1974

Operant Analysis of Behavior Associated With Oral Self-Administration Of Drug Solutions in Rats

Joseph David Zabik
University of Rhode Island

OPERANT ANALYSIS OF BEHAVIOR ASSOCIATED WITH ORAL SELF-ADMINISTRATION OF DRUG SOLUTIONS IN RATS

BY

JOSEPH EDWARD ZABIK

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

PHARMACEUTICAL SCIENCES

UNIVERSITY OF RHODE ISLAND

1974

DOCTOR OF PHILOSOPHY THESIS

OF

JOSEPH EDWARD ZABIK

Approved:

Thesis Committee:

Chairman

Dean of the Graduate School

UNIVERSITY OF RHODE ISLAND

1974

ABSTRACT

Since many drugs which are abused by man are taken orally, it was desirable to develop a method suitable to quantitatively and reliably measure oral self-administration of drugs and their effects on behavior in experimental animals.

Water deprived rats were trained to lick for drug solutions (4.34 ul/lick) and bar press for food on a Fixed Interval (FI) 60 second schedule and press another bar for secondary reinforcements on a Fixed Ratio (FR)-5 schedule as three concurrent operants. Non-discriminated responding was inconsequential. An appropriate drug solution was substituted for water or the drugs were injected intraperitoneally before the session. For each drug, a dose-response was determined with usually six replicate sessions per dose for each rat. Three rats were usually used in each study.

Substitution of solutions of amphetamine (0.5, 0.99 and 1.99 m Molar) resulted in concentration dependent decreases in discriminated and non-discriminated licking, and discriminated lever pressing for secondary reinforcement. Non-discriminated lever pressing for secondary reinforcement or food pellets increased. Consequential lever pressing for food pellets was unaffected. The effects of amphetamine on lever pressing and licking were similar whether an acute injection was made before the session or amphetamine was self-ingested during the session.

Chronic injections of amphetamine (5 mg/kg, I.P., 18 hours before the water session, given daily for 5 days prior to the study and during the study for 30 days) resulted in an increased sensitivity to ingested amphetamine. This increased sensitivity was manifested by a shift of

concentration response curves to lower concentrations (0.125, 0.25, 0.50 m Molar).

Chlorpromazine (0.5 mg/kg, I.P., 30 minutes before the session) significantly increased the licking rates for solutions of amphetamine (0.5 mM or 1.0 mM).

Substitution of solutions of ethanol (10, 20, 40, 80% v/v) resulted in concentration dependent decreased in discriminated and non-discriminated licking, and discriminated lever pressing for secondary reinforcement. Non-discriminated lever pressing for secondary reinforcement or food pellets was increased. Consequential lever pressing for food pellets was unaffected. While the licking rate decreased with increased concentrations of ethanol, the grams of absolute ethanol ingested increased. The effects of oral injections of ethanol (12 ml/kg, of a 50% v/v solution, 15 minutes before the session on behavior were similar to the effects of ingested ethanol except for a decrease in number of food pellets obtained.

Disulfiram (50 mg/kg, I.P., 60 minutes before the ethanol session) did not affect behaviors for various contingencies during water sessions or initial portions of ethanol (20% v/v) sessions. However, disulfiram pretreatment depressed behaviors completely after the inital ingestion of small quantities of ethanol.

Rats were given increasing doses of morphine sulfate, until a total daily dose of 200 mg/kg was attained.

Deprivation of these rats of their daily morphine for four successive days had little effect on water licking, but licking rates for a solution of amphetamine (0.5 m Molar) decreased during the abstinence while licking rates for a solution of ethanol (80% v/v) remained con-

sistently higher than those for amphetamine. Nalorphine (4 mg/kg abolished licking for water in three of four rats indicating a difference between nalorphine induced and abstinence induced withdrawal.

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to Dr. Harbans Lal, his major professor, for his guidance and endless patience throughout the study and in the preparation of this thesis. Special thanks are also conveyed to Dr. Harbans Lal for his part in the shaping of the author's attitude and ability which are essential for a career in research.

The author wishes to express his gratitude to the members of his graduate committee for their guidance in the preparation of this thesis.

The author wishes to express his gratitude to Anne Partenheimer and Pamela Brink for the typing of this thesis.

The author also wishes to convey his thanks to his fellow students for their suggestions during these studies and to all the others who have been so helpful in all phases of the preparation of this thesis.

The author is grateful to the University of Rhode Island for providing financial assistance during these studies.

DEDICATION

The author would like to dedicate this thesis to his wife, Regina, without whose constant encouragement, confidence and prayers this thesis could not have been possible.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

I. INTRODUCTION

Self-administration of drugs by man is not a unique phenomenon but dates back before recorded history (Lewin, 1964). To understand the basic aspects of drug self-administration, it is essential that it be studied in an experimental situation using experimental animals to eliminate the complication of psychological and personality factors which complicate studies with humans.

Since Weeks (1962) described a technique for intravenous self-administration of morphine in the rat, a considerable amount of research has been devoted to the study of intravenous self-administration of opiates (Thompson and Schuster, 1964), stimulants (Pickens, 1968), and ethanol (Deneau et al, 1969).

Since many drugs which are abused by man are taken orally, it was desirable to develop a method suitable to quantitatively and reliably measure oral self-administration of drugs in experimental animals, in order to extrapolate the results to the human situation. Utilizing the observation of Falk (1961) that rats trained to obtain food pellets on a variable interval 90 second schedule, will consume three to five times their normal water intake in a session when water was freely available, Lester (1961) reported intakes of 5.6% ethanol by rats to the point of intoxication.

The present investigation utilized a modification of Falks (1961) schedule induced polydipsia with operant licking chosen as the means by which to study oral self-administration of drugs, rather than using lever pressing for dipper presentation of fluid. Operant licking was chosen because it was a novel approach and never utilized in this way,

secondly, ingestion by licking is the way in which a rat routinely ingests fluids.

The present investigation sought evidence to determine:

1. Whether fluid acquired by operant licking would provide reliable, quantitative data with which to study oral self-administration of drugs by rats.
2. Whether orally ingested drugs exerted similar effects on behavior as the same drugs injected before the session.
3. Whether chronic treatment with drugs would affect subsequent self-administration of the same drug.
4. Whether chlorpromazine pretreatment would have any effect on amphetamine self-ingestion.
5. Whether this system could serve as a model with which to study the effects of disulfiram on ethanol consumption.
6. The effect of substitution of solutions of ethanol or amphetamine for water during abstinence induced withdrawal in morphine dependent rats.
7. The behavior of the morphine antagonist, nalorphine, on morphine dependent rats.

II. LITERATURE SURVEY

Self-administration of drugs by man is not a unique phenomenon but dates back before recorded history (Lewin, 1964). Drugs are used in two ways - first for their therapeutic effect and secondly in an abusive manner. Although the use of drugs by man precedes recorded history, the recognition of the problem of dependence (Opioid) is a comparatively recent phenomenon (Light and Torrence, 1929). About this same period, it was discovered that biological factors involved in drug dependence could be studied in animals (Tatum et al, 1929). To place developments in the study of dependence and self-administration of drugs in closer perspective yet, two of the first review articles on the subject have been just recently published (Schuster and Villarreal, 1967; Schuster and Thompson, 1969).

In one of the earliest experiments which suggested that morphine self-administration might be brought under operant control, Spragg (1940), demonstrated that physically dependent chimpanzees, who had been deprived of morphine, would choose a box containing a morphine-filled syringe over a box containing food. The experimenter then injected the animal with morphine. If the animal had recently received an injection of morphine, it would choose the box containing food. In 1955, Headlee et al presented a study designed to show operant conditioning of drug self-administration. They have also been the only investigators to use an intraperitoneal route of self-administration. In their study, restrained rats were conditioned to turn their heads laterally and interrupting a beam of light falling on a photo-electric cell, thus starting

a pump which infused a morphine solution through a needle inserted through the body wall into the peritoneal cavity.

