submitted contained drugs other than alcohol. In a similar study conducted by Woodhouse (1975) and sponsored by the U. S. Department of Transportation, 710 blood, urine, and bile specimens were examined for the presence of 44 commonly abused drugs. Specimens were submitted by coroners and medical examiners from fatally injured drivers. Results indicated that 13% of the specimens showed the presence of a prescription drug. In all, 29 different drugs were found of which the largest proportion were of the sedative-hypnotic type.

In another interesting study conducted by Glauz and Blackburn (1975) involving the auto drivers of Lincoln, Nebraska and Miami, Florida, it was shown that approximately 4.3% of each group evidenced the presence of one or more of the 41 drugs for which tests were conducted. The drivers were randomly stopped at times and places of previous fatal accidents. Breath, urine, blood, and lip swab specimens were requested. Surprisingly, a cooperation rate of 78% was achieved. One thousand and twenty-nine urine samples and 840 blood samples were collected and in these samples, sedatives particularly phenobarbital were the most commonly detected drug. This study, involving living drivers and after comparing the results with studies involving fatally injured drivers, concluded that "users of drugs are about four times as likely to be fatally injured in a vehicular crash as non-users."

The preceding studies show that drugs, especially the sedative-hypnotics and other psychotropes, have become a major factor contributing to automobile accidents and fatalities. With a steadily increasing number of psychotropic drugs available to physicians for treatment of the driving public, there appears to be all too little discussion of the effects these drugs have on the ability of one to drive an automobile.

This is brought on in part by the lack of research that correlates actual blood levels of a given drug to any psychomotor impairment that may be noted. There are a number of laboratory studies that have been conducted to show the effect of a given dose of one drug or another, either alone or in combination with alcohol, on psychomotor function with respect to driving an automobile, but a serious defect in all of them is the lack of blood level correlation. If only dosage to psychomotor impairment correlations are made and blood levels are omitted, then those factors which influence the blood levels of a given drug such as absorption, distribution, metabolism, and excretion are not considered. The effect that one dose of a given drug may have on one individual may not be the same as on another individual, especially under uncontrolled circumstances. Much of the research conducted in this area has omitted this important consideration.

Lawton and Cahn (1963) attempted to determine whether diazepam, a minor tranquilizer, effected psychomotor skills and if there was any potentiation by the drug of alcohol effect as measured by psychomotor tests. The psychological tests represented both simple and complex psychological and motor skills. The study was conducted for 16 days on 20 male subjects using a replicated latin square design. Results showed a small but significant tendency for psychomotor performance to be influenced with either alcohol or placebo drink. There was no evidence of potentiation between alcohol and diazepam.

Forney and Hughes (1964) demonstrated the effects of meprobamate, a mild hypnotic and psychotherapeutic agent, and ethanol, either alone or in combination, on a series of verbal and arithmatical tests while under delayed audio feedback (DAF). DAF of a subject's own voice induces a state of stammering, stuttering, repetition, and reversal of reading

patterns. Eight paid volunteers were subjected to nine psychological tests, and a modified Cornell Medical Index questionnaire was completed by the subjects at the end of the experiments. Results showed that alcohol at a level of 0.05% by weight effected a pronounced deficiency in performance of the verbal and arithmatical tests. Meprobamate caused a notable decrease in ability to perform the tasks in two of the nine tests; however, a general trend toward deficiency of performance was evident. In several of the tests, meprobamate plus alcohol produced greater deficiency than either alone.

Forney and Hughes (1964) using a series of different drugs, ie. clemizole - a tranquilizer with antihistaminic properties, diphenhydramine and tripelenamine - sedative antihistaminics, and alcohol, demonstrated the effects of these drugs on the mental and motor performance of 16 subjects while under the anxiety stimulus of DAF. Results showed that alcohol consistently effected a significant impairment of both mental and motor performance. No significant mental impairment was observed when the antihistaminic drugs were given alone, nor was the effect of alcohol potentiated by them significantly. When motor performance was measured, none of the antihistaminics alone produced significant effects. In the presence of ethanol, the action of diphenhydramine was potentiated in two tests. The depressant properties of the antihistaminics studied was much more apparent to the subjects than that of ethanol, and yet, significant impairment was observed only with alcohol.

In a similar fashion, Hughes et al, (1965) demonstrated the effects of chlordiazepoxide, diazepam, and alcohol alone or in combination on mental and physical performance of 18 human subjects. The test procedures and apparatus used were similar to those previously employed by Forney and Hughes (1964). DAF was also used to induce an anxiety. Results

showed that ethanol was the only drug which when used alone impaired motor performance. Over-all drug alcohol interaction was not significant with diazepam or chlordiazepoxide; however, in one pattern a synergistic effect of diazepam with alcohol occurred. Under anxiety induced with DAF, only alcohol effected a decrease in performance scores in mental performance. No appreciable additive effect of chlordiazepoxide or diazepam with alcohol (in low blood concentrations) was evident.

Hollister and Clyde (1967) demonstrated the effects of pentobarbital, meprobamate, and meprobamate-tybamate conbination on clinical effects as measured by self reporting mood questionnaires. In this study, serum or plasma levels of the drugs were measured just prior to answering the mood questionnaires. Results showed that with pentobarbital, after eight hours, high serum levels were correlated with high aggressive scores on a mood scale. With meprobamate, none of six possible correlations at two time period were significant, although correlations approached significance with regard to sleepiness. Similar findings applied to tybamate. All in all, studies conducted in this report indicated a lack of significant correlation between blood levels of the drugs mentioned and usual clinical effects as measured by questionnaire.

Landauer, McIver, and Patman (1969) showed the effect of amitriptyline and alcohol on the psychomotor skills of 21 volunteers. Simulated driving tasks, a dot tracking test, and the pursuit rotor were used to measure psychomotor function. Results indicated that amitriptyline potentiated the effects of alcohol on driving skills. The interaction was significant after a single dose and especially pronounced after two doses.

Crancer et al. (1968) attempted to compare the effects of marihuana and alcohol on simulated driving performance. Thirty-six subjects were used and each subject was given three separate treatments involving marihuana alone, alcohol alone, and then neither. All tests were run

on a driver training simulator using a 23 minute driving film which monitored driver reaction to various stimuli. Results showed that subjects experiencing a "social marihuana high" accumulated significantly more speedometer errors than when under normal conditions, whereas there were no significant differences with the other tests. The same subjects when intoxicated with alcohol accumulated more total errors in acceleration, brake, signal, and speedometer areas and showed no significant difference in steering errors when compared with normal conditions. It was concluded that increased marihuana dosage does not seem to increase impairment of simulated driver performance. It would seem in this study that even though the blood alcohol levels were known, if the tetrahydrocannabinol levels were not determined, then meaningful or significant correlations could not be made with regard to impairment of driver performance.

Borg et al. (1972) showed the effects of amobarbital and amphetamine on physical performance. Twenty healthy male subjects with normal E.C.G. underwent a cycling strength endurance test (CSET) which was performed on a special bicycle ergometer. Results showed that amphetamine tended to improve performance and amobarbital tended to cause a decrease in performance ability. Results were interpreted to show that those in the drug group had their performance altered because their motivation to do well in the tests was altered by the drugs. It is presupposed that amphetamine and amobarbital effect that part of the C. N. S. that is connected with work motivation. One might also infer here that amobarbital and amphetamine would alter the motivation needed to control physical performance required to drive an automobile.

Betts et al. (1972) showed the effects of chlordiazepoxide, amylobarbitone sodium, trifluoperazine, and haloperidol on actual low speed driving performance tests; ie. weaving, parking, and gap estimation.

One hundred subjects, 50 men and 50 women, were tested. Results showed an effect on low speed driving performance with each drug with the possible exception of haloperidol. Also of importance in this study was the indication that those subjects effected by the drug in question were unaware they were being effected. Results obtained in this study would have taken on a greater significance if they could have been correlated with actual drug blood levels.

Linnoila and Hakkinen (1973) showed the effects of diazepam and codeine alone or in combination with alcohol on simulated driving involving 70 professional drivers. Every subject drove for 40 minutes beginning 30 minutes after ingestion of drug and drink in a Sim-L-Car. The aim of the study was to show drug induced risks for traffic, not to show minimal impairment of skills. Results showed that the drugs could increase risks in driving. Alcohol induced one to neglect instructions; higher doses of diazepam effected one's ability to react in emergency situations; those subjects taking codeine were less indifferent to their surroundings but tended to drive off the road more than those taking alcohol or diazepam; codeine and diazepam taken in combination with alcohol slightly reduced the alcohol induced negligence of instruction; and potentiation of diazepam and alcohol was indicated.

The use of a Sim-L-Car or any similar driving simulator to determine psychomotor impairment induced by drugs was confirmed by Linnoila and Mattila (1973). Tests involving clutch, brake, gears, flashing lights, and changes in steering and speed were recorded. The driving period was 40 minutes starting 30 minutes after drug intake. The drugs used in the experiment were diazepam, codeine phosphate, and isoniazed given in combination with alcohol. Results confirmed a previous study with these drugs and alcohol with regard to driving skills. (Linnoila and Mattila,

1973). Results also suggested that simple tests could be used to predict drug interactions that would reduce driving skills. These results would also indicate that under controlled situations, drug dosage levels give some results that can be correlated to driving behavior; but in uncontrolled circumstances, that is when one does not know how much drug was taken or when it was taken last or how much food was ingested with the drug, etc., it would seem that only a blood level figure would have direct meaning with regard to performance.

There are a number of other laboratory studies that have been conducted using a variety of drugs to show their effect on psychomotor performance as it relates to driving an automobile. Linnoila (1973) used atrophine and glycopyrrhonium in combination with alcohol. Landauer et al. (1973) demonstrated the effects of benzoctamine, a drug similar to diazepam, and alcohol on a battery of motor skill tests. Adams (1974) compared the effects of butabarbitone and nitrazepam on five short psychological tests designed to measure performance impairment. Dureman and Norrman (1975) showed the effects of clorazepate and diazepam on a series of physiological and psychomotor tests. Seppala et al. (1975) demonstrated the effects of amitriptyline, doxepin, nortriptyline, and chlorimipramine, alone or in combination with alcohol on skills related to driving. All of these studies, as well as the others mentioned, do not correlate drug blood levels to psychomotor impairment, but rather correlate dosage values.

To the legislator, who may have to enact a law which states at what blood level an individual is under the influence of a given drug; or to the judge and jury, which may have to decide whether a person is under the influence of a drug when presented with a laboratory finding, these studies leave much information undetermined. Until actual blood levels of a given drug can be correlated to definite psychomotor impairment, then

those professional people who have to interpret laboratory findings as to blood level values of various drugs will be, at best, unsure of their conclusions.

III. EXPERIMENTAL

Eight healthy, young, adult volunteers were selected from among the employees of the Rhode Island Department of Health, Division of Laboratories. Six females and two male subjects ranging in age from 25 to 40 years were used. The tentative plan of procedure was explained to each individual making sure that each understood that the project could last up to a year and that during that time period, blood samples would be taken on the days of the tests. The actual drug testing was conducted at the Rhode Island Department of Health in the Division of Laboratories building in an average size room away from distractions of the daily business routine. Parts of the room were used for storage of laboratory chemicals and reagents and access to the room by outside traffic was minimal.

The test equipment used was supplied by the University of Rhode Island, Department of Psychology and Department of Pharmacology. It was decided that a pursuit rotor test and a simple math test would be used to measure a psychomotor and a cognitive aspect of behavior. These tests should give an indication of the test group's ability to coordinate observation with motor response and to perform simple mental exercises. Both of these behavioral skills appear to be important to the proper operation of a motor vehicle.

The pursuit rotor, a Variable Pursuit Tracker manufactured by Pentagon Devices Corporation, employed a light which rotated in an eight inch circle at a predetermined rpm. The test subject, holding a wand with a photo cell detector at the end, had to track the rotating light. The test ran for 50 seconds and the cumulative time the subject stayed on target within those 50 seconds was measured by means of an electronic

timer. The math test consisted of a series of addition problems involving seven double digit numbers. The test subject solved as many of the addition problems as he could in three minutes. The number of correct answers was recorded. In order to familiarize the group with the testing equipment, for a period of two months each of the eight subjects performed the tests between six and eight times. The average tracking times of four trials on the pursuit rotor and the average of the correct scores of three trials at the addition problems were plotted and graphed.

Before the drugging experiments were started, a medical profile on each of the test subjects was obtained which included: 1. a medical history with specific emphasis on any allergy to barbiturates or other drugs, 2. a physical examination given by a licensed physician, 3. a complete blood count, 4. liver enzyme blood levels, 5. bilirubin blood levels, and 6. urinalysis. A liability waiver was also signed by each participant releasing the University of Rhode Island and the Rhode Island Department of Health from responsibility for any damages that he or she may incur as a result of participation in the project.

The protocol for the actual drugging experiment was planned so that on the day of the test the individual involved would have a normal breakfast and report to work as usual. A mid-morning coffee break would be allowed, but no other beverages or snacks afterwards. The test subject would not have lunch and at approximately 1330 hours he would report to the testing room where the math test and pursuit rotor test would be performed. Each person would act as his or her own control and these first values would be a baseline for the day's experiment. At 1400 hours, a 100 mg. capsule of secobarbital sodium would be ingested. One hour later, 1500 hrs., a blood sample (approximately 15 cc.) would be taken

and the test procedure administered again. Two hours after this, 1700 hrs., a second blood sample would be taken and the test procedure administered for a third time. After this final testing, the test subject would be allowed to go home with the instructions that he not take any other drugs or alcoholic beverages for a period of 24 hours. Each subject underwent this procedure three times during the course of the investigation.