Weeks (1962) described a technique for intravenous self-administration of drugs in the rat. He demonstrated clearly that rats, rendered physiologically dependent by programmed intravenous administration of morphine, will then maintain the dependent state by pressing a lever to obtain the drug. The self-administration technique was then extended to physically dependent monkeys with similar results (Thompson and Schuster, 1964).

Deneau et al (1969) went a step further and were able to demonstrate that monkeys which were not physiologically dependent upon morphine would initiate and maintain self-administration of morphine. These results indicate that the monkeys developed a psychological dependence - a preference to exist under the influence of the drug - before physiological dependence could develop. That non-dependent monkeys will self-administer morphine has also been confirmed by Schuster (1970).

Nichols et al and Coppock (1956) conditioned rats to self-ingest morphine solutions following establishment of physical dependence. Kumar et al (1968) have shown it is possible to induce a preference for morphine in rats without making them physically dependent. The method involved making the rats accustomed to satisfying their normal thirst during a limited time daily, and then substituting morphine solutions for the water normally given.

Alcohol Self-Administration

The human disease state of "alcoholism" is so complex that even today it defies adequate description and consequently adequate therapeutic procedures. As in most other examples of human disease, many workers have

attempted to develop an animal model for alcoholism. If such a model for alcoholism could be developed, laboratory experimentation could be carried out under controlled conditions, hopefully with results extrapolatable to the human problem. At the present time, there is a paucity of viable studies in this area, especially of coordinated, multiparameter studies from the same laboratory.

Factors Influencing Alcohol Consumption

Alcoholism is not a disease state endogenous to animals. Alcohol solutions are not readily ingested by many animals. Despite these problems, many investigators have looked at the factors which influence voluntary consumption of alcohol by animals with mixed results.

(a) Physical Characteristics of the Alcohol Solution

(1) Odor-Taste - The odor and taste of solutions influence the ingestion of alcohol by rats. For example, when ability to taste was diminished by methylpentynol, rats were found to drink a solution of alcohol as high as 20% (Dicker, 1958). Olfactory phenomena also seem to have an affect, since rats made anosmic by extirpation of the olfactory bulbs selected higher concentrations of alcohol than prior to surgery (Kohn and Stellar, 1960).

(2) Concentration - Rats will preferentially select a solution of alcohol over water if the concentration of alcohol is not excessive. For example, Myers (1968) reported that several strains of rats prefer solutions of alcohol over water only when concentration of the solutions are less than 7%.

(3) Caloric Content - Since solutions of alcohol are a ready source of calories, this factor must also be considered in interpreting

results of alcohol ingestion. Rats have been shown to reduce their food intake in proportion to the concentration of alcohol consumed (Richter, 1953). However, the aversiveness of concentrations greater than 7% was sufficient to offset the caloric value of alcohol during severe food deprivation (Myers and Carey, 1961).

(b) Animal Factors

Many factors concerning the experimental animals have also been described in studies of alcohol consumption.

(1) Age - Alcohol preference was reported to be greater in young rats (2-3 months of age) than in animals up to 2 years old (Parisella and Pritham, 1964). However, Goodrick (1967) reported that alcohol ingestion increased in rats 1-5 months old, and was greater at every concentration in rats 24 months old as compared to rats 15 months of age.

(2) Sex - The question of whether male or female animals drink more alcohol has yielded results that are contradictory. Mardones (1960) and McClearn and Rodgers (1959) reported no sex differences in alcohol consumption by rats; Aschkenasy-Lelu (1960) and Eriksson and Malmstrom (1967) reported that female rats consume more alcohol than males; while Schaldewald et al (1953), Clay (1964) and Powell et al (1966) reported more alcohol consumed by male than by female rats. A wide individual variation in alcohol consumption within animals of the same strain, sex, age etc. (Mardones, 1960 and Eriksson, 1969) has been demonstrated.

(3) Genetic Factors - By outbreeding Wistar rats which differed in their alcohol consumption, Eriksson (1968) has raised two genetically different lines. Marked differences between the sexes and strains were evident, with regard to alcohol consumption, by the eighth generation.

Mardones and co-workers (1953) had previously shown that a clear correlation existed between alcohol consumption of parents and offspring. Forsander (1967) has also demonstrated a genetic factor in alcohol consumption.

(c) Miscellaneous Factors

In addition, there are significant effects of a variety of miscellaneous factors on alcohol consumption by laboratory animals.

(1) Ambient Temperature - Eriksson (1969) reported that rats maintained at an environmental temperature of 5°C consumed more alcohol than similar animals in environments of 22°C or 32°C. This work contradicted the earlier report of Myers (1962) that rats consumed more ethanol at 18°C than at 27°C.

(2) Effect of Pretreatment - As mentioned before, rats of several strains will usually prefer solutions of alcohol over water if the concentrations are lower than 7-8% (Myers, 1968). By restricting the animals fluid intake exclusively to solutions of alcohol, ingestion of alcohol in concentrations up to 20% has been reported (Richter, 1953, Mardones, 1960).

Other techniques such as injecting the animals with alcohol have also been investigated. Myers (1963) has demonstrated a preference for alcohol in rats following repeated intracranial infusions of alcohol. However, Koz and Mendelson (1967) were unable to produce the same phenomena in monkeys.

(3) Stress - In an attempt to increase voluntary alcohol consumption by imposition of a stressful environment, Myers and Holman (1967) stressed rats by intense shock given randomly around the clock for 14 days. The

hypothesis that an increased intake of alcohol would provide relief from the stress was not supported as no increase occurred. Preference for alcohol has been reported when a cue as a warning light was associated with presentation of shock on a random basis (Cicero et al, 1968 and Senter and Persensky, 1968). However, the preference was only observed during periods of stress and not afterward.

(4) Schedule - Induced Alcohol Consumption - Utilizing the observation of Falk (1961) that rats trained to obtain food pellets on variable intervals of 90 seconds, will consume 3-4 times their normal water intake in a session when water was freely available, efforts have been made to induce alcohol consumption. Using this technique, Lester (1961) reported intakes of 5.6% alcohol solution by rats to a point of intoxication. As with other attempts, this one also failed to create a preference of alcohol over water (Senter and Sinclair, 1967).

(5) Nutritional Factors - With regard to alcohol consumption in self-selection experiments, it must also be remembered that the choice is not really a simple one between alcohol and water, but rather a three-way choice in which the caloric value of alcohol can also substitute for food (Hausmann, 1932). This situation has been recently reiterated by Forsander (1967).

Tolerance

In general, forced consumption of alcohol solutions for long periods of time has not led to an increased preference for alcohol in rats (Richter, 1953; Mardones, 1960). In fact, Essig (1968) has reported that rats show a preference for water after prolonged periods of alcohol

consumption.

In a series of self-selection (preference) experiments, Arvola and Forsander (1963) demonstrated a variety of species tendencies. Based on a comparison of the percentage of alcohol in the daily fluid intake in a choice situation of water or 10% alcohol, these authors found that guinea pigs preferred water to an extreme, consuming about 10% of their daily fluid as alcohol. Hamsters, on the other hand, consumed alcohol solutions preferentially, taking in almost 90% of their daily fluid intake as alcohol. Rats fall at an intermediate stage, with about a 30% intake.

While tolerance to alcohol has yet to be shown in rats self-ingesting alcohol, it has been observed and measured by behavioral tasks if alcohol is administered intragastrically. Rats trained to escape foot shock have displayed tolerance after receiving alcohol intragastrically for a period of time (Moskowitz and Wapner, 1964; and Chen, 1968). Tolerance, as measured by the ability of rats to run on a motor driven belt suspended over an electrified grid, has been shown to develop maximally within three weeks following intoxicating administration of alcohol and to be significantly reduced after one week during which no alcohol was administered (LeBlanc, et al, 1969).

When investigating the consumption of alcohol by rats for a length of time, the possible development of tolerance, whether due to metabolic changes or to cellular changes in the central nervous system (Mendelson, 1970) is an area for much needed research. More work is needed in the area of self-ingestion as compared to involuntary administration before the mechanism of tolerance can be clearly defined.

One related area of particular interest is the metabolic fate of alcohol. While agreement exists that liver alcohol dehydrogenase is the major enzymatic pathway for the metabolic degradation of alcohol (Westerfeld, 1955) the exact relationship of the activity of this enzyme to the plasma half-life of alcohol remains unclear. For example, in the studies of Wilson et al (1961), two strains of mice, the C57 Bl/6J and C3H/Agautie were shown to have widely differing levels of liver alcohol dehydrogenase activity. Despite this difference, the plasma half-life of alcohol in the two strains was virtually indistinguishable (Wilson, 1967). This correlates well with the studies of Asade and Galambos (1963) who were unable to correlate the rate of disappearance of alcohol from blood with liver alcohol dehydrogenase activity in humans.

Behavioral Studies

Research on the effects of alcohol on laboratory animals has the disadvantage that one cannot ask the subjects how they feel, but on the other hand there is much more control and flexibility in animal experimentation than in human experiments. In general, the use of animal behavioral techniques has provided some information on the effects of alcohol.

The earliest report of the effect of alcohol on conflict behavior was made by Masserman et al (1944, 1945), and Masserman and Yum (1946). Cats were first trained to obtain food and were later subjected to an air blast or electric shock at the food, resulting in avoidance behavior. Alcohol, injected intraperitoneally, restored the food approach behavior. Similar experiments have also been conducted using rats (Conger, 1951;

Barry and Miller, 1962; Grossman and Miller, 1961; Freed, 1967, 1968a). In an experiment in which rats were induced to drink alcohol, similar effects were observed (Freed, 1968b).

Experiments have given evidence that alcohol reduces frustration as produced by extinction (Barry et al, 1962). Rats under the influence of alcohol (injected intraperitoneally) had faster running speeds during extinction trials (no food available) than saline treated rats.

A generalized depressant effect of alcohol was demonstrated in a lever pressing response for water reward maintained by DRL (Differential Reinforcement for Low Rate) schedule (Sidman, 1955; Laties and Weiss, 1962). The total number of lever presses decreased to less than half the normal amount.

Several studies report that doses of alcohol causing ataxia are required before there is any impairment in avoidance performance in rats trained to avoid shock either in a shuttle box or by jumping up on a pole (Walgren and Savolainen, 1962; Chittal and Sheth, 1963; Broadhurst and Walgren, 1964).

Deneau et al (1969) demonstrated that monkeys which were not physiologically dependent upon alcohol would initiate and maintain self-injection of alcohol as was also demonstrated for morphine.

Stimulant Self-Administration

Initial studies of drug self-administration by animals were concerned with either alcohol or morphine since it was thought that only drugs which produce a physiological dependence in man would be self-administered by animals. Yet many stimulants such as cocaine and amphetamine do not

induce physiological dependence but are widely abused by man. (Durrant, 1965; Connell, 1968).

The self-injection of stimulant drugs by monkeys was first reported by Deneau et al (1964). Since then, Pickens and Thompson (1968), Pickens (1968), and Woods and Schuster (1968) have shown cocaine to be self-administered intravenously by both rats and monkeys. Methamphetamine has been found to be self-administered intravenously by rats (Pickens, 1968; Pickens, Meisch and McGuire, 1967). Amphetamine was shown to be self-administered intravenously by monkeys (Deneau et al, 1969) and rats (Pickens, 1968; Pickens and Harris, 1968). Nicotine has been shown to be self-administered intravenously (Deneau and Inoki, 1967) and inhaled as tobacco smoke by monkeys (Jarvik, 1967). A comparison between stimulant self-administration and opiate self-administration has recently been published by Thompson and Pickens (1970). Stimulant self-administration differs from opiate self-administration in at least four respects: acquisition of self-administration is rapid for stimulants while very gradual for opiates. The intervals between infusions is extremely stable for stimulants but variable for opiates. Self-administration of stimulants is cyclic with alternating intake and abstinence patterns while no such pattern is observed with opiates. Finally, a long burst of responses occurs at a very high rate during extinction of stimulant self-administration while in opiate extinction, responding persists at a low rate for weeks and even months after discontinuing reinforcement.

Minor Tranquilizer Self-Administration

Recently Harris et al (1968) have applied operant techniques to study

oral self-administration of another class of drugs, the minor tranquilizers, in rats. In their study, drugs were used as secondary reinforcers. Rats were initially tested for preference between water and chlordiazepoxide, meprobamate, LSD, nicotinic acid and quinine. In all instances, the rats preferred water. The rats were then trained to lick the drug bottle in order to obtain food reinforcement. Subsequent testing revealed that following the association of ingestion of drug with food reinforcement, the animals drank significant quantities of chlordiazepoxide, meprobamate and nicotinic acid. The effect was not obtained with LSD or quinine.

III. EXPERIMENTAL

Materials

Subjects - Male albino-rats of Sprague-Dawley strain, random bred, weighing between 250-300 grams at the start of the experiment, were obtained from Charles River Breeding Farms, Wilmington, Massachusetts. They were housed individually in an air-conditioned, light-controlled room (lights on 12 hours - off 12 hours). Food was available ad libitum, but water was available only for 30 minutes in the home cage, 2-4 hours after the drug session.

Apparatus - Two animal test cages (LHV Model 1417C) housed in sound attenuated chambers (LHV Model 1417C) were used to train and test the rats. In each cage were two levers, a food magazine and a licking operandum (Figure 1) for presentation of fluid. Each drop of fluid delivered was 4.35 ul (Table 1). Drop size was determined by activating operandum electrically and collecting fluid. The levers were separated by the food magazine and licking operandum.

Drugs - Ethyl Alcohol (absolute) was obtained from U.S. Industrial Chemicals Company, Division of National Distillers and Chemicals Corporation, New York, New York. The drugs used in this investigation were obtained from their respective manufacturers.

Procedure

Behavioral Methods - The oral self-administration of drugs was quantitatively analyzed with a free-operant technique composed of multiple concurrent schedules (Figure 2). Responding on the left lever on a FR-5