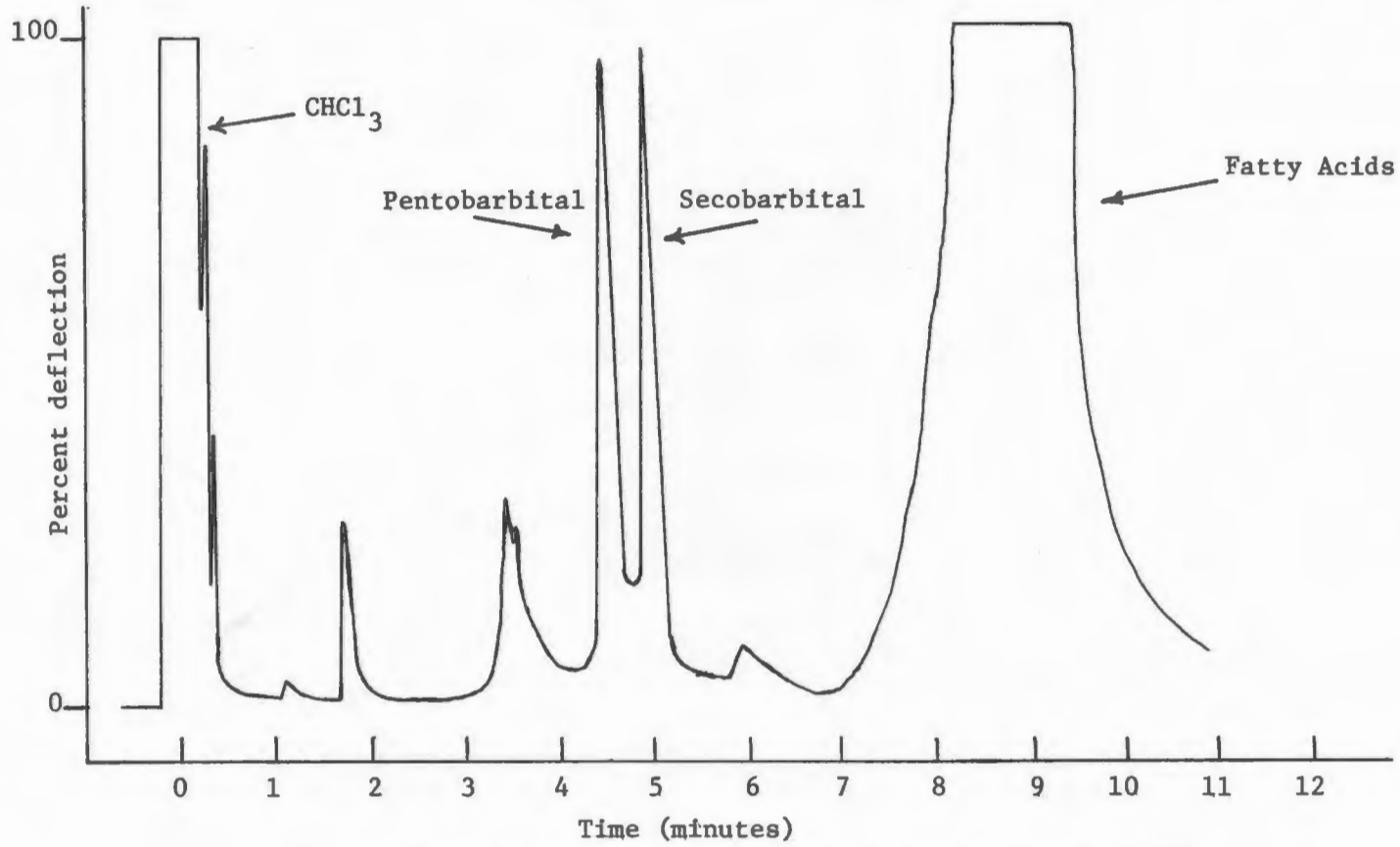
Quantitation of the secobarbital in the blood specimens is based on the acidic drug extraction procedure of Forester and Mason (1974) using n-butyl chloride and modified by Bushee et al. (unpublished). Five mls. of blood are pipetted into a 15 ml. round bottom screw cap test tube. One ml. of 4M NaH_2PO_4 and 5 mls. of n-butyl chloride are added. The mixture is placed on an Ames Aliquot Mixer and extracted for 15 minutes after which it is centrifuged for another 15 minutes at 1500 rpm. The top or n-butyl chloride layer is pipetted into another clean 15 ml. round bottom test tube. This initial extraction is repeated and the n-butyl chloride layers are combined. Four mls. of 0.45M NaOH is added to the combined extracts and this mixture is extracted for another 15 minutes. The layers are separated by centrifugation and the n-butyl chloride is pipetted off and discarded. The NaOH layer is aerated for 2 minutes to remove all residual n-butyl chloride. The NaOH is transferred to a 12 ml. conical test tube and made acid with three drops of conc. H_2SO_4. One-hundred micro-liters of spectro-grade chloroform which contains 100 nanograms of pentobarbital per micro-liter as internal standard is added and mixed thoroughly on a Vortex Genie mixer. The layers are separated by centrifugation. The chloroform layer is now ready for quantitation by gas chromatography. A series of standard

secobarbital solutions ranging from 0.05 mgs.% to 0.5 mgs.% are run along side the blood specimens.

Two micro-liters of the chloroform extract are injected into a Hewlett-Packard model 5710 gas chromatograph interfaced by means of a Hewlett-Packard model 18652A analog to digital convertor to a Hewlett-Packard model 3352B Laboratory Data Systems computer. The gas chromatograph column and operating parameters are as follows: column--6 ft. X ¼ inch 2.5% SE-30 at 180° C; injection port and flame ionization detector at 250° C; nitrogen carrier gas flow rate - 60 mls./ minute; air flow - 240 mls./ minute; hydrogen flow rate - 40 mls./ minute; and electrometer attenuation at range 1 X 32. Under these conditions, the pentobarbital internal standard will appear at approximately 4½ minutes from the time of injection and the secobarbital at approximately 5½ minutes (Figure 1). When the run is complete, the areas of the pentobarbital and secobarbital peaks are obtained from the computer teletype print-out. The ratio of the area of secobarbital to the area of pentobarbital is then calculated and plotted. The quantity of secobarbital in the blood specimens is read from the graph plotted from the standard secobarbital samples.

Statistical analyses of the data obtained from both the math and pursuit rotor tests were performed using an alpha level of 0.05. Analysis of variance based upon the treatments-by-treatments-by-subjects design as described by Bruning and Kintz (1968) was performed. Analysis of the population dependent means, using the Student's "t" test as described by Johnson (1976), obtained at the time of drug administration or zero time to the first hour after drug administration, from zero time to the third hour after drug administration, and from the first hour to the third hour after drug administration was done. The Spearman rank-

FIG. 1 GAS CHROMATOGRAM OF SECOBARBITAL AND PENTOBARBITAL



Typical gas chromatogram obtained from the injection of two micro-liters of chloroform extract of five cc. of blood.

order correlation test (Bruning and Kintz, 1968) to determine whether the percent change in performance in the test subjects was significantly related to the blood level of secobarbital detected, and linear regression analysis (Johnson, 1976) of the percent change in performance versus the blood level of secobarbital to determine the best line of fit between the two sets of data was done.

IV. RESULTS

For a period of approximately two months prior to the actual drugging experiments, the test subjects went through the testing procedures in order to familiarize themselves with the equipment and test requirements. After each individual had been tested between six and eight times, it became apparent that they had reached a fairly stable level of performance as indicated by the non-drugging trials graphs shown in Figures 2-17. The data presented in Figures 2-17 show the results in graph form of the non-drug trials or learning stage, and the drug trials or experimental stage for each subject performing each of the two test procedures. With the math test, the average of the number of correct answers obtained from three tests each lasting three minutes were plotted. With the pursuit rotor, the average of the tracking times obtained from four trials each lasting for 50 seconds was plotted.

Each subject appeared to improve with time in his or her performance in the non-drug testing and for the most part reached a level of performance that was sufficiently stable to warrant going on to the drug experiments. In the drug experiments, the initial testing or baseline values obtained before the secobarbital was administered, was fairly consistent with the majority of the test subjects, with their respective values obtained after two months of non-drug testing further indicating that the test subjects had reached a consistent level of proficiency with the test equipment.

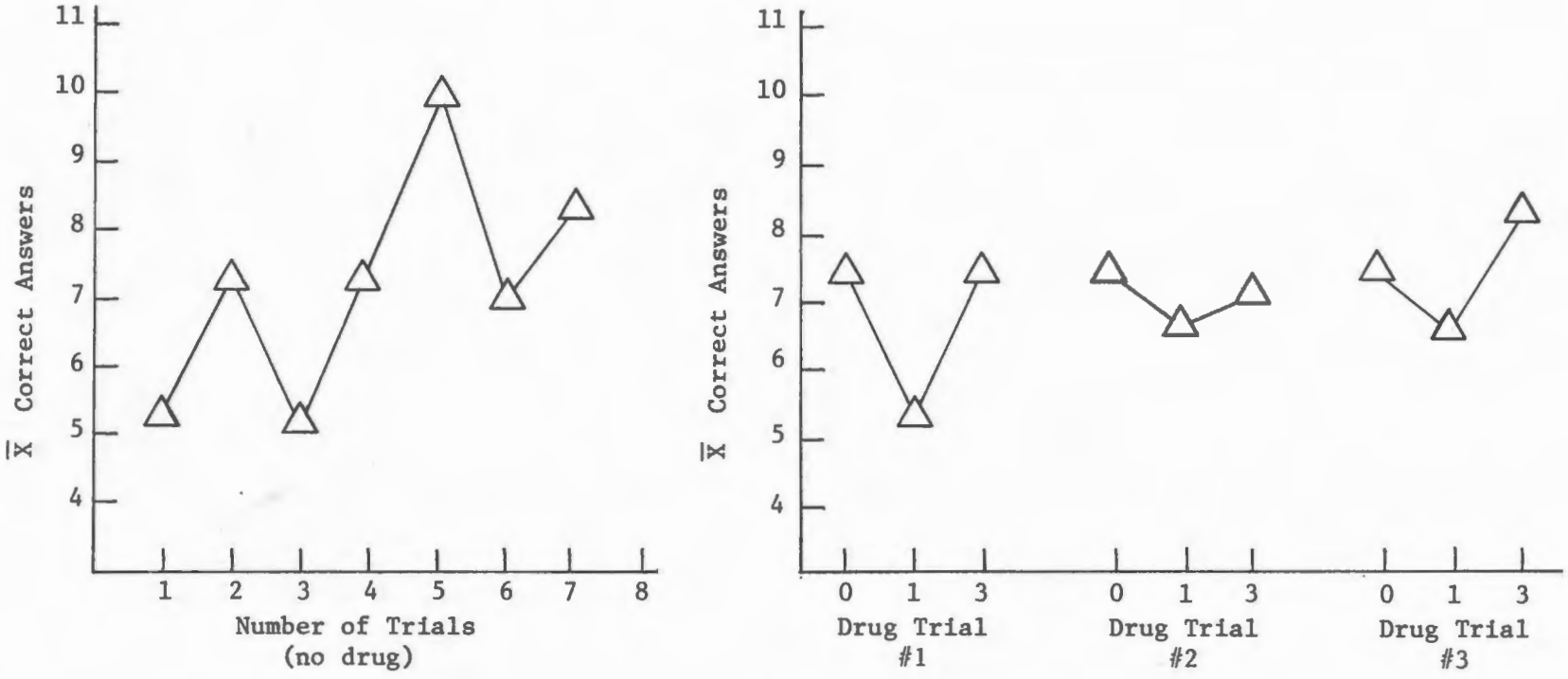
After three drug trials on each individual, math test results at the one hour and three hour time intervals after secobarbital administration were recorded and the results shown in the drug trial graphs in Figures 2-17. At the one hour time interval, subjects 1, 3, 4, 5 and 6 showed a

drop in performance during each drug trial; subjects 2 and 8 showed mixed performances in that they improved during the first and third drug trials and deteriorated during the second; subject 7 improved her performance during the first drug trial and decreased her performance during drug trials two and three. At the three hour time interval after drug administration, subjects 1, 2, 3, 4, and 7 improved their performance from the first hour test period; subject 5 showed a further decline in performance during trials one and two and increased her performance during drug trial three; subject 6 improved her performance during trials one and two and showed no change in drug trial three; subject 8 improved his performance during drug trial one and showed no change in drug trials two and three (Figures 2-17).

Pursuit rotor test results at the one hour and three hour time intervals were recorded and the results are also shown in drug trial graphs in Figures 2-17. At the one hour time interval, subjects 1, 2, 3, 4, 5, 6, and 8 showed a decrease in performance; subject 7 during the first two drug trials showed an increase in performance and showed a decrease in performance during the third drug trial. At the three hour time interval after secobarbital administration, subjects 1, 2, 3, 6, and 8 showed an improvement in performance from the first hour during each drug trial; subject 4 improved in performance during trial one and showed a continual decrease in performance in drug trials two and three; subject 5 showed no change in performance during drug trial one, a decrease in drug trial two, and an increase in drug trial three; subject 7 showed a decrease in performance during each drug trial (Figure 2-17).

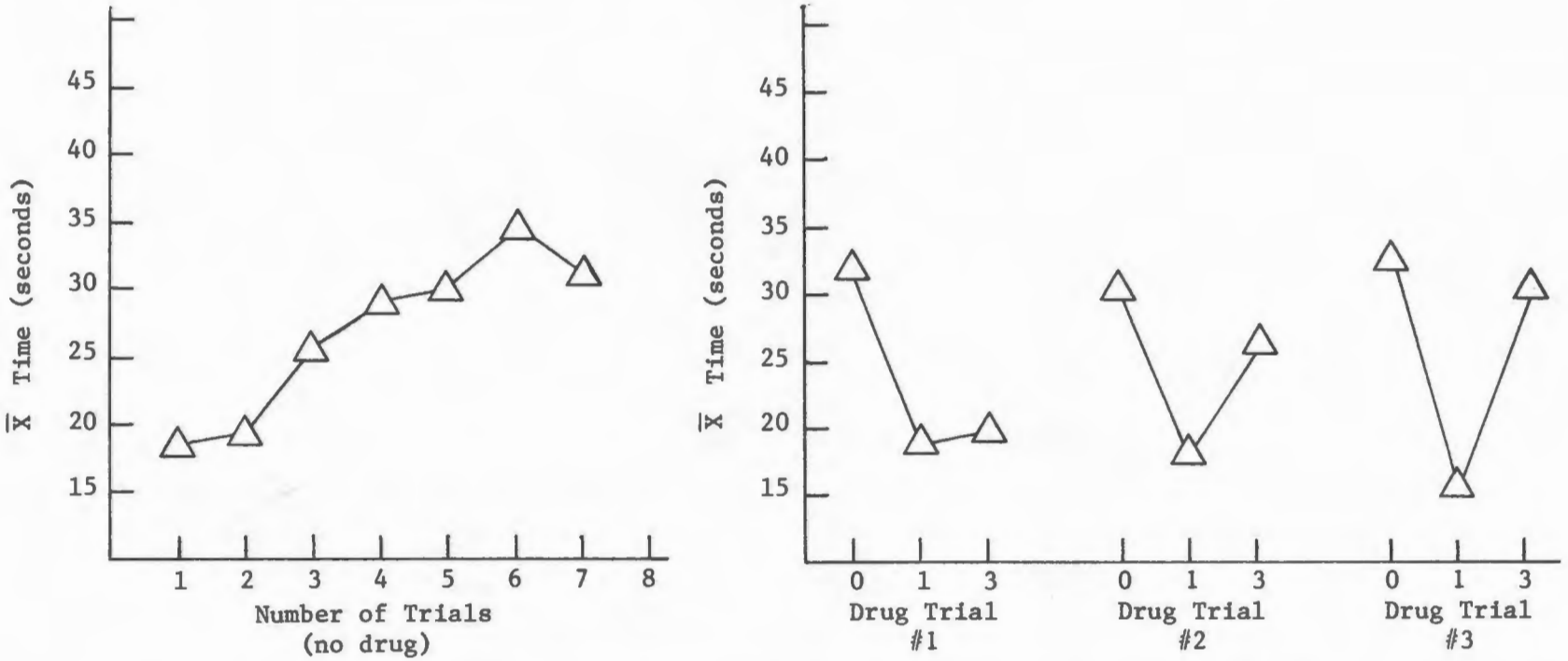
Analysis of variance of the mean scores obtained in both the math and pursuit rotor tests was based on the treatments-by-treatments-by-