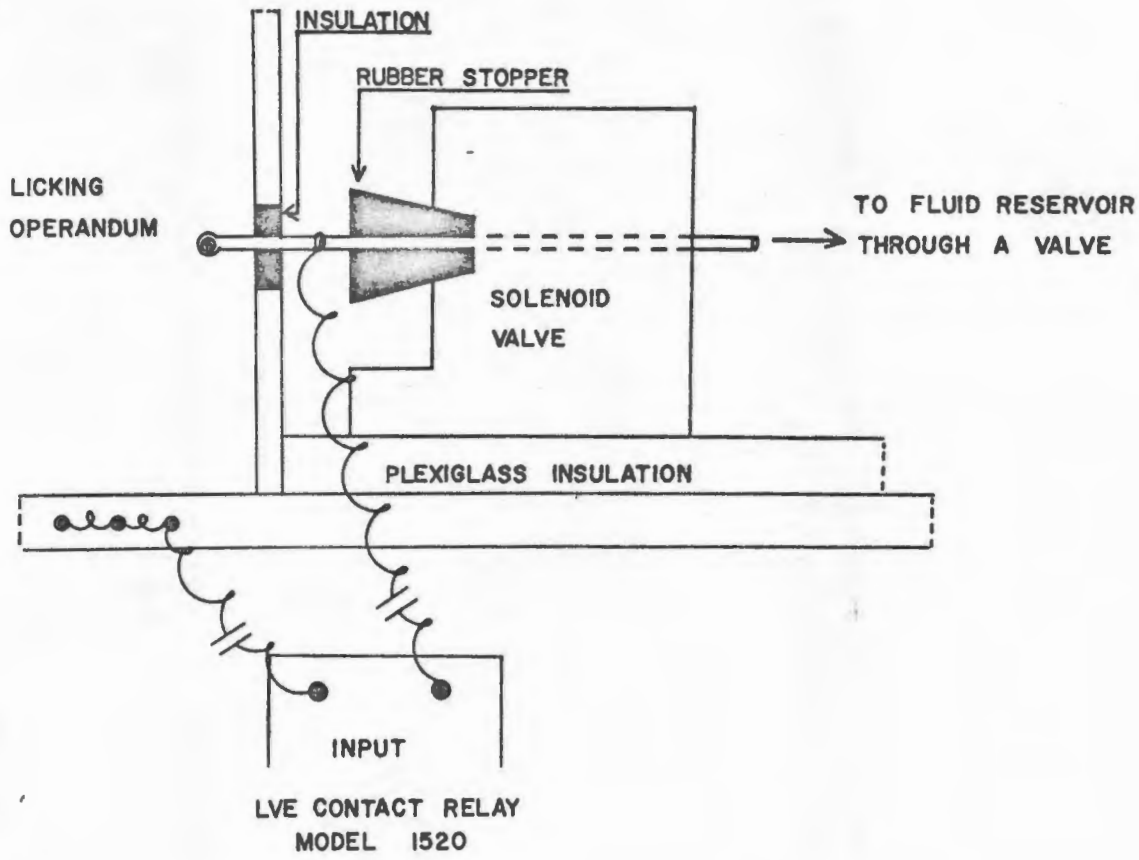

Figure 1. Diagram of Licking Operandum

TABLE 1

DETERMINATIONS OF VOLUME OF DROPS DELIVERED FROM LICKERANDUM

Replicate Determinations	Drops	Box - 1 Volume(ml)	Box - 1 ul/Drop	Box - 2 Volume(ml)	Box - 2 ul/Drop
1	7200	26.40	3.67	28.30	3.93
2	10400	46.50	4.47	49.00	4.71
3	6545	29.00	4.43	24.40	3.73
4	7600	42.00	5.39	35.25	4.63
5	8950	39.75	4.44	37.50	4.19
6	7900	30.00	3.80	38.00	4.81
Mean			4.37 **		4.33 **
+ S.E.			0.25		0.18
(N) *			(6)		(6)
Grand Mean ± S.E. (N)		4.35 ± 0.14 (12)			

* N = Number of replicate determinations.

** Difference between two means was non-significant ($P > 0.05$)

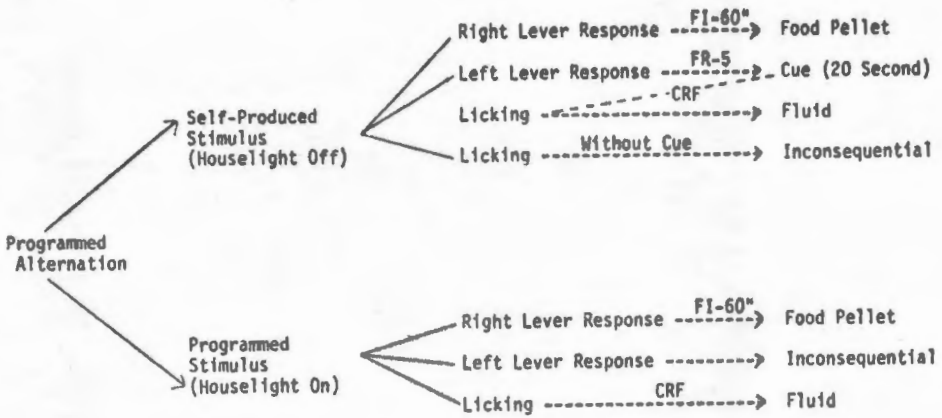

Figure 2. Representation of Schedules

schedule produced 20 seconds of cue light (secondary reinforcement). Each lick during this 20 second period was a discriminated response and provided 4.35 ul (Table 1) of fluid (primary reinforcement). Further responses on the left lever during this 20 second period were inconsequential. Every five consecutive 20 second cue-light periods were followed by 130 seconds of programmed stimulus not contingent upon lever pressing. Each lick during this period also provided 4.35 ul of fluid. Left lever presses during this 130 second period were inconsequential. Responding on the right lever on a FI-60 seconds schedule produced 45 mg Noyes food pellets.

Shaping - The shaping was accomplished in the following steps:

(a) Naive, water deprived rats were placed into the training cage and allowed to lick a drop of water which was hanging from the licking spout. Acquisition to licking for water usually occurred within ten minutes (Figure 3).

(b) Once rats were licking consistantly for ten minutes or more, licking time was programmed to be contingent on left lever pressing (FR-1). This was termed consequential licking time and was signaled by a cue-light above the left lever. The ratio on the left lever was gradually increased to FR-5 in the same session. Once this behavior was established, the consequential licking time, following five responses on the left lever, was set at 20 seconds and termed self-produced stimulus segment.

(c) A programmed stimulus segment, in which 130 seconds of continuous cue (house light) was programmed to occur following the end of the fifth (20 second) self-produced stimulus segment, was then

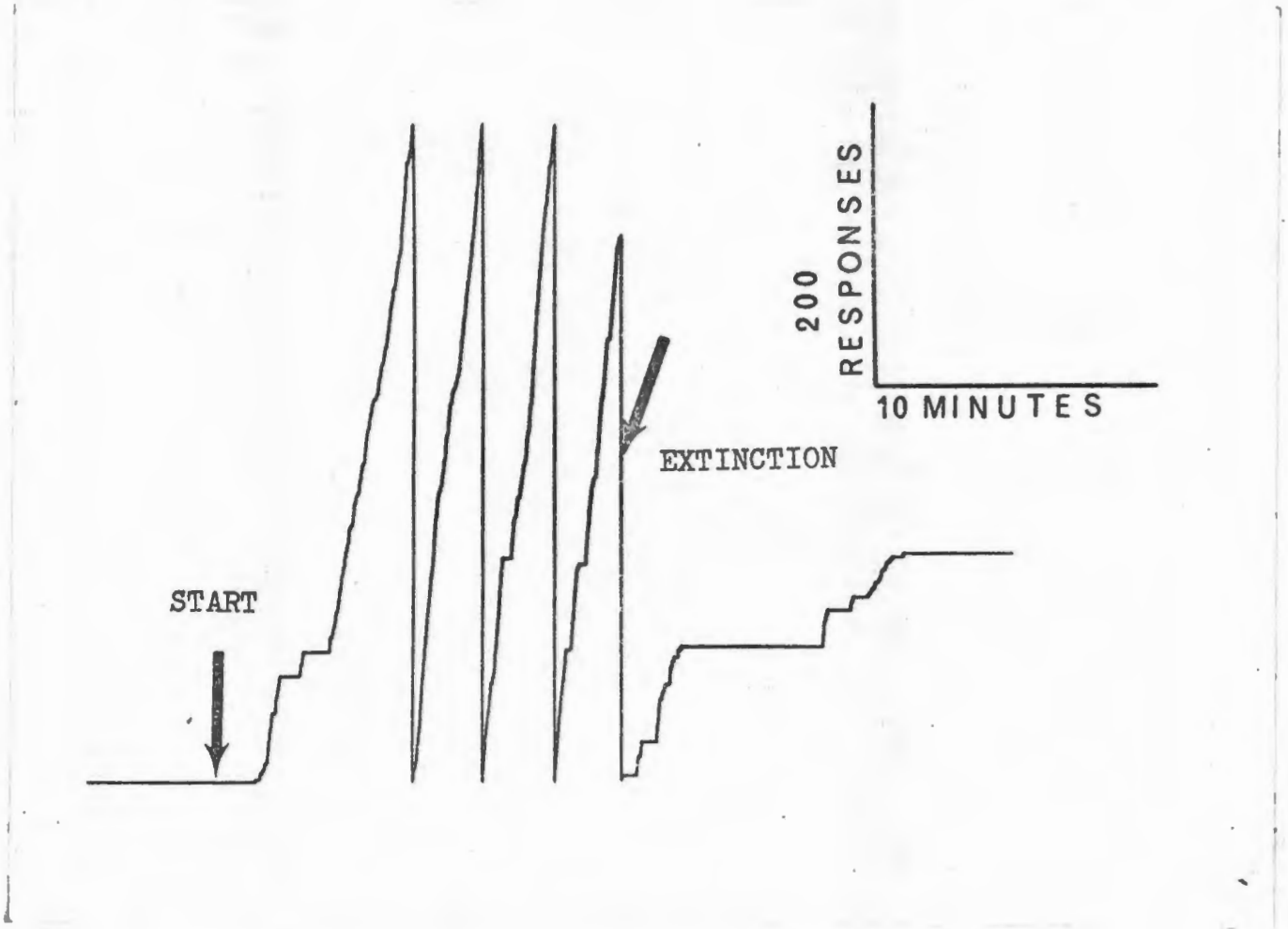

Figure 3. Acquisition to licking for water in a naive rat.

introduced. Each lick during this programmed stimulus segment also provided 4.35 ul of fluid.

(d) Rats were shaped to press the right lever on a FI-60 second schedule for 45 mg. Noyes Pellets by the method of successive approximations.

Recording - Responding during each session was recorded on a Harvard Cumulative Recorder (Gerbrands Model C-3). A typical cumulative record of the components of the session is given in Figure 4. During the self-produced stimulus segment (20 seconds of cue-light following five responses on the left lever), the fifth left lever press was recorded as a downward deflection of the stepper pen which remained deflected for the 20 second duration. A left lever press during the 20 second period was inconsequential and recorded as an upward deflection of the stepper pen. Licking during the self-produced stimulus segment activated the stepper. Licking which occurred between any of the five consecutive self-produced stimulus segments was non-discriminated and non-consequential but also activated the stepper pen. Discriminated licking is distinguished from non-discriminated licking on the cumulative record in that the stepper pen is not deflected downward before the non-discriminated licks. To differentiate the self-produced stimulus segments from the programmed stimulus segments on the cumulative record, the stepper was programmed to reset at the end of the fifth consecutive 20 second self-produced stimulus segment. Licking during the 130 second programmed stimulus segments also activated the stepper. Left lever presses during programmed stimulus were inconsequential and recorded as a downward deflection of

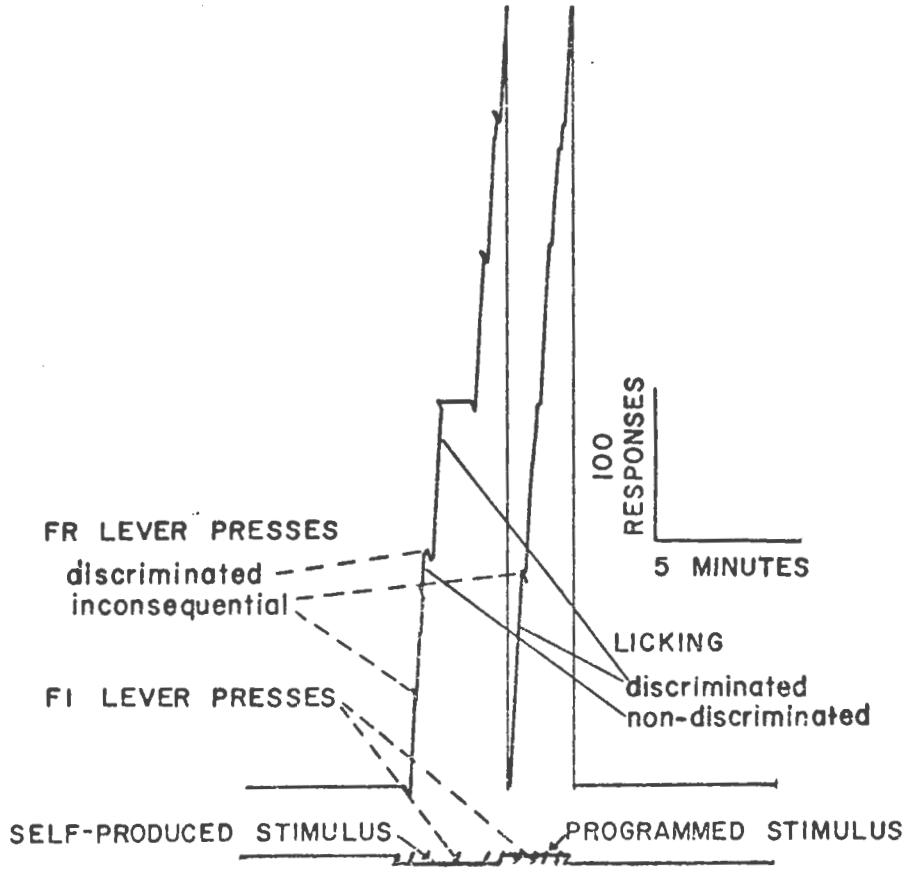

Figure 4. Typical cumulative record with labeled components.

the stepper pen. To further differentiate between the two stimulus segments on the cumulative record, the event pen was in the downward position for the five consecutive self-produced stimulus segments and in the upward position for the programmed stimulus segment. All right lever presses (as no attempt was made to distinguish between consequential and inconsequential right lever presses on the cumulative record) were recorded as deflections of the event pen, upward during self-produced, and downward during programmed stimulus segments.

In addition to the cumulative records, all responses (discriminated and nondiscriminated) were recorded on digital counters. The cumulative duration of each stimulus segment, self-produced and programmed, was recorded on elapsed time meters. All recording equipment with the exception of the cumulative recorders was programmed to record for only the specified length of the session to insure quantitative recording of the data. The cumulative records were measured (30 minutes/6 inches) from the start of the session to give the exact cumulative record corresponding to the session.

Calculation of Response Rate - All data necessary for calculation of response rate (responses/minute) was obtained from digital counters and elapsed time meters. The cumulative records were used to illustrate the pattern of responding during the sessions. Each session, unless otherwise specified, was of 30 minutes duration. The cumulative durations of each stimulus segment were obtained from the elapsed time meters. The cumulative total of each response which occurred under the respective stimulus segment was obtained from digital counters. The rate (responses/

minute) of each response, discriminated or nondiscriminated, was determined by dividing the total number of each response by the appropriate cumulative value (minutes) corresponding to that portion of the session in which the response was made.

Statistical Methods - A univariate factorial analysis of variance was performed on the data to test for significance in main effects as treatment (drugs), dose or concentration, stimulus segment, rat and in their interactions. A fortran computer program (MANOVA) supplied by the Biometric Laboratory, University of Miami was used for the analyses. All statistical analyses were performed on an I.B.M. CDC 6600 computor located at the research computing center at Indiana University, Bloomington, Indiana.

The students "t" test was also used to test for differences between control and experimental groups (Dixon and Massey, 1969). The level of significance was determined by comparison of "t" values with values from standard tables.

Design

Predrug Session - The first of the two daily sessions was designated as predrug session. It served two purposes: first, to determine if the rats were behaviorally fit for the session and, secondly, it served as a control for the drug session which followed 4-6 hours later.

Drug Session - The second daily session, following the predrug session was designated as the drug session. An appropriate drug solution was substituted for water for the rats to ingest during this session, or

the drugs were injected intraperitoneally before the session and water was made available for licking in the training cage. The drug session was not run on the day a subject did not perform favorably during the predrug session.

Drug Studies - For each drug, a dose-response was determined with usually six replicate sessions per dose for each rat. Three rats were usually used in each study. The experiments performed are listed according to the drug involved.

Amphetamine - The effect of amphetamine were studied according to the experiments as follows:

Amphetamine Licking - Two Operant Schedules

Three rats, Z-29, Z-30, Z-33, were trained on two operant schedules - licking and left lever pressing for secondary reinforcement. The right lever was present but not programmed to deliver food pellets. These rats were initially trained to lick for water then log concentrations of amphetamine (0.50, 0.99, 1.98 mM) were randomly substituted for water in the second daily sessions. Each of the concentrations was presented until approximately six replicates at each concentration were obtained.