FIG. 2 MATH TEST PERFORMANCE OF SUBJECT #1



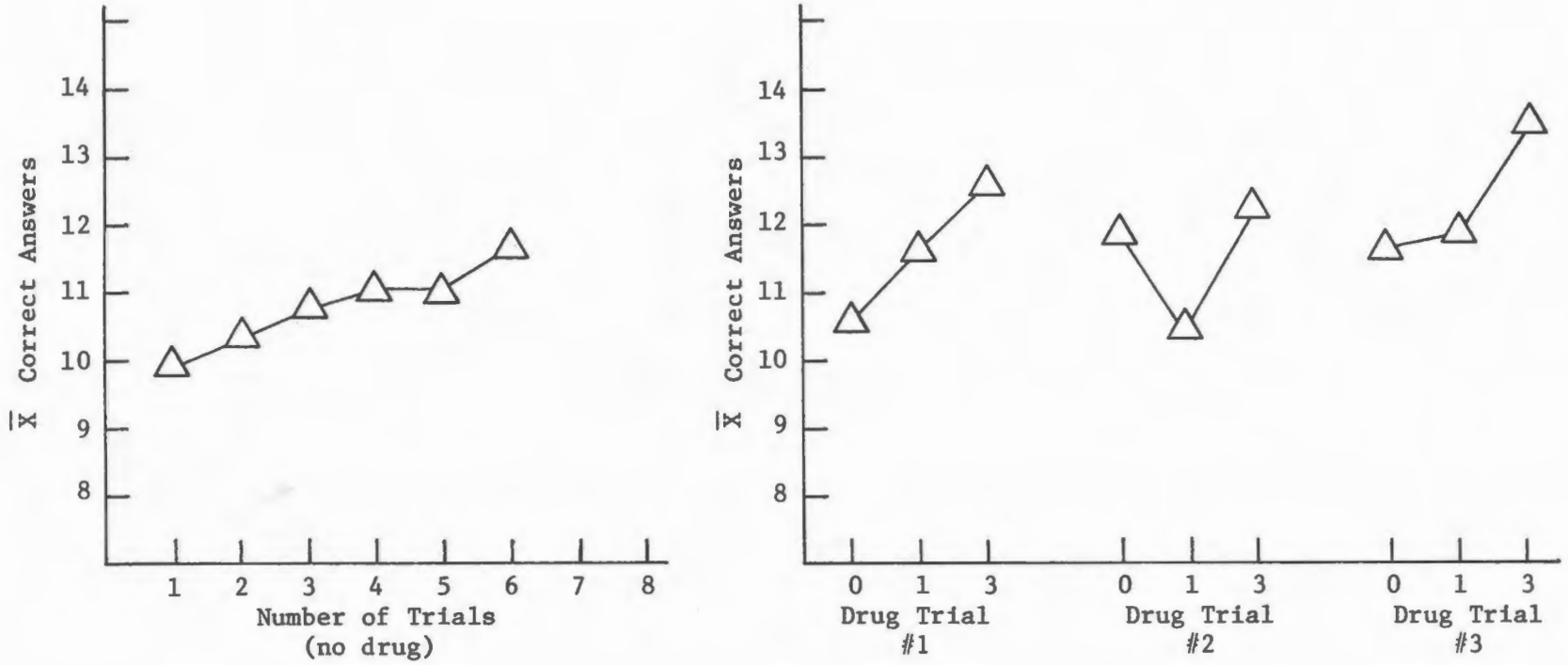
Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 3 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #1



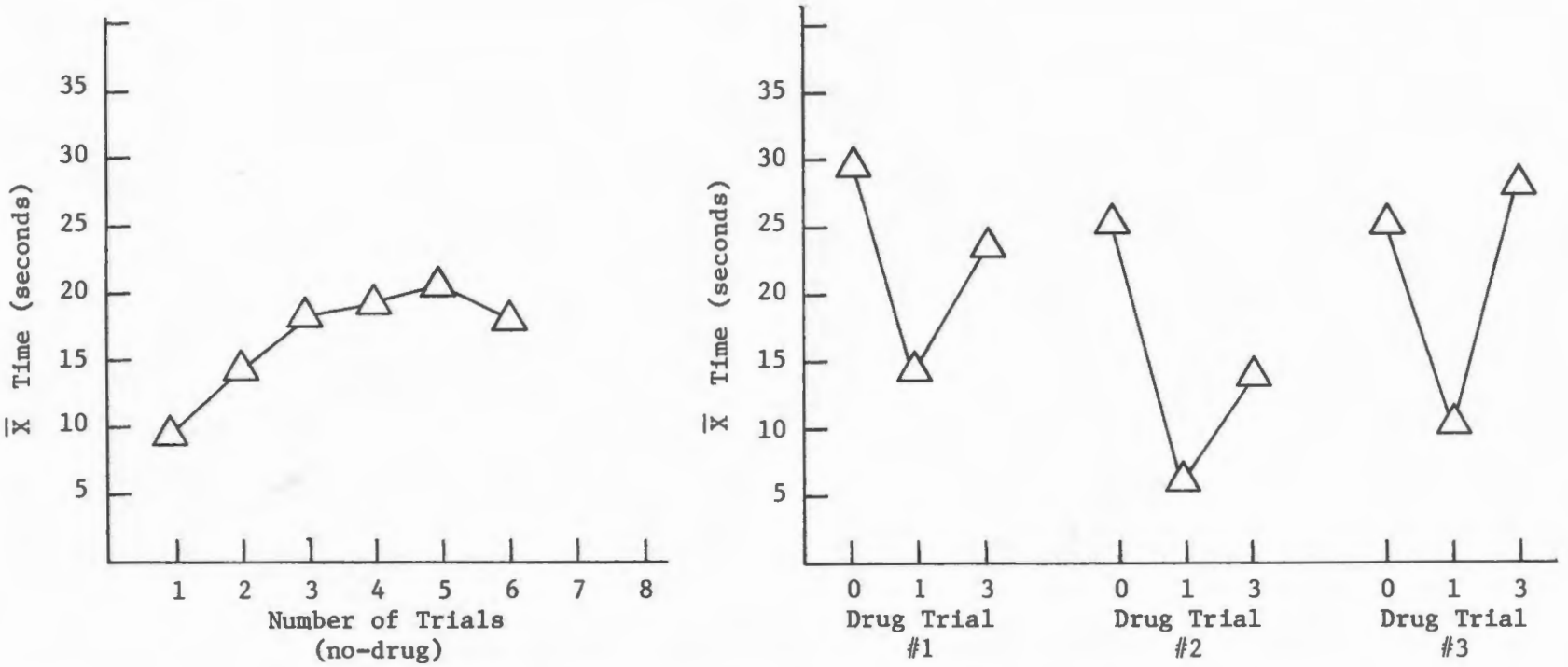
Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 4 MATH TEST PERFORMANCE OF SUBJECT #2



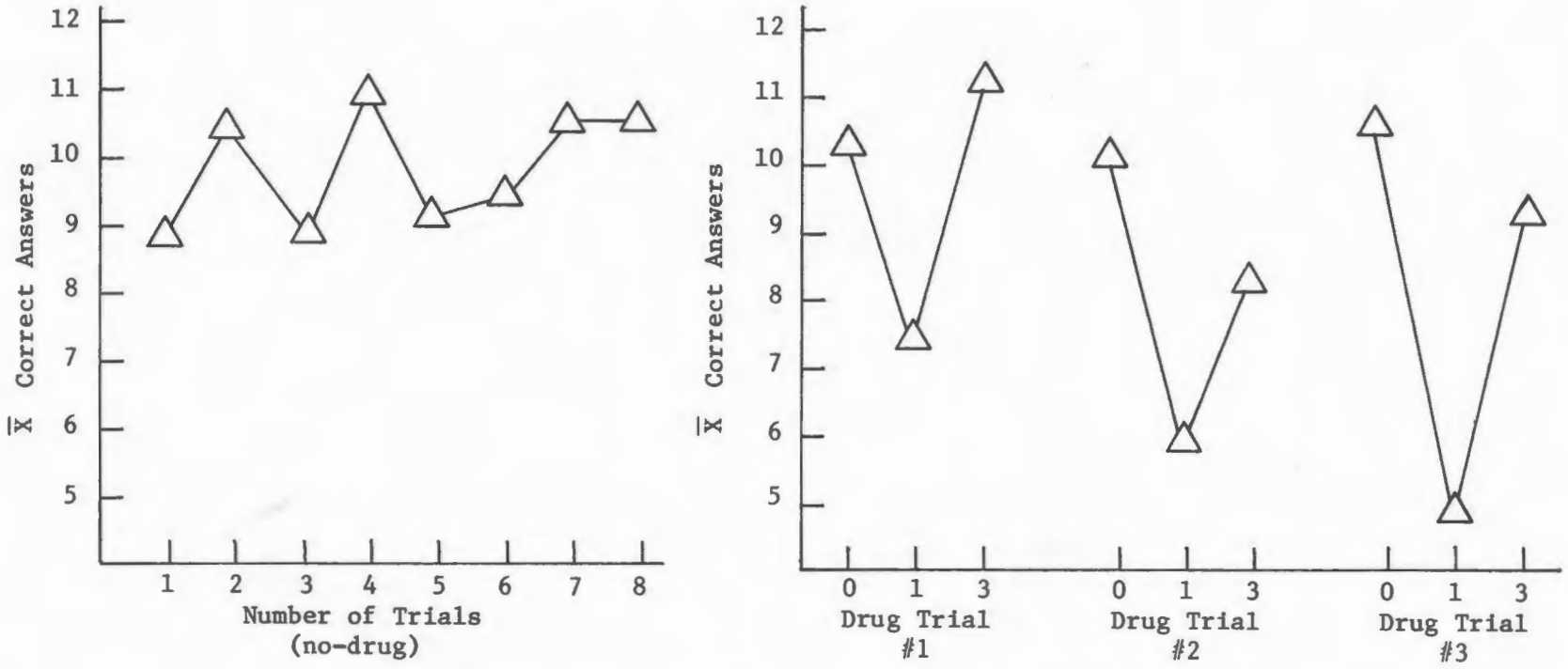
Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 5 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #2



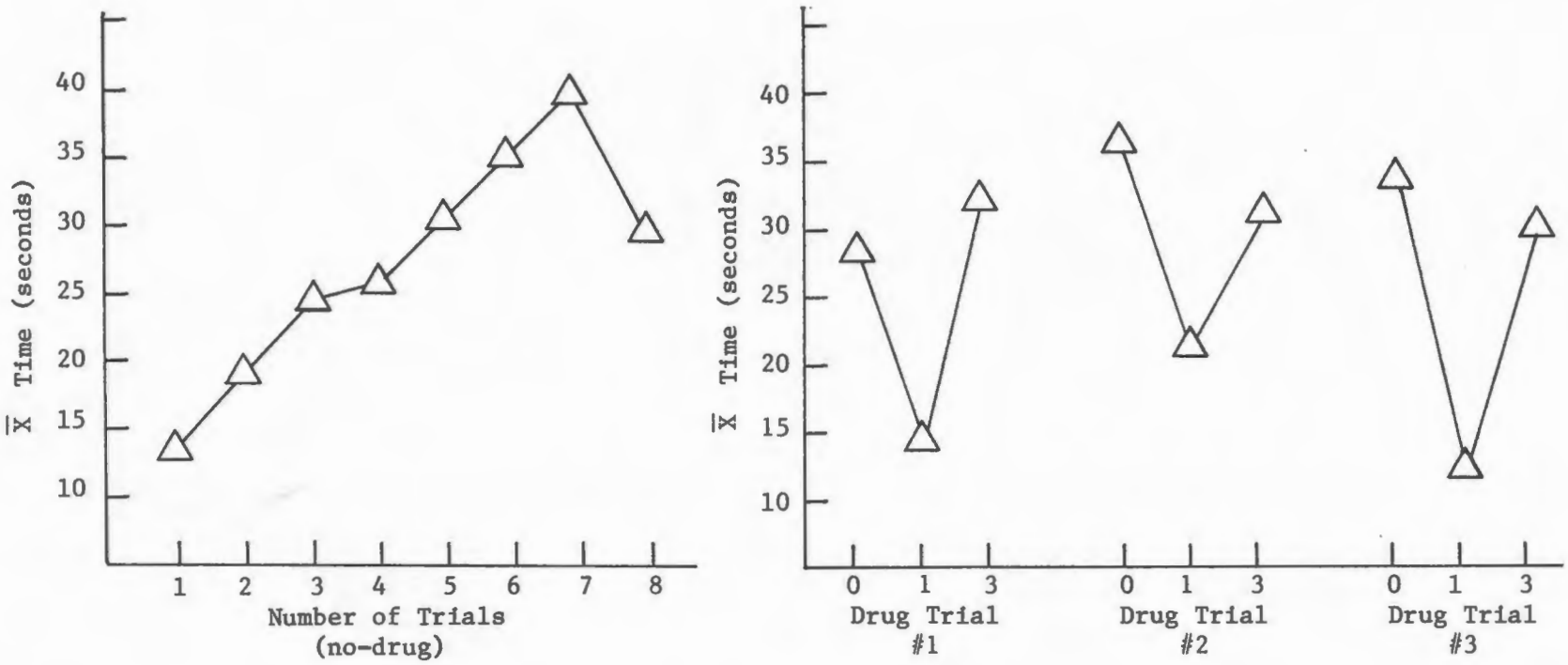
Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 6 MATH TEST PERFORMANCE OF SUBJECT #3