Effect of Chronic Amphetamine Injection on Amphetamine Licking

The same three rats (Z-29, Z-30, Z-33) as used in the amphetamine licking under two operant schedules, were injected daily for 40 days with a 5 mg/kg dose of amphetamine intraperitoneally four hours after the second daily session. The following log concentrations of

amphetamine (0.125, 0.25, 0.50 mM) were randomly substituted for water in the second daily sessions during this time. Each of the concentrations was presented until approximately six replicates at each concentration were obtained. At the end of this series, hexobarbital (130 mg/kg I.P.) sleeping time determinations were carried out in these rats as well as in two other groups of non-trained rats which received either daily saline or amphetamine (5 mg/kg I.P.) injections for about 40 days also.

Effect of Chlorpromazine Pretreatment on Amphetamine Licking

The effect of chlorpromazine pretreatment (0.5 mg/kg injected I.P. 30 minutes before the amphetamine session) on licking rate for amphetamine solution was determined. For rats Z-29, Z-30 and Z-33, the solution of amphetamine was 0.5 mM while for rats Z-50, Z-51 and Z-52, the solution of amphetamine used was 1.0 mM.

Amphetamine Licking - Three Operant Schedules

Three rats Z-34, Z-35, and Z-37 were trained on two operant schedules - licking and left lever pressing for secondary reinforcement. In addition, they were also trained to press the right lever to obtain 45 mg Noyes Food Pellets on a FI-60 second schedule. The rats were initially trained to lick for water then amphetamine solutions (0.0625, 0.125, 0.25, 0.50 mM) were randomly substituted for water in the second daily sessions. Each of the concentrations was presented until approximately six replicates at each concentration were obtained.

Effect of Amphetamine Injection on Water Self-Administration

Three rats, Z-19, Z-20, Z-22 were trained on two operant schedules-licking and left lever pressing for secondary reinforcement. The right lever was present but not programmed to deliver food pellets. These rats were trained to lick for water. Once trained, the rats were injected with either normal saline (1 ml/kg,ip) or log doses of amphetamine (0.25, 0.50, 1.0, 2.0 mg/kg,ip) given randomly. The injections were given 30 minutes before the second daily session until approximately six replicates at each dose were obtained.

Ethanol - The effects of ethanol were studied in thirteen rats. They were divided into four experiments as follows:

Ethanol Licking - Two Operant Schedules

Four rats, Z-25, Z-26, Z-27, Z-28 were trained on two operant schedules - licking and left lever pressing for secondary reinforcement. The right lever was present but not programmed to deliver food pellets. These rats were initially trained to lick for water, then log concentrations (10, 20, 40, 80% v/v) of ethanol were randomly substituted for water in the second daily sessions. Each of the concentrations were presented until approximately six replicates at each concentrations were obtained.

Ethanol Licking - Three Operant Schedules

Three rats, Z-41, Z-42, Z-43 were trained on three operant schedules. In addition to licking and left lever pressing for secondary reinforcement, the right lever was also programmed on a FI-60 second schedule to deliver Noyes 45 mg. food pellets. These rats were also

initially trained to lick for water, then log concentrations (5, 10, 20, 40, 80% v/v) of ethanol were randomly substituted for water in the second daily sessions. Each of the concentrations was presented until approximately six replicates at each concentration were obtained.

Disulfiram Effects on Ethanol Ingestion

Three rats, Z-59, Z-60, Z-61 were trained on three operant schedules. Once trained with water for licking, a solution of ethanol (20% v/v) was substituted for water in the second daily session. The water session was kept at 30 minutes but the ethanol session was increased to 60 minutes. The rats were run for five days on ethanol before the start of the disulfiram treatment. A suspension of disulfiram, prepared by homogenizing the powder in 5% carboxymethylcellulose with a drop of tween added, was injected (50 mg/kg) intraperitoneally 60 minutes before the ethanol session. Disulfiram was injected for six consecutive days and its effect on ethanol ingestion measured. The rats were then run on ethanol for three more additional days immediately after the disulfiram treatment.

Effects of Oral Ethanol Injections

Three rats, Z-53, Z-54, Z-55 were trained on three operant schedules. A solution of ethanol (20% v/v) was given each rat ad lib in the home cages for about 30 days. During this period a solution of ethanol (40% v/v) was substituted for water for licking in most of the ethanol sessions. In addition, a solution of ethanol (50% v/v) in a dose of 12 ml/kg was injected orally 15 minutes

before drug sessions. Four injections were made when ethanol was available for licking and six injections were made when water was available for licking.

Morphine - Rats were injected with morphine according to the method of Wikler et al, (1960). An initial dose of 10 mg/kg, I.P. was given twice daily and increased by 10 mg increments every third day until a total daily dose of 200 mg/kg was reached. At this time, a single daily dose of 200 mg/kg was administered.

During the morphine dosage schedule, these rats were also trained on the multiple-operant schedule so when they reached a dose of 200 mg/kg, the experiments were also ready to proceed. Four rats were selected, two (Z-44 and Z-45) were trained on two-operant schedules (no food pellets available) and two (Z-47 and Z-49) were trained on three-operant schedules (food pellets available).

Morphine injections were made daily, four hours prior to the first session. The second session was run about four hours after the first session.

Effect of Withholding Morphine Injection on Amphetamine and Ethanol Ingestion

Amphetamine Ingestion - A solution of amphetamine 0.5 mM was substituted for water in the second session only on the last day of morphine injection. Responding in the behavioral box was measured for the next four consecutive days also (when no morphine injections were made) and then the rats were given morphine injections for at least one day before the procedure was repeated. This procedure

was repeated for a total of five replicates for rats Z-44 and Z-45 and three replicates for rats Z-47 and Z-49.

Ethanol Ingestion - A solution of ethanol (80% v/v) was substituted for water in the second session on the last day of morphine injection for rats Z-47 and Z-49. Three, five day replicates were made in the same way as for amphetamine ingestion.

Effect of Nalorphine Injection on Water Ingestion

The effect of Nalorphine 4 mg/kg, I.P., injected 60 minutes before the second session, was determined in rats receiving daily morphine injections. Water was available for licking in both sessions. The Nalorphine injection was replicated about six times in both groups of rats Z-44, Z-45 and Z-47, Z-49.

IV. RESULTS

PREDRUG SESSIONS

As previously indicated in the experimental section, rats were run on predrug sessions to determine whether there was any carry-over effect of previous treatment. The decision to run a rat on any given day was based on responding throughout the 30 minute session of at least 75 percent of normal.

The data of predrug sessions is presented in appendices in the same sequence data of drug sessions is presented in the results section. This predrug data has been analyzed by Factorial Analysis of Variance (ANOVA) in the same way as data from drug sessions. Wherever a statistically significant effect occurred between predrug sessions of corresponding drug sessions, further analysis of the data was made by use of Duncans Multiple Range Test (DMRT). The statistical significance is seen not to occur between groups of sessions corresponding to doses or concentrations in any ordered manner (successively increasing or decreasing) but rather in a random manner indicative of variability in day-to-day responding of the rats.

AMPHETAMINE

Amphetamine Licking - Two Operant Schedules

Consequential Licking

The effect of ingesting amphetamine solutions of increasing concentrations is presented for Rat Z-19 in Figure 5. The cumulative records on the left side are of predrug sessions when water was

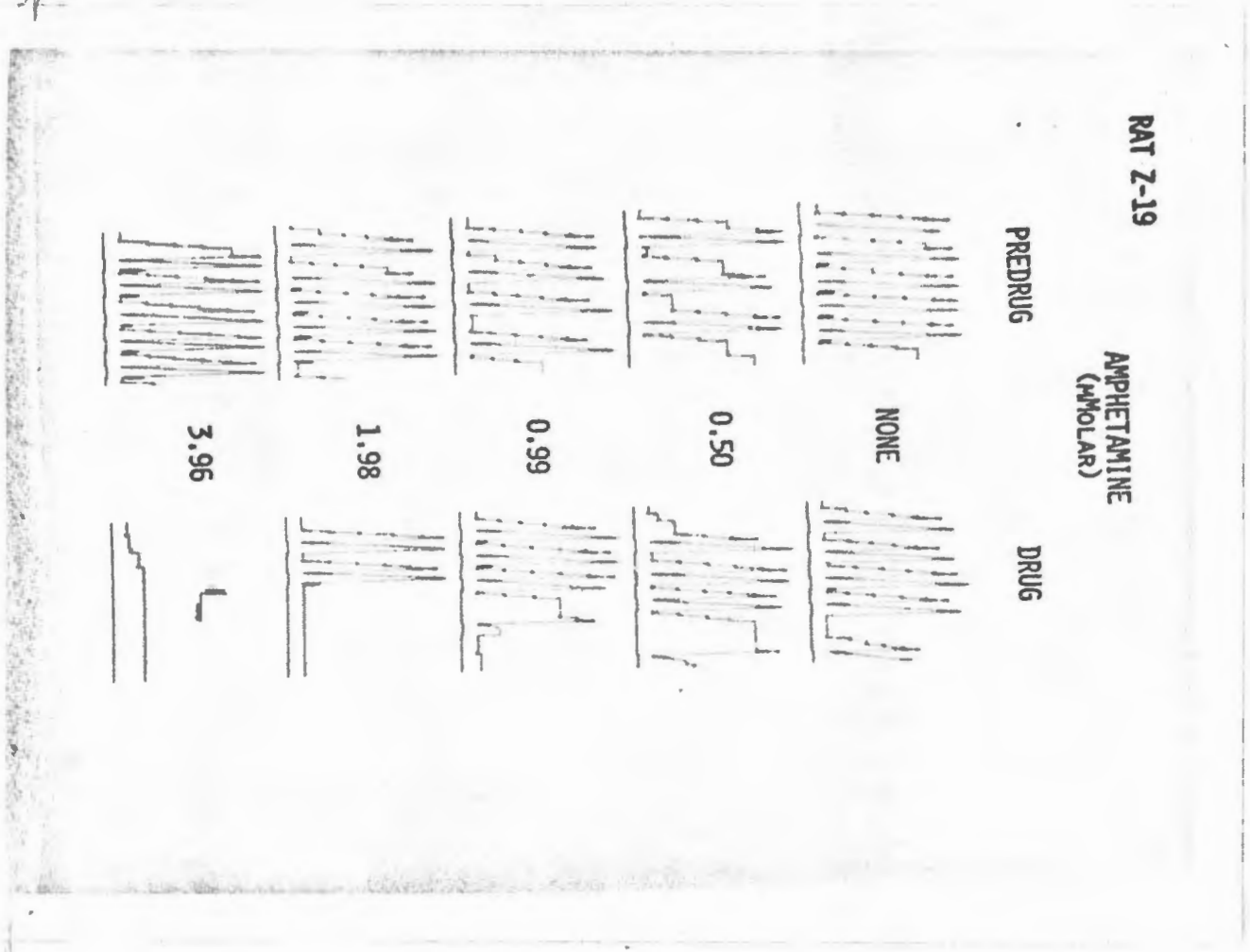

Figure 5. Effect of self-ingestion of amphetamine on licking rate and lever pressing in Rat Z-19. Daily predrug (water) sessions are on left with corresponding amphetamine sessions on the right. Complete explanation of the cumulative records is presented in Figure 4.

available for licking. The rates of licking were relatively high for all the session. On the right side are the corresponding drug sessions where solutions of increasing concentrations of amphetamine were substituted for water. The licking rate as well as percent of time spent in licking decreased as the concentration of amphetamine increased to where it was almost totally abolished at the highest concentration.

The effect of increasing concentrations of amphetamine solutions on consequential licking rate in Rats Z-29, Z-30 and Z-33 is presented graphically in Figure 6. These data have been presented and analyzed in Table 2. The substitution of increasing concentrations of amphetamine for water produced a statistically significant effect ($P < 0.001$). Further analysis by DMRT showed the effect to be concentration dependent with increasing concentrations producing progressive decreases significantly different ($P < 0.05$) from water and with only the 1.98 and 0.99mM concentrations not statistically different ($P > 0.05$) from each other under both simulus conditions. According to ANOVA, the rats did not differ significantly ($P < 0.05$) among themselves; there was no significant effect ($P > 0.05$) due to stimulus condition and none of the possible interactions showed significant relationships ($P > 0.05$).

As can be seen from Figure 5, the time spent in licking decreased as increasing concentrations of amphetamine solutions were substituted for water for Rat Z-19. According to ANOVA, time spent in licking was significantly affected ($P < 0.001$) due to substitution of amphetamine solutions for water in Rats Z-29, Z-30 and Z-33. The data and analyses are presented in Table 3. Further analysis of

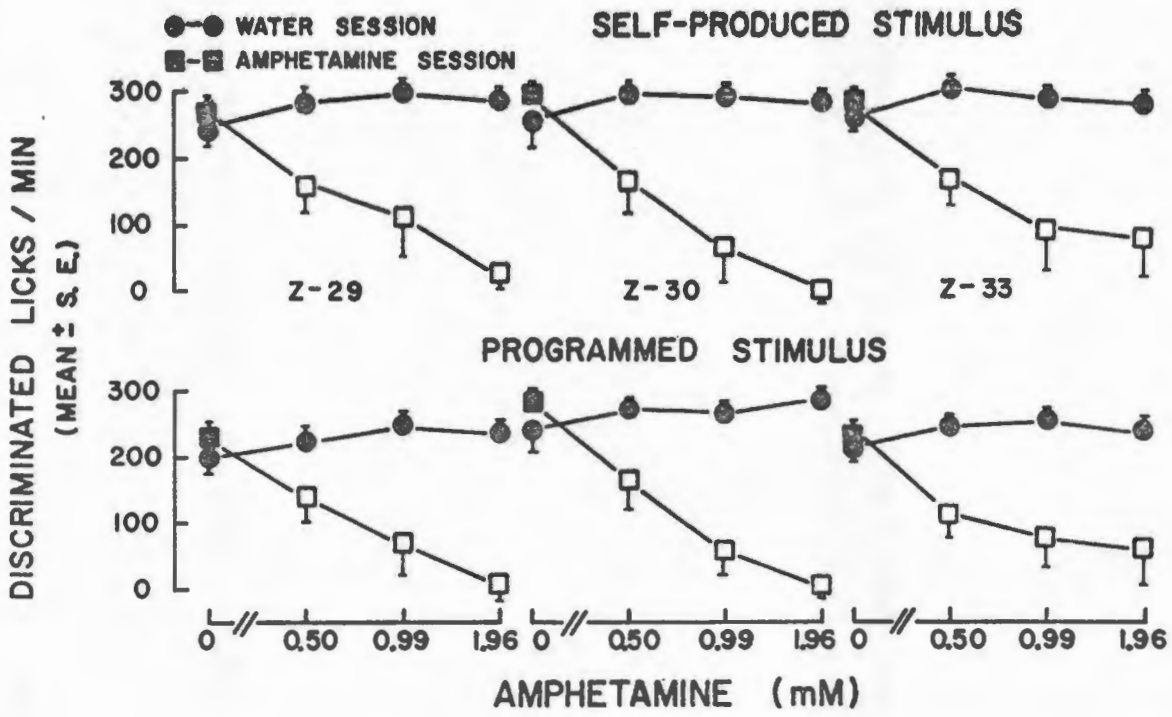

Figure 6. Effect of amphetamine self-ingestion on consequential licking rate under self-produced and programmed stimulus in Rats Z-29, Z-30, Z-33. Clear squares represent significant differences ($P < 0.05$) between amphetamine sessions and corresponding predrug sessions (circles).

TABLE 2

EFFECT OF AMPHETAMINE SELF-INGESTION ON CONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN NORMAL RATS Z-29, 30, 33.