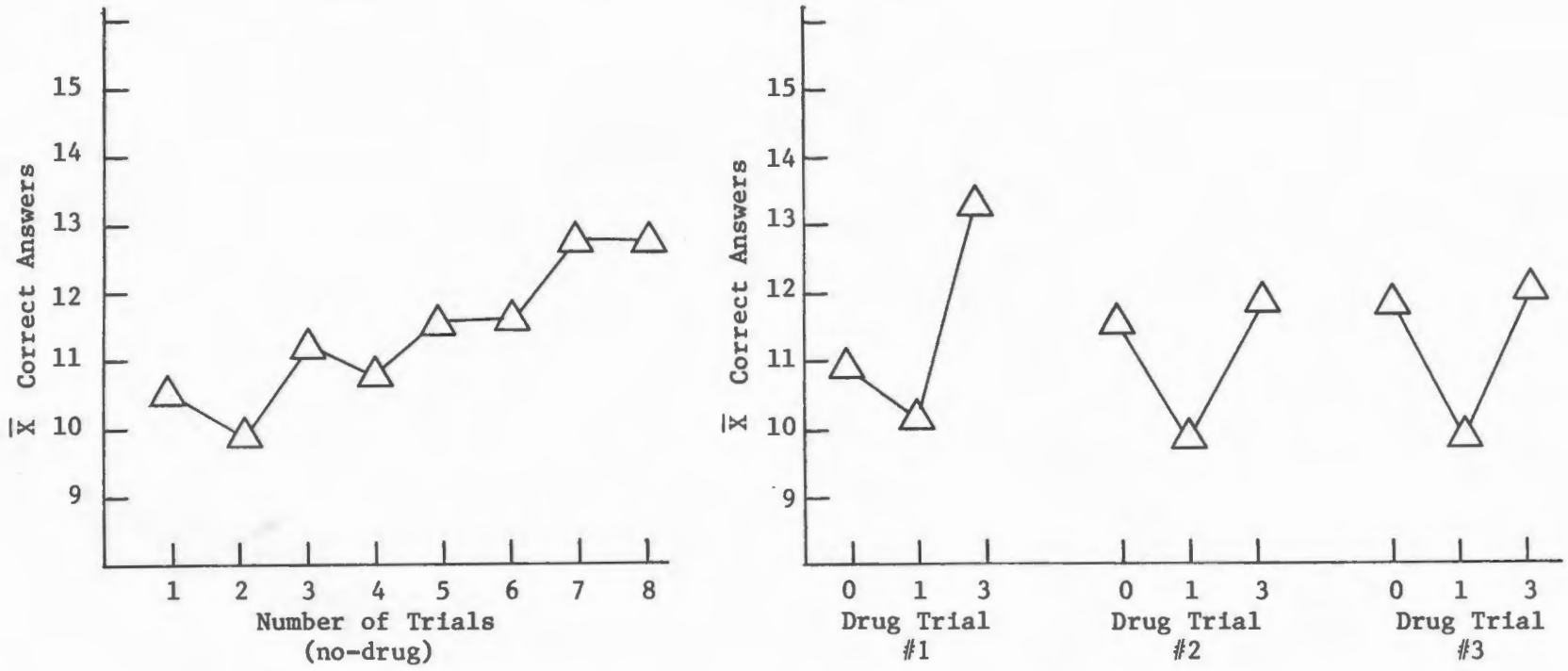
Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 7 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #3



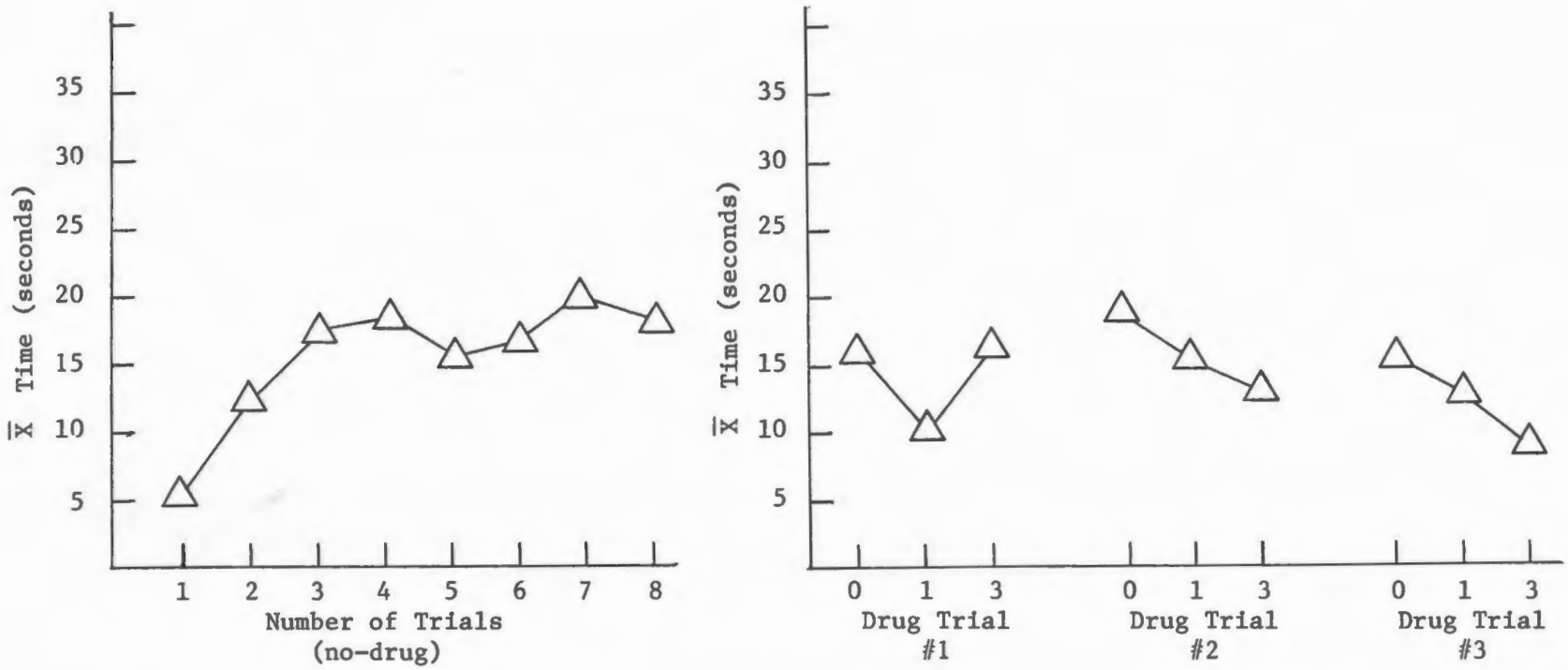
Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 8 MATH TEST PERFORMANCE OF SUBJECT #4



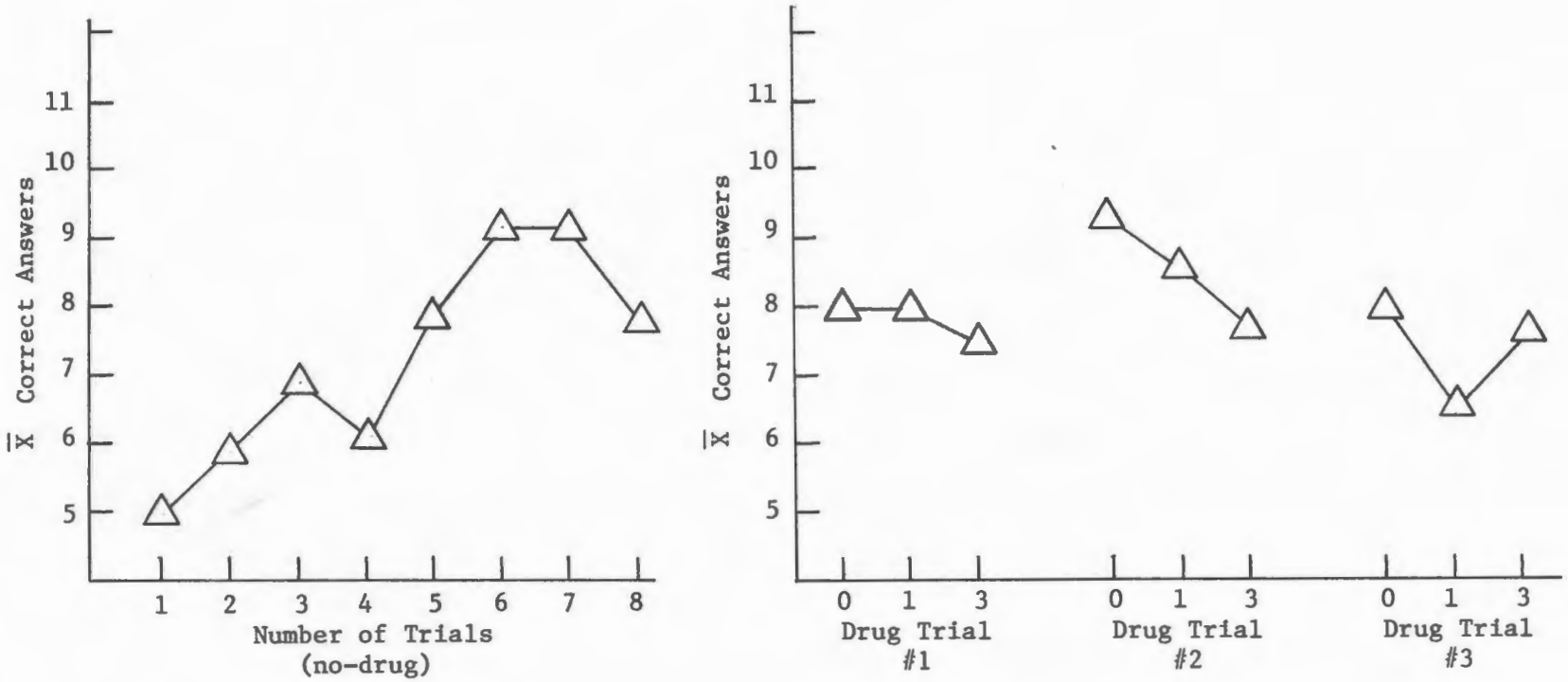
Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 9 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #4



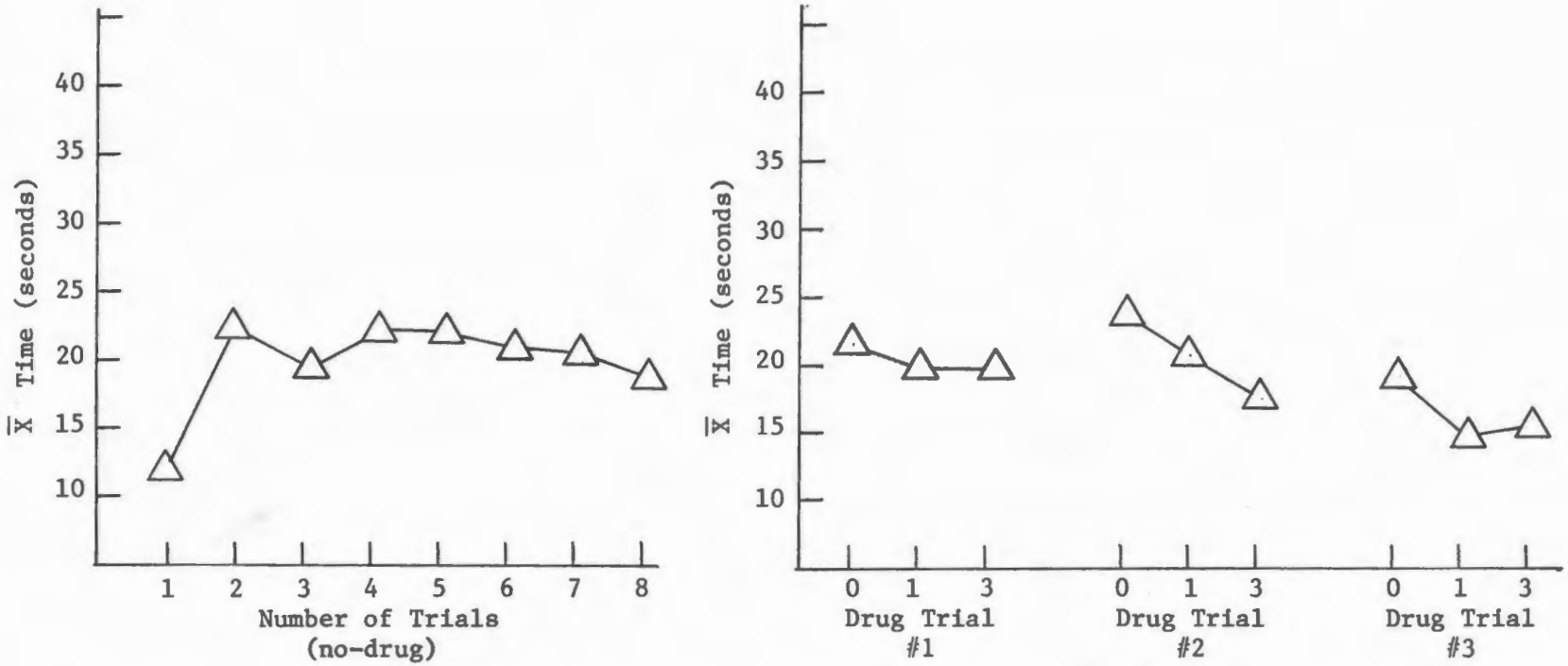
Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 10 MATH TEST PERFORMANCE OF SUBJECT #5



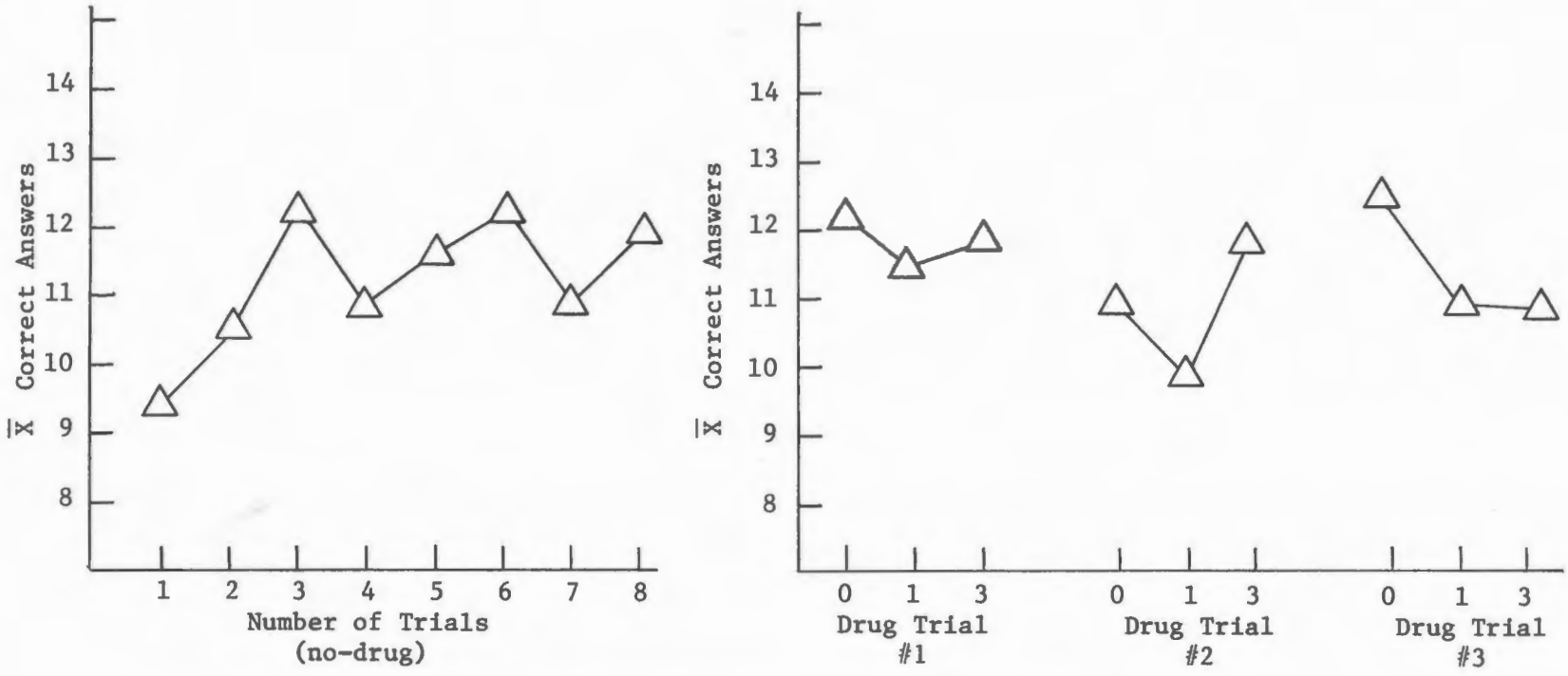
Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 11 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #5