CONC(mM)		Z-29 N	Z-29 SPS	Z-29 PS	Z-30 N	Z-30 SPS	Z-30 PS	Z-33 N	Z-33 SPS	Z-33 PS
0.0	$\bar{X}$	8	263.75	211.75	7	295.14	284.43	5	279.00	239.00
	SE		10.93	9.78		10.94	17.76		13.07	12.15
0.50	$\bar{X}$	6	159.67	137.67	6	170.17	162.83	7	169.29	112.43
	SE		39.43	30.57		48.57	43.93		41.15	28.16
0.99	$\bar{X}$	5	114.08	68.60	6	66.20	57.33	5	93.90	75.69
	SE		63.58	42.06		46.47	40.18		60.17	42.90
1.98	$\bar{X}$	6	23.72	5.90	5	6.40	4.20	5	83.00	64.00
	SE		8.65	5.82		2.84	3.23		59.30	59.13

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	368720.43	52.62***
STIMULUS SEGMENT	(S)	1	24090.65	3.44
RAT	(R)	2	1055.82	0.15
C X S		3	792.18	0.11
C X R		6	8449.72	1.20
S X R		2	3074.61	0.44
C X S X R		6	605.39	0.09
ERROR		118	7010.40	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 2 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	1.98	0.99	0.50	0.00	1.98	0.99	0.50	0.00
MEANS	37	90	167	279	24	67	136	244

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 3

EFFECT OF AMPHETAMINE SELF-INGESTION ON TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN NORMAL RATS Z-29, 30, 33.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	8	7.67	9.34	7	8.67	10.32	5	8.33	9.74
	SE		0.71	0.79		0.44	0.62		0.65	0.87
0.50	$\bar{X}$	6	4.84	5.79	6	5.06	6.51	7	4.81	6.11
	SE		0.81	1.21		0.73	1.48		0.99	1.21
0.99	$\bar{X}$	5	4.40	5.64	6	2.84	3.98	5	2.73	3.04
	SE		1.09	1.11		0.98	1.53		0.46	0.53
1.98	$\bar{X}$	6	2.50	3.62	5	1.53	2.60	5	1.67	1.30
	SE		0.68	1.07		0.54	0.81		0.38	0.53

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	301.41	59.92***
STIMULUS SEGMENT (S)	1	45.48	9.04**
RAT	2	11.23	2.23
C X S	3	1.46	0.29
C X R	6	6.34	1.26
S X R	2	1.37	0.27
C X S X R	6	0.51	0.10
ERROR	118	5.03	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 3 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	1.98	0.99	0.50	0.00	1.98	0.99	0.50	0.00
MEANS	1.94	3.29	4.90	8.18	2.59	4.20	6.14	9.78

Any two means not underscored by the same line are significantly different at $P < 0.05$.

this effect by DMRT showed, as with consequential licking rates, there was a significant effect ($P < 0.05$) with increasing concentrations of amphetamine producing progressive decreases significantly different from water as well as between each increasing concentration with the only exception of the 1.98 and 0.99 mM concentrations under programmed stimulus not being statistically different ($P > 0.05$) from each other. There was a statistically significant difference ($P < 0.01$) between the two stimulus segments in minutes spent in licking and it can be seen from the data of Table 3 that more time was spent under programmed stimulus than under self-produced stimulus. The rats did not differ significantly ($P > 0.05$) among themselves in amount of time spent in licking nor were any of the possible interactions significant ($P > 0.05$).

According to ANOVA, the number of reinforcements (drops of fluid) delivered showed a statistically significant effect ($P < 0.001$) when increasing concentrations of amphetamine solutions were substituted for water. The data and analyses are present in Table 4. Further analysis by DMRT showed the effect to be concentration dependent with increasing concentrations producing progressive decreases significantly different ($P < 0.05$) from water and from each other with only the 1.98 and 0.99mM concentrations not statistically different ($P > 0.05$) from each other under both stimulus conditions. There was no significant difference ($P > 0.05$) between the two stimulus conditions nor among the rats. None of the possible interactions showed any significant ($P > 0.05$) relationships.

TABLE 4

DROPS OF FLUID DELIVERED DURING AMPHETAMINE SELF-INGESTION UNDER SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN NORMAL RATS Z-29, 30, 33.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	8	2025.75	2011.75	7	2567.86	2891.86	5	2355.00	2361.20
	SE		204.26	210.39		187.66	149.69		278.27	297.38
0.50	$\bar{X}$	6	877.00	969.00	6	957.00	1293.00	7	924.00	845.43
	SE		258.45	238.19		267.91	391.27		344.61	356.78
0.99	$\bar{X}$	5	472.80	446.80	6	404.67	479.33	5	283.80	265.40
	SE		288.01	274.40		309.52	348.16		204.44	189.83
1.98	$\bar{X}$	6	49.33	12.83	5	23.00	18.00	5	164.20	138.80
	SE		20.05	12.44		9.80	14.37		103.73	128.90

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	37451363.45	102.58***
STIMULUS SEGMENT	(S)	1	122280.91	0.34
RAT	(R)	2	1042792.64	2.86
C X S		3	37431.30	0.10
C X R		6	450007.75	1.23
S X R		2	186650.62	0.51
C X S X R		6	30011.83	0.08
ERROR		118	365094.20	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 4 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	1.98	0.99	0.50	0.00	1.98	0.99	0.50	0.00
MEANS	77	388	920	2298	54	409	1026	2407

Any two means not underscored by the same line are significantly different at $P < 0.05$.

According to ANOVA, the milligrams of amphetamine sulfate ingested by the rats was significantly affected ($P < 0.05$) as increasing concentrations of amphetamine solutions were substituted for water. The data and analyses are presented in Table 5. Further analysis by DMRT showed the amphetamine ingested at the highest concentration (1.98mM) was significantly less ($P < 0.05$) than under either of the two lesser concentrations under both stimulus conditions. The amount of amphetamine ingested under the two lesser concentrations (0.99 and 0.50mM) was not significant ($P > 0.05$) between them. According to ANOVA, there was no significant difference ($P > 0.05$) between the two stimulus conditions nor among the rats. None of the possible interactions showed any significant relationships ($P > 0.05$).

Inconsequential Licking

According to ANOVA, the substitution of solutions of amphetamine for water resulted in a significant effect ($P < 0.05$) on inconsequential licking rate. The data and analyses are presented in Table 6. Further analysis by DMRT showed all concentrations produced a significant ($P < 0.05$) decrease when compared to water. Increasing concentrations of amphetamine solutions produced progressive decreases in inconsequential licking rates, but none were significantly different ($P > 0.05$) from each other. There was no significant difference ($P > 0.05$) among the rats nor in the interaction between concentrations and rats.

Consequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, the substitution of solutions of amphetamine for water resulted in a significant effect ($P < 0.001$) on consequential

TABLE 5

DOSE OF AMPHETAMINE (MG) DELIVERED DURING SELF-INGESTION UNDER SELF-PRODUCED (SPS) AND PROGRAMMED (SP) STIMULUS IN NORMAL RATS Z-29, 30, 33.

CONC(mM)		Z-29			Z-30			Z-33		
		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	-	-	-	-	-	-	-	-	-
	SE		-	-		-	-		-	-
0.50	$\bar{X}$	6	1.92	2.11	6	2.08	2.81	7	2.02	1.84
	SE		0.56	0.52		0.58	0.85		0.75	0.78
0.99	$\bar{X}$	5	2.06	1.94	6	1.76	2.16	5	1.23	1.16
	SE		1.25	1.19		1.33	1.52		0.89	0.83
1.98	$\bar{X}$	6	0.43	0.11	5	0.20	0.16	5	1.43	1.21
	SE		0.17	0.11		0.08	0.13		0.90	1.12

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	15.57	3.71*
STIMULUS SEGMENT	(S)	1	0.06	0.02
RAT	(R)	2	0.40	0.10
C X S		3	0.06	0.02
C X R		6	2.05	0.49
S X R		2	0.54	0.13
ERROR		84	4.20	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 5 CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.00	1.98	0.99	0.50	0.00	1.98	0.99	0.50
MEANS	-	0.67	1.69	2.00	-	0.47	1.78	2.23

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 6

EFFECT OF AMPHETAMINE SELF-INGESTION ON INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED STIMULUS (SPS) IN NORMAL RATS Z-29, 30, 33.

CONC(mM)		Z-29 N	Z-29 SPS	Z-30 N	Z-30 SPS	Z