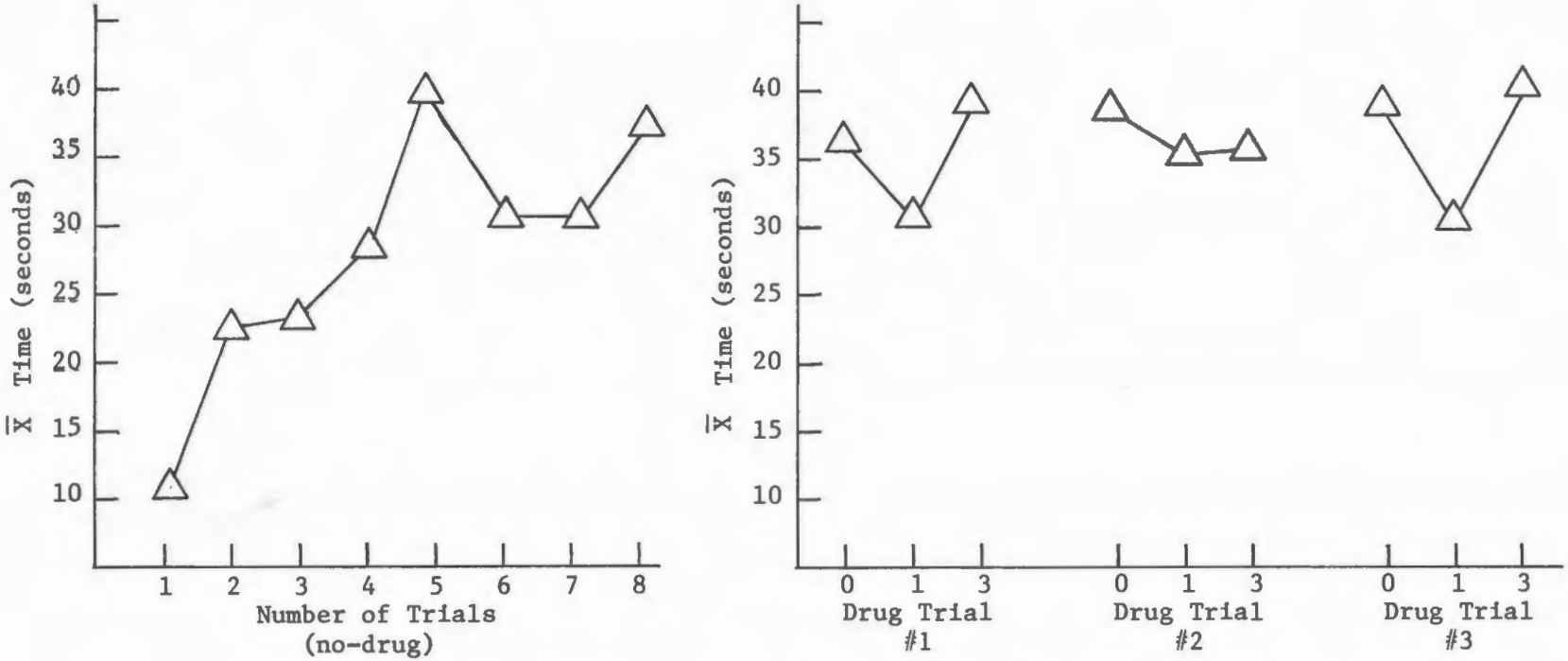
Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 12 MATH TEST PERFORMANCE OF SUBJECT #6



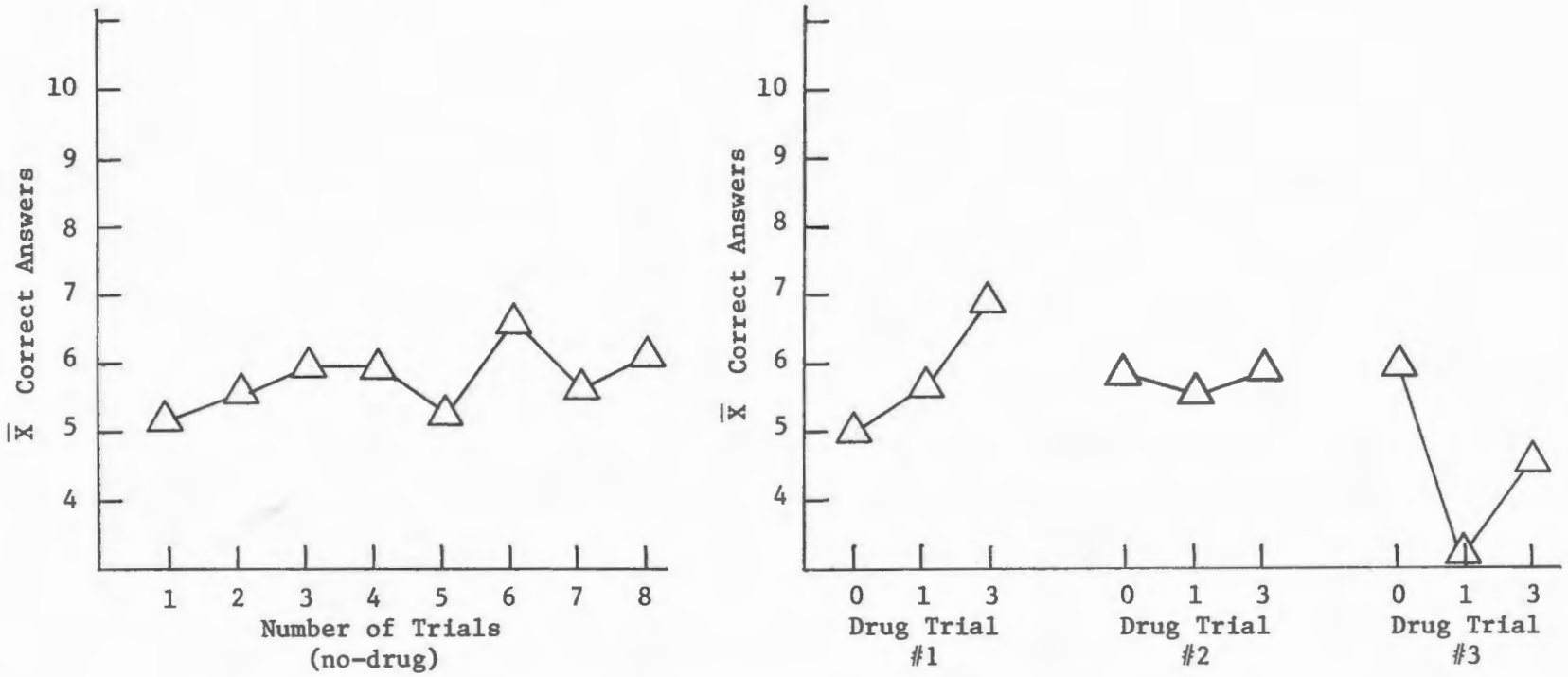
Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 13 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #6



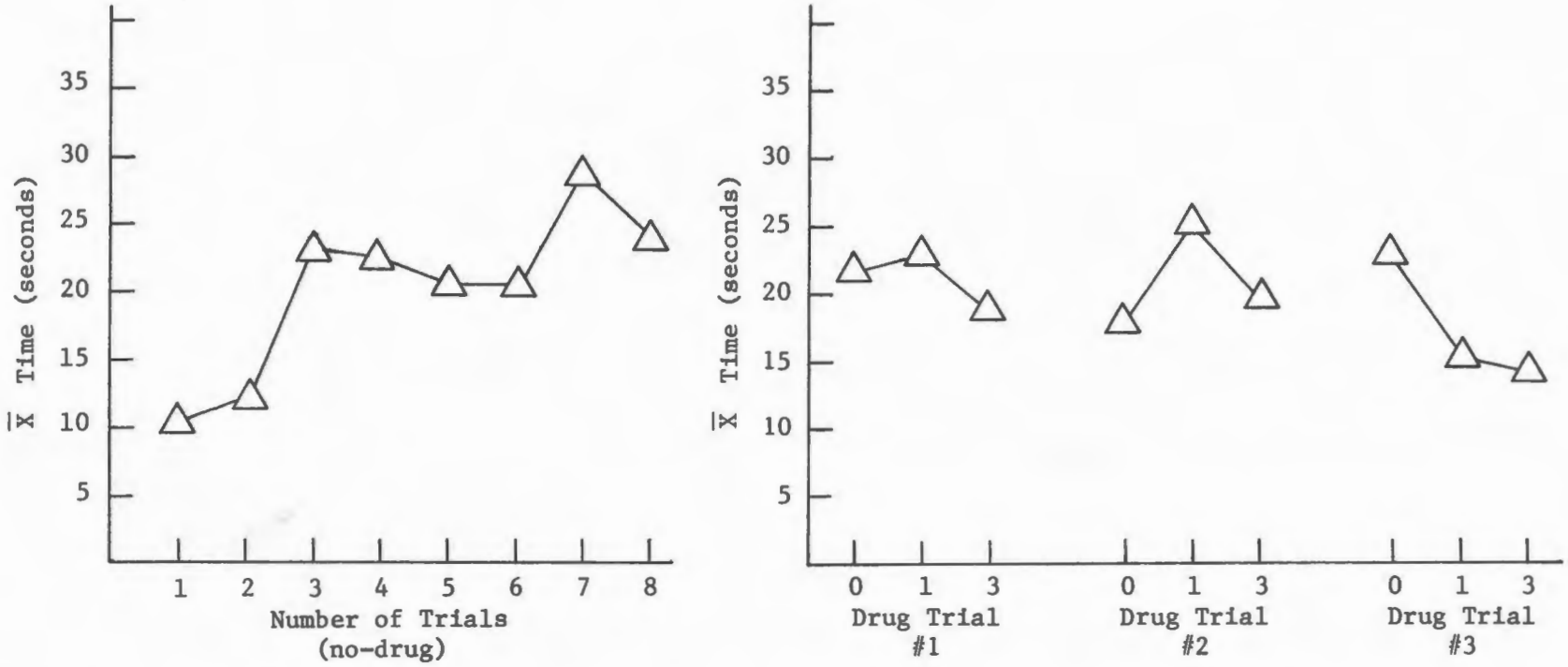
Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 14 MATH TEST PERFORMANCE OF SUBJECT #7



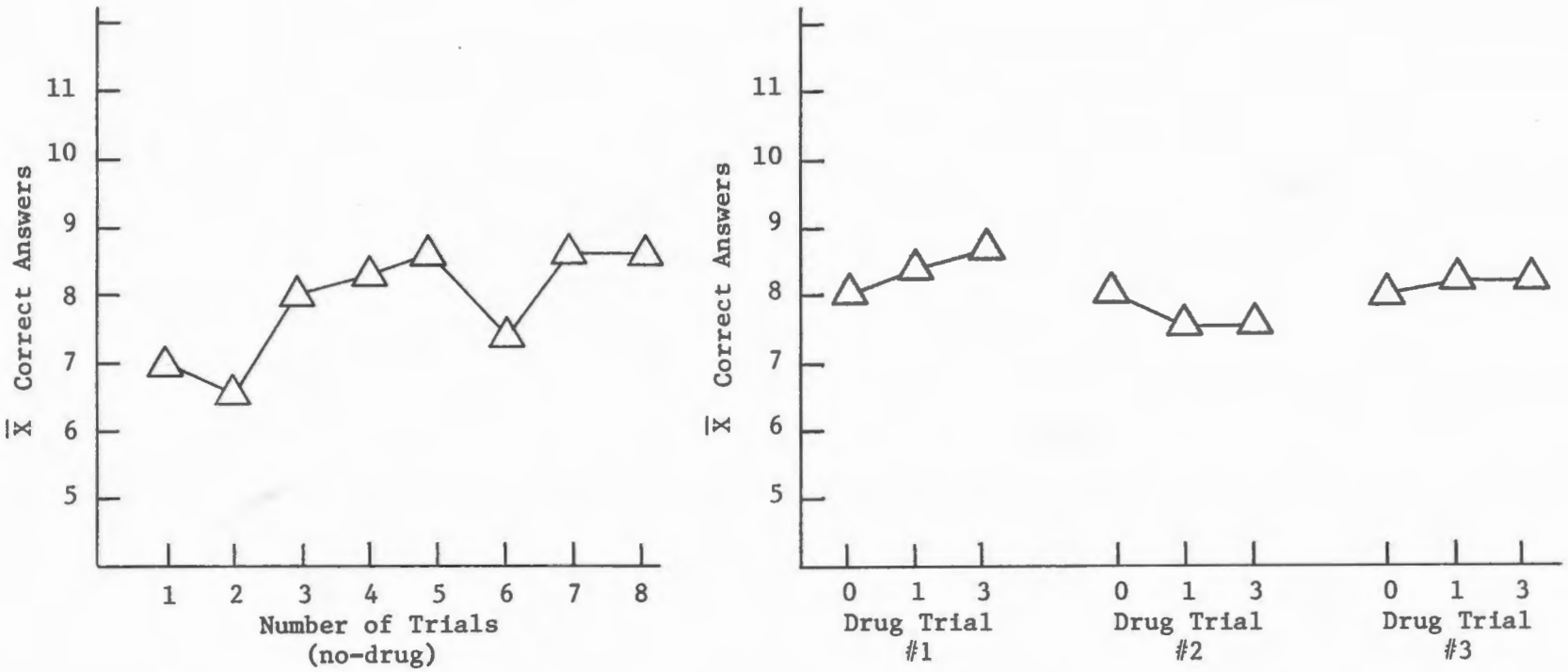
Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 15 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #7



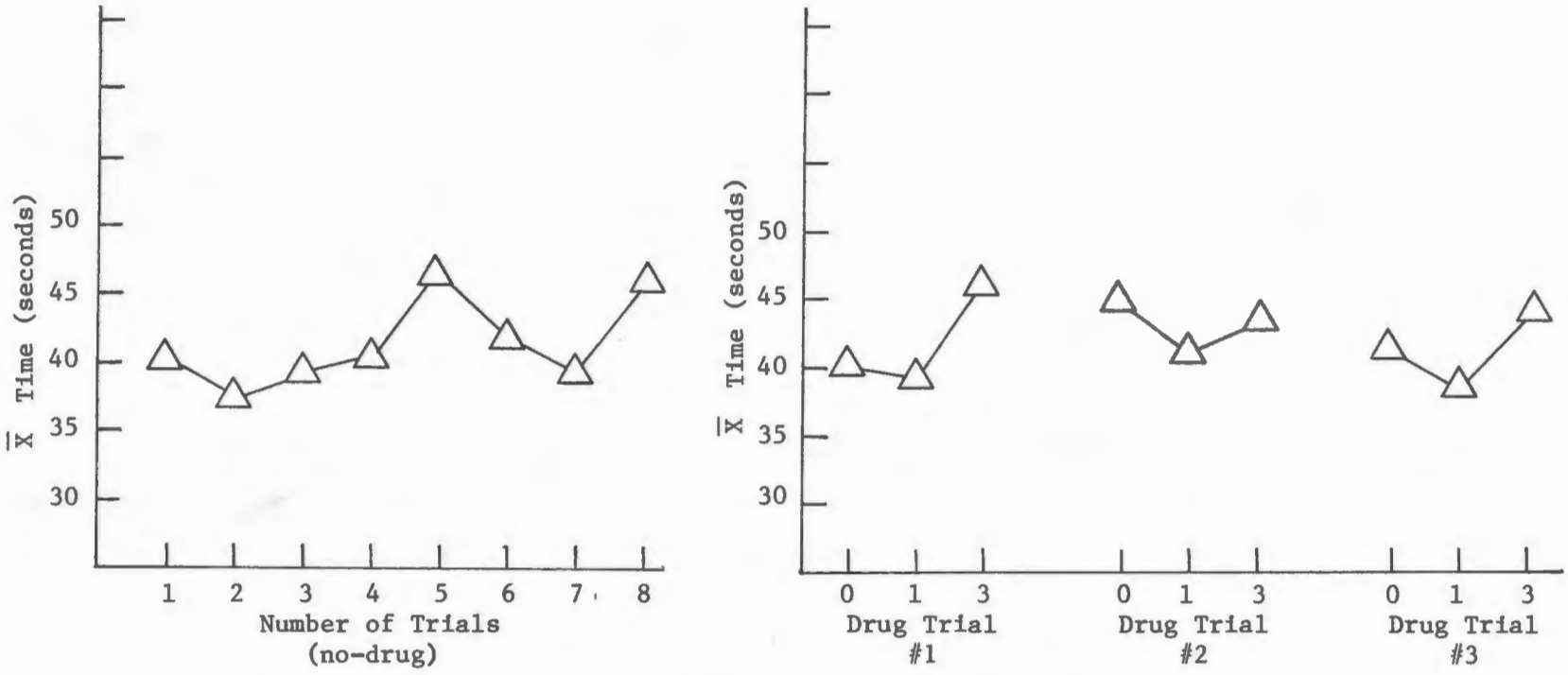
Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 16 MATH TEST PERFORMANCE OF SUBJECT #8



Math test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

FIG. 17 PURSUIT ROTOR TEST PERFORMANCE OF SUBJECT #8



Pursuit rotor test results plotted from the no-drug trials and from drug trials 1, 2, and 3; 0-control; 1-first hour; 3-third hour.

subjects design. This statistical procedure should indicate 1. whether there was any significant variation between the three drug trials, 2. whether any significant alteration in psychomotor performance occurred between any two time intervals in the drug trials, and 3. if the three drug trials were independent units having no significant interaction between them. For both the math and pursuit rotor tests, there was no significant variation in the three drug trials taken as units. (F_m = 0.81, F_{pr} = 0.36, critical F, df 2/14, = 3.74).[1] There was a significant alteration at some point in each drug trial. (F_m = 6.79, F_{pr} = 7.12, critical F, df 2/14, = 3.74).[1] Each drug trial was independent and no significant interaction between them had occurred. (F_m = 2.71, F_{pr} = 2.31, critical F, df 4/28, = 2.71).[1] The source table for the analysis of variance appears in appendix A.

Analysis of the population means obtained at the zero time, first hour, and third hour time intervals in both the math and pursuit rotor tests were tested for significance (Table 1). The critical value of "t" was equal to 1.89 (df,7) in all instances. With the math test, a significant negative change in performance was detected in the group in drug trials two and three at the first hour after taking secobarbital. (t_{m1} = 1.15, t_{m2} = 2.95, t_{m3} = 2.38).[1] Significant improvement in math test performance was shown from the first hour to the third hour. (t_{m1} = 2.86, t_{m2} = 2.34, t_{m3} = 3.09).[1] Pursuit rotor test results in each drug trial showed a significant decrease in performance at the first hour

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1. F_m - experimental F value obtained for math test in analysis of variance for drug trials 1, 2, and 3.
   F_{pr} - experimental F value obtained for pursuit rotor test in analysis of variance for drug trials 1, 2, and 3.
   $t_{m1,2,3}$ - experimental dependent "t" values obtained for math test during drug trials 1, 2, and 3.
   $t_{pr1,2,3}$ = experimental dependent "t" values obtained for pursuit rotor test during drug trials 1, 2, and 3.

Table 1

Population Means For Math Test And Pursuit Rotor Test; Dependent "t" Test Values

Math Test

	Population Means			Dependent "t" Scores		
Drug Trial	0 Time	1st hr	3rd hr	0-1st hr	0-3rd hr	1st - 3rd hr
1	9.063	8.538	9.963	1.15	2.32*	2.86*
2	9.438	8.088	9.100	2.95*	0.92	2.34*
3	9.512	7.850	9.377	2.38*	0.41	3.09*

Pursuit Rotor Test

	Population Means			Dependent "t" Scores		
Drug Trial	0 Time	1st hr	3rd hr	0-1st hr	0-3rd hr	1st - 3rd hr
1	28.40	21.71	27.28	2.83*	0.49	2.27*
2	29.73	23.77	25.69	2.01*	3.12*	0.89
3	29.29	19.65	27.27	3.79*	1.33	2.59*

* Data significant at $P < 0.05$

after taking the secobarbital. (t_{pr1} = 2.83, t_{pr2} = 2.01, t_{pr3} - 3.79).[1] In drug trials one and three, significant improvement in performance was shown between the first and third hour with the group returning to near baseline levels of performance. (t_{pr1} = 2.27, t_{pr3} = 2.59).[1] In drug trial two, a significant decrement in psychomotor performance persisted at the third hour after taking secobarbital. (t_{pr2} = 3.12).[1]

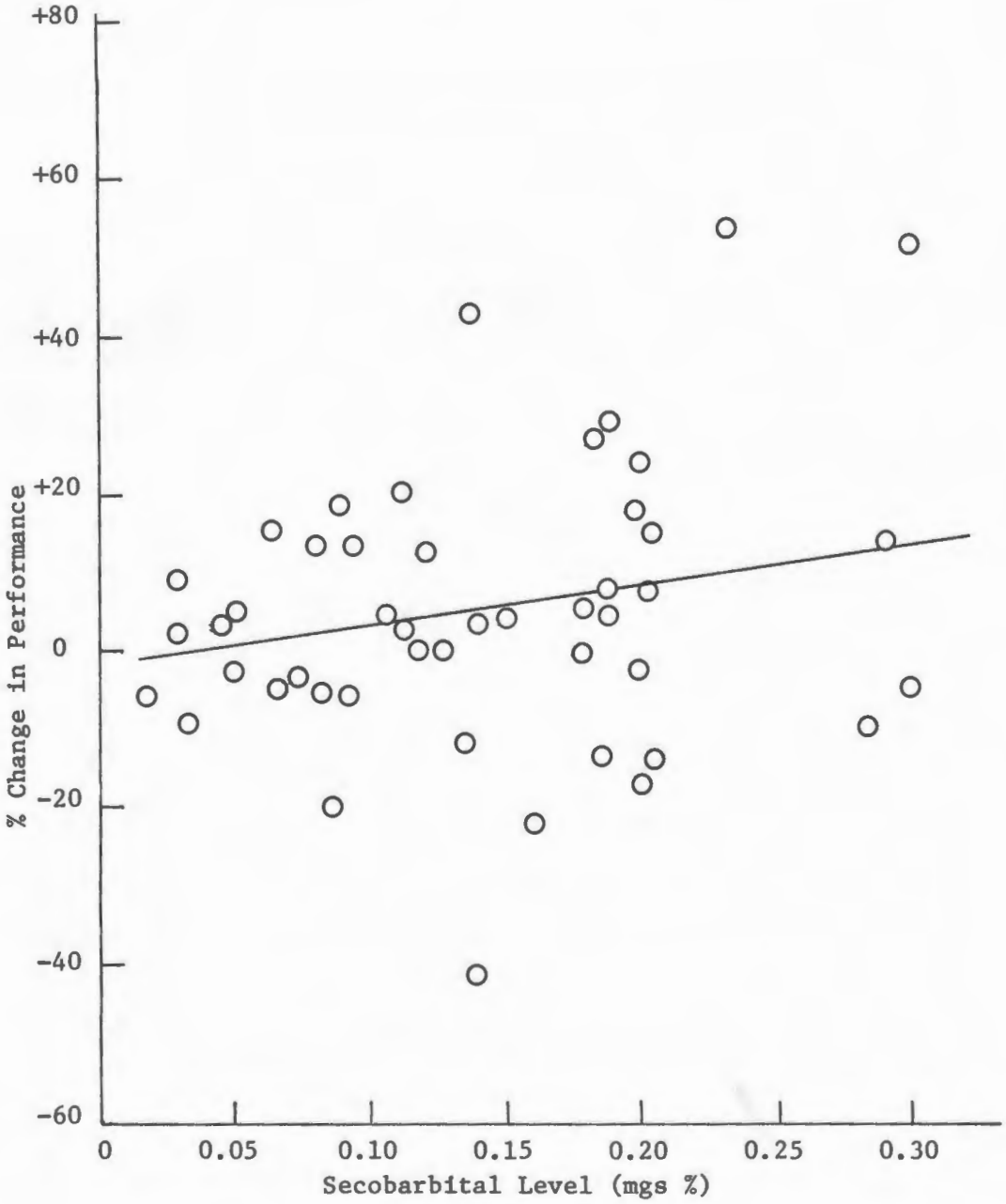
The Spearman rank-order correlation test was performed on the data obtained in both the math and pursuit rotor tests at the first and third hours after drug administration and also on the data taken at the first hour alone. The percent change in performance from baseline for each subject was plotted against the blood secobarbital level found. (Figures 18-21, Table 2). A positive percent change indicated a decrement in performance and a negative percent change indicated an improvement in performance. The critical "Z" value was 1.96. With the math test, both the combined first and third hour data and the first hour data alone failed to show a significant relationship, the "Z" values being 1.40 and 1.10 respectively. In the pursuit rotor test, both the combined first and third hour data and the first hour data alone showed significant rank order correlation in that their "Z" values were 3.31 and 2.59 respectively. This would indicate that a correlation existed between blood levels of secobarbital and the amount of change in the test subjects' ability to coordinate observation and motor response as measured by the pursuit rotor.

Linear regression analysis performed on the data as described for the Spearman rank-order correlation test showed similar results. (Figures 18-21). The math test data, the first and third hours combined and the first hour alone, failed to show a significant linear cor-

relation in that their regression coefficients, "r", were 0.246 and 0.248 respectively. The pursuit rotor test data however, showed significant linear correlation in both instances. The first and third hour regression coefficient was 0.432 and the first hour regression coefficient was 0.424. Critical values of "r" for both the math and pursuit rotor tests were 0.279 for the combined data and 0.404 for the first hour alone. Lines of best fit were plotted in each case. Here again, regression analysis indicated that one could predict, on the average, the extent of impairment in these test subjects of the coordination of observation and hand movement if the blood secobarbital level were known.

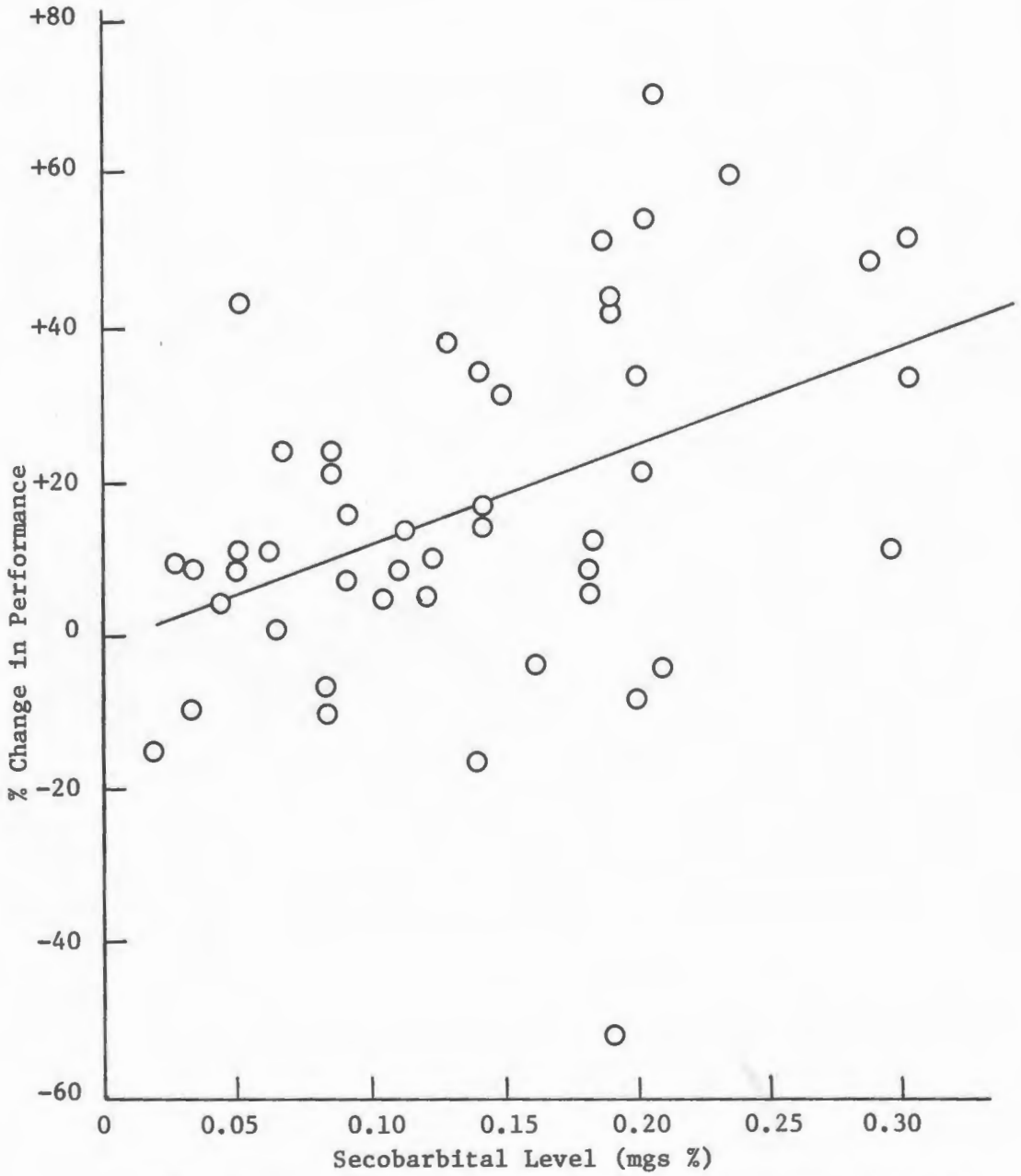
Blood secobarbital levels for the eight test subjects ranged from 0.03 mgs.% to 0.30 mgs.% at the first hour after drug ingestion, and from 0.02 mgs.% to 0.20 mgs.% at the third hour after drug ingestion. (Table 3). The obvious behaviorial effects of the secobarbital on the test subjects at the one hour time period, based on personal observation of their actions and appearance, ranged from awake, mildly sedated, and competent to sedated, unsteady, and preferring sleep. At the third hour time period, each subject in the test group appeared to return to normal behavior and appearance even though blood levels of secobarbital remained relatively high.

FIG. 18 EFFECT OF SECOBARBITAL ON MATH TEST PERFORMANCE: 1st AND 3rd HOURS COMBINED



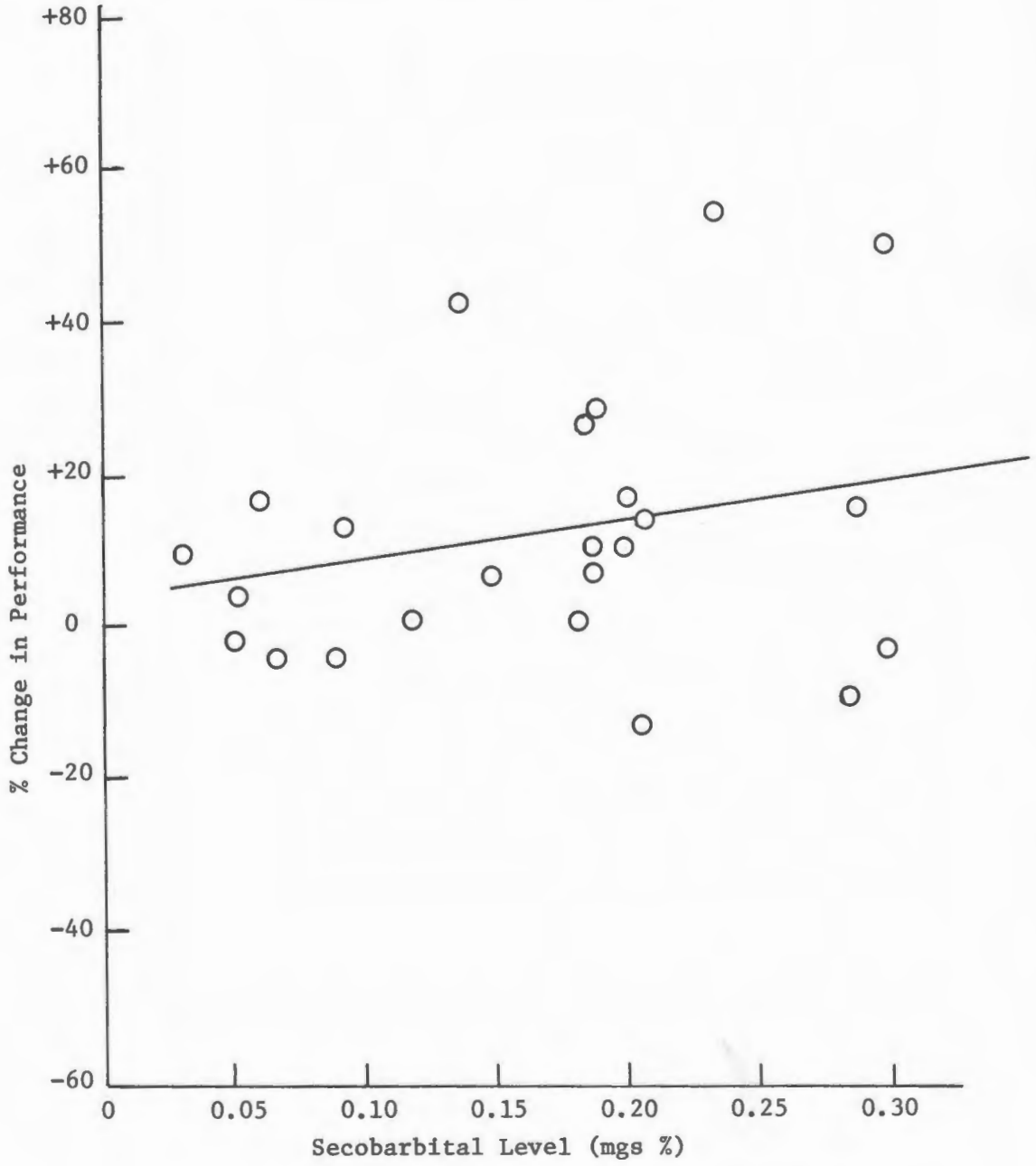
Linear regression of 1st and 3rd hour math test data for test group taken as a whole. Blood secobarbital levels plotted against percent change in performance.

FIG. 19 EFFECT OF SECOBARBITAL ON PURSUIT ROTOR PERFORMANCE; 1st AND 3rd HOURS COMBINED



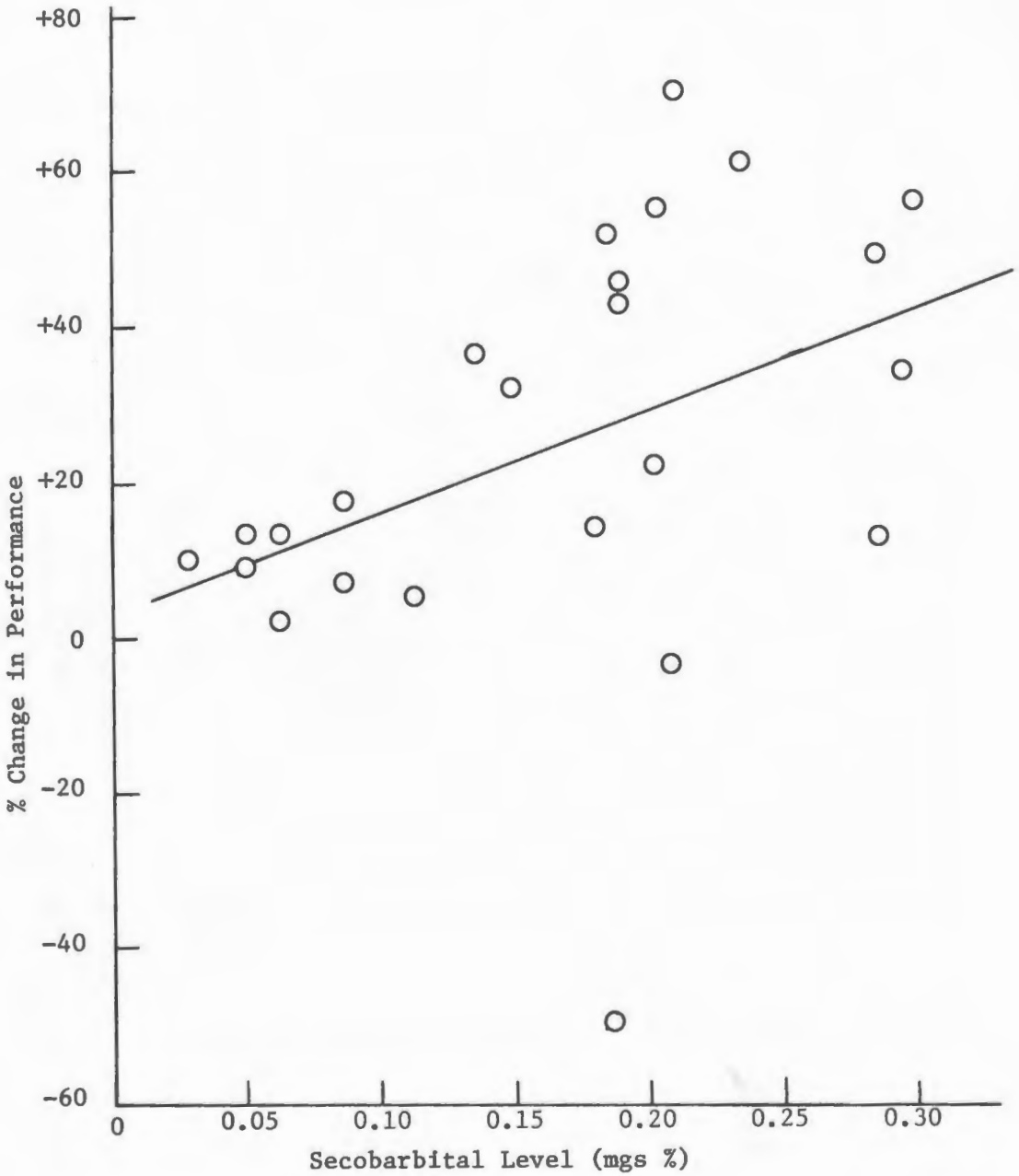
Linear regression of 1st and 3rd hour pursuit rotor test data for test group as a whole. Blood secobarbital levels plotted against percent change in performance.

FIG. 20 EFFECT OF SECOBARBITAL ON MATH TEST PERFORMANCE; 1st HOUR DATA



Linear regression of 1st hour math test data for test group taken as a whole. Blood secobarbital levels plotted against percent change in performance.

FIG. 21 EFFECT OF SECOBARBITAL ON PURSUIT ROTOR PERFORMANCE; 1st HOUR DATA



Linear regression of 1st hour pursuit rotor test data for test group taken as a whole. Blood secobarbital levels plotted against percent change in performance.

Table 2

Secobarbital Blood Levels And Percent Change In Performance

Subject	Drug Trial	Blood Level** 1st hr	Blood Level** 3rd hr	% Change-Math Test* 1st hr	% Change-Math Test* 3rd hr	% Change-Pursuit Rotor Test* 1st hr	% Change-Pursuit Rotor Test* 3rd hr
	1	0.190	0.125	27.4	0.0	43.4	39.4
1	2	0.190	0.110	9.5	4.1	42.5	9.1
	3	0.20	0.180	9.5	-13.6	54.4	8.9
	1	0.290	0.085	- 9.4	-18.7	48.9	21.0
2	2	0.205	0.050	14.4	- 2.5	69.8	41.9
	3	0.30	0.20	- 3.4	-14.7	53.4	- 8.3
	1	0.190	0.135	26.2	- 9.7	50.8	-15.4
3	2	0.140	0.110	41.7	19.4	35.2	12.8
	3	0.230	0.120	52.8	12.3	60.7	9.8
	1	0.150	0.160	6.4	-20.9	31.7	- 2.9
4	2	0.060	0.070	13.8	- 3.4	11.5	24.9
	3	0.290	0.20	14.1	- 2.5	12.5	35.7
	1	0.120	0.10	0.0	5.0	5.8	5.3
5	2	0.180	0.085	7.5	18.3	14.3	24.8
	3	0.20	0.14	17.5	5.0	22.2	17.2
	1	0.050	0.030	5.7	2.4	11.4	-10.0
6	2	0.030	0.035	9.1	- 9.1	8.9	8.2
	3	0.090	0.080	12.7	12.7	16.3	- 8.5
	1	0.205	0.140	- 8.0	-40.0	- 3.5	15.2
7	2	0.190	0.180	6.7	0.0	-51.5	-10.6
	3	0.30	0.20	50.0	23.3	33.6	36.5
	1	0.065	0.020	- 3.7	- 7.5	1.3	-15.7
8	2	0.050	0.045	5.0	5.0	8.9	4.2
	3	0.090	0.080	- 3.8	- 3.8	7.6	- 6.6

*Positive numbers indicate a decrement in performance.
Negative numbers indicate an improvement in performance.

**Secobarbital Blood levels expressed in mgs.%.

Table 3

Secobarbital Blood Levels (mgs %)

Test Subject	Wt. (lbs)	Drug Trial #1		Drug Trial #2		Drug Trial #3	
		1st hr	3rd hr	1st hr	3rd hr	1st hr	3rd hr
1	132	0.190	0.125	0.190	0.110	0.20	0.180
2	130	0.290	0.085	0.205	0.050	0.30	0.20
3	118	0.190	0.135	0.140	0.110	0.230	0.120
4	125	0.150	0.160	0.060	0.070	0.290	0.20
5	140	0.120	0.10	0.180	0.085	0.20	0.140
6	173	0.050	0.030	0.030	0.035	0.090	0.080
7	125	0.205	0.140	0.190	0.180	0.30	0.20
8	173	0.065	0.020	0.050	0.045	0.090	0.080

V. DISCUSSION

Driving an automobile is a complex process involving the acquisition of data concerning the surrounding environment, the assimilation of this data, and the response by the driver to the situation at hand. This entire behavioral process sometimes has to occur in milliseconds.

The psychological tests used for this experiment examined both a cognitive aspect of behavior and a motor response aspect of behavior. The math test measured a cognitive skill in that it demonstrated the ability of the test subjects to observe a mental task and react to it by adding the numbers presented. An analagous situation in driving an automobile would be a driver's ability to mentally evaluate a hazardous road situation such as a sharp bend in the road and respond by applying the car brakes and lowering his speed. The pursuit rotor test measured a psychomotor skill in that it reflected the ability of the test subjects to coordinate motor response with observation. An analagous driving situation would be when a driver has to follow a winding road and stay in his lane of traffic.

Because driving an automobile involves monitoring multiple environmental signals such as speed, steering control, acceleration, etc. all at one time, tests which measure only one psychological parameter at a time such as eye-hand coordination or mental alertness would not correspond to the actual driving situation. It would be recommended in future studies of this kind that the testing procedures use driving simulators which expose the test subjects to multiple signals and stimuli. This would more closely resemble the actual driving situation. The use of flying simulators as used by McKenzie and Elliott (1965) would be acceptable for this purpose in that the simulators expose the test subjects

to multiple signals. In their study, the test subjects had to monitor dials which measured air speed, turn, bank, and engine rpm and keep the respective dial needles in the center position. Although flying an airplane is not driving an automobile, the test environment of the airplane cockpit could be compared to the multiple response environment encountered in the automobile driver's seat.

The sedative-hypnotic effects of a secobarbital are well known and documented (Sharpless, 1970). A therapeutic dose, 100 mgs., is known to cause sedation, relief of anxiety, disinhibition, and the induction of sleep. Needless to say, this is not a condition conducive to the proper handling of an automobile. Secobarbital in therapeutic doses has also been shown to effect sensory mechanisms which could effect one's ability to drive an automobile. Holzman et al. (1975) showed that secobarbital disrupted smooth-pursuit eye tracking performance in five male subjects after a 100 mg. dose. A dose of 130 mgs. effected one individual's eye tracking performance for up to 24 hours.

The secobarbital blood levels detected in the test group in this experiment were consistent with therapeutic blood levels reported by Garriott (1974) and by Baselt et al. (1975) after a 100 mg. dose. In the light of these blood levels it is the opinion of this investigator based on observation of the test subjects in this experiment that at the one hour time interval each individual exhibited a negative effect of the secobarbital. The extent of the negative effect was directly related to the blood level found. The test subjects on the average appeared sluggish and slightly uncoordinated. Actions which would normally be done without effort, such as walking a straight line, had to be concentrated on to be accomplished. Individuals with the higher blood

levels, subjects 1, 2, 3, 4, 5, and 7, by their own admission would not want to assume the responsibilities of driving an automobile. At the third hour time period, each test subject, without exception, looked and felt normal even though blood levels of secobarbital in the majority of them could still be considered to be in the therapeutic range. Each person felt totally competent to drive an automobile. The test results obtained with subject #3 would typify this observation. (Table 3). Baseline values for subject #3 obtained at the start of each drug trial were consistent and could be compared with test scores obtained in the non-drug trials. At the one hour time period, test scores in both the math and pursuit rotor tests fell dramatically. Blood levels at this time period in the three drug trials were 0.187 mgs.%, 0.140 mgs.%, and 0.230 mgs.% respectively. At the third hour time period, test results rebounded to near baseline levels of performance while blood secobarbital levels remained relatively high. Blood values of 0.135 mgs.%, 0.110 mgs.%, and 0.120 mgs.% respectively were recorded.

These observations coupled with the statistical results of the math test and pursuit rotor test seemed to indicate that perhaps a second element, time since drug ingestion, should be considered when trying to determine whether a person is under the influence of secobarbital. It would appear that at the one hour time period the test subjects could not adjust to the psychological effects of the secobarbital or readily adjust to the physical manifestations of these effects. Both the math test and pursuit rotor test used in this experiment seemed to have a degree of sensitivity and reasonable reproduceability necessary to detect some change in the test subject's behavior. The data from both the math test and pursuit rotor test showed that a significant decrease in cognitive

and psychomotor performance was evident at one hour after ingesting a therapeutic dose of secobarbital and that this decrement in performance was not evident at three hours after secobarbital ingestion. In only one instance, the pursuit rotor test in the second drug trial, did the third hour results show a significant decrement from baseline values. Perhaps when an individual is suspected of being under the influence of secobarbital and his blood level is determined to be in the therapeutic range, ie., 0.10 mgs.%, it may be necessary to know how much time has elapsed since the drug was first ingested. The time factor may be an important element in determining whether a person's behavior is being effected by a therapeutic dose of secobarbital. This study would indicate that individuals who do not normally use secobarbital for any reason are effected by the drug more at the initial stages of drug action than at the later stages even though blood levels remain in a therapeutic range. This could be an indication of acute tolerance. It is conceivable that habitual or chronic users of secobarbital may not show this effect and indeed may even improve psychomotor performance in some areas. This hypothesis would certainly be worth investigating.

An alternative explanation for the difference in the test results obtained at the one and three hour time periods could be the process of state dependent learning. This phenomenon could account for the group improving their test results at the three hour time period in the light of relatively high secobarbital blood levels. The test subjects learned to achieve while under the effects of secobarbital.

The data from the pursuit rotor test at the one hour time period alone and at the combined one and three hour time periods indicated that a significant correlation could be shown between the blood level

of secobarbital and the percent change in psychomotor performance. This would indicate that with this test group at one hour after taking a therapeutic dose of secobarbital, one could predict the amount of impairment of those psychomotor functions measured by the pursuit rotor test if the blood level of secobarbital were known. The math test data did not show this correlation. The impairment of cognitive function as measured by the math test could not be significantly correlated to the blood level of secobarbital. It would appear, with this test group, that although secobarbital significantly effects both simple mental exercises and coordination of observation and motor response, only with the latter can one correlate an actual percent change in performance with blood levels of secobarbital. It would be recommended in future studies of this kind to increase the dose of secobarbital, ie., 200 mgs., and thereby raise the blood levels. Under this condition more conclusive results may be obtained as to the correlation of percent impairment with blood levels. To know the extent of impairment of those functions used in driving an automobile would be a valuable piece of information necessary to determining whether a person is capable of operating a motor vehicle.

It is hoped than an eventual outcome of a study of this kind would be to uncover information which would enable legislators of any given society to enact laws that would protect the people of that society from those who drive while under the influence of drugs. With alcohol the literature shows that an individual's performance is effected at a given blood level regardless of when the alcohol was ingested, given sufficient time for absorption to occur. State legislatures have been able to pass laws which state with a high degree of scientific certainty at what blood level a person is driving under the influence of alcohol.

With drugs this information is not available. This study would indicate that there is both a cognitive and psychomotor effect brought on by a therapeutic dose of secobarbital as measured by a simple math test and pursuit rotor test.

The limitations of this particular study are obvious and have been discussed. It would be recommended for future studies concerning the effects of drugs on psychomotor behavior to use a larger number of test subjects and expose these individuals to testing procedures which require multiple monitoring of test parameters and thereby require division of attention. This would more closely simulate the actual driving situation. A large range of doses of secobarbital would be recommended. This would create a situation which could better examine the effect of time on behavior while under the influence of secobarbital. As has been done with alcohol, thousands of individuals will have to be examined using a variety of tests which demonstrate the effect of drugs on the many facets of human behavior which are relied upon when driving an automobile. Only when this is done can responsible legislation be enacted with regard to the effects of secobarbital on driving an automobile. When one reflects on all the investigative work that has been done concerning the effects of alcohol on human behavior and considers all the drugs that are commonly used by the driving public, it staggers the imagination to think what must be done before responsible legislation can be written concerning the effects of drugs on driving. It is hoped that this study will make a contribution to that end.

VI. SUMMARY AND CONCLUSIONS

An investigation was made concerning the effects of secobarbital on skills used to drive an automobile. One hundred mgs. of secobarbital was administered to eight subjects and a psychomotor and cognitive aspect of their behavior was measured. The testing procedure consisted of a simple math test and a pursuit rotor test. Performance in each of three drug trials was measured before drug administration and at one and three hours after drug administration. Blood samples were taken before the one and three hour testing sessions.

A significant decrement in cognitive and psychomotor performance was measured at one hour after drug ingestion. Only in the second drug trial did a psychomotor impairment persist at the three hour time period. Pursuit rotor test results, as a measure of psychomotor function, showed a significant rank-order correlation to blood levels of secobarbital. Percent impairment at the one hour time period and at the combined one and three hour time periods showed significant correlation to blood drug levels. A significant line of best fit could be drawn following linear regression analysis. Math test results as a measure of cognitive function did not show rank-order correlation nor could a significant line of best fit be drawn between drug levels and percent impairment.

Time, as well as blood secobarbital level, appeared to be an important factor when behavior impairment is to be measured. Impairment in both cognitive and psychomotor function was noted at the one hour time period but not at the three hour time period even though secobarbital blood levels remained in the therapeutic range. Further investigation of this observation is warranted.

VII. APPENDIX A

Table 4

Analysis Of Variance Source Table For Pursuit Rotor Data

Source	SS	df	ms	F	p
Total	7381.5	71			
Subjects	5461.6	7			
Tests (1st, 2nd, 3rd)	11.6	2	5.82		NS
Hours (0, 1, 3)	689.1	2	344.57	7.119	0.05
Tests X Hours	77.8	4	19.47		NS
Error Test	227.6	14	16.26		
Error Hours	677.6	14	48.40		
Error Test X Hours	235.9	28	8.42		

Table 5

Analysis Of Variance Source Table For Math Test Data

Source	SS	df	ms	F	p
Total	431.1	71			
Subjects	350.1	7			
Tests (1st, 2nd, 3rd)	1.4	2	0.72		NS
Hours (0, 1, 3)	24.9	2	12.47	6.79	0.05
Tests X Hours	4.6	4	1.15	2.71	0.05
Error Test	12.5	14	0.89		
Error Hours	25.7	14	1.83		
Error Test X Hours	11.8	28	0.42		

VIII. REFERENCES

Adams, R.G.: Presleep ingestion of two hypnotic drugs and subsequent performance. Psychopharmacologia 40: 185-190, 1970.

Baselt, R.C., Wright, J.A., Cravey, R.H.: Therapeutic and toxic concentrations of more than 100 toxicologically significant drugs in plasma, blood, or serum: A tabulation: Clinical Chemistry 21: (1): 44-62, 1975.

Borg, G., Edstron, C.G., Linderholm, H.: Changes in physical performance induced by amphetamine and amobarbital. Psychopharmacologia 26: 10-18, 1972.

Bruning, J.L., Kintz, B.L.: Computational Handbook of Statistics, Scott Foresman and Co., Illinois, 1968.

Crancer, A. Jr., Dille, J., Delay, J., Wallace, J., Haykin, M.: Comparison of the effects of marihuana and alcohol on simulated driving performance. Science 162: 1234, 1968.

Department of California Highway Patrol: The role of carbon monoxide, alcohol, and drugs in fatal single car accidents. State of California Transportation Agency: 1965.

Dureman, I., Norrman, B.: Clinical and experimental comparisons of diazepam, clorazepate, and placebo. Psychopharmacologia 40: 279-284, 1975.

Finkle, B.S., Biasotti, A.A., Bradford, L.: The occurance of some drugs and toxic agents encountered in drinking driver investigations. Journal of Forensic Sciences 13: (2): 236-245, 1968.

Forney, R.B., Hughes, F.W.: Meprobamate, ethanol, or meprobamate-ethanol combinations on performance of human subjects under delayed audio feedback. The Journal of Psychology 57: 431-436, 1964.

Forrester, E.H., Mason, M.F.: Preliminary studies on the use of n-butyl chloride as an extractant in drug screening procedures. Journal of Forensic Sciences 19: (1): 155-162, 1974.

Garriott, J.C.: Therapeutic and toxic concentrations of common drugs and poisons. The Forensic Science Gazette 5: (3): 3-5, 1974.

Glauz, W.D., Blackburn, R.R.: Drug use among drivers; U.S. Department of Transportation. DOT/HS 801, 1975.

Hollister, L.E., Clyde, D.J.: Blood levels of pentobarbital sodium, meprobamate, and tybamate in relation to clinical effects. Clinical Pharmacology and Therapeutics 9: (2): 204-208, 1967.

Holzman, P.S., Levy, D.L., Uhlenhuth, E.H., Procter, L.R., Freedman, D.X.: Smooth pursuit eye movement and diazepam, CPZ, and secobarbital. Phychopharmacologia 44: 111-115, 1975.

Hughes, F.W., Forney, R.B.: Comparative effects of three antihistaminics and ethanol on mental and motor performance. Clinical Pharmacology and Therapeutics 5: (4): 414-421, 1964

Hughes, F.W., Forney, R.B.: Comparative effects in human subjects of chlordiazepoxide, diazepam, and placebo on mental and physical performance. Clinical Pharmacology and Therapeutics 6: (2): 139-145, 1965.

Johnson, R.R.: Elementary Statistics, 2nd ed., Duxbury Press, Massachusettes, 1976.

Landauer, A.A., McIver, R.M., Patman, D.M.: Alcohol and amitriptyline effects on skills related to driving behavior. Science 163: 1467-1468, 1969.

Landauer, A.A., Laurie, W., Milner, G.: The effects of benzoctamine and alcohol on motor skills used in car driving. Forensic Science 2: 275-283, 1973.

Lawton, M.P., Cahn, B.: The effects of diazepam and alcohol on psychomotor performance. Journal of Nervous and Mental Disorders 136: 550-554, 1963.

Linnoila, M., Hakkinen, S.: Effects of diazepam and codeine alone and in combination with alcohol, on simulated driving. Clinical Pharmacology and Therapeutics 15: 368-373, 1973.

Linnoila, M., Matila, M.J.: Effects of isoniazid on psychomotor skills related to driving. Journal of Clinical Pharmacology 8-9: 343-349, 1973.

Linnoila, M., Matila, M.J.: Interaction of alcohol and drugs on psychomotor skills as demonstrated by a driving simulator. British Journal of Pharmacology 6: 671-672, 1973.

Linnoila, M.: Drug effects on psychomotor skills related to driving: interaction of atropine, glycopyrrhonium, and alcohol. European Journal of Clinical Pharmacology 6: 107-112, 1973.

Manheiner, D.I., Mellinger, G.D., Balter, M.B.: Psychotherapeutic drugs: use among adults in California. California Med. 109: 445-452, 1968.

McKenzie, R.E., Elliott, L.L.: Effects of secobarbital and D-amphetamine on performance during simulated air mission. Aerospace Medicine 36: 774-779, 1965.

Milner, G.: Drugs and Driving. vol. 1 of Monographs on Drugs; edited by Avery, G.S., Basel, S. and Karger, A.G.: 1972.

Parry, H.I.: Use of psychotropic drugs by U.S. adults. Public Health Reports 83: (10): 799-810, 1968.

Seppala, M.B., Linnoila, M., Elonen, E., Matilla, M., Maki, M.: Effect of tricyclic antidepressants and alcohol on psychomotor skills related to driving. Pharmacology and Therapeutics 17: 1975.

Sharpless, S.K.: Hypnotics and Sedatives; in The Pharmacological Basis of Therapeutics, eds. Goodman, L.S., Gilman, A.: The MacMillan Co., New York, 1970, p. 100-113.

Swinyard, E.A., Harvey, S.C.: Sedatives and Hypnotics; in Remington's Pharmaceutical Sciences. Mack Publishing Co., Pennsylvania, 1970.

Traffic Laws Commentary (Editorial): Drugs and Driving: No. 65-1, 1-17, 1965.

Woodhouse, E.J.: The incidence of drugs in fatally injured drivers. U.S. Dept. of Transportation, DOT/Hs 800, 753, 1972.

Woodhouse, E.J.: The incidence of drugs in fatally injured drivers. U.S. Dept. of Transportation, DOT/HS 800, 411, 1975.

IX. VITA

Robert Arthur Miller was born to Mr. and Mrs. Arthur Miller on November 20, 1940 in Pawtucket, Rhode Island. Mr. Miller obtained his elementary and secondary education in Pawtucket, Rhode Island. In 1958, Mr. Miller enrolled at the University of Rhode Island and received the Bachelor of Science degree in Biology in September, 1962. Mr. Miller began full-time graduate studies at the University of Rhode Island in September, 1974 where he completed the requirements for the Master of Science degree in Pharmacology and Toxicology in June, 1978.

Mr. Miller is married to the former Joyce Marilyn Hunt of Cumberland, Rhode Island. He is presently employed as Principal Toxicologist at the Rhode Island Department of Health where he supervises the Law Enforcement Laboratory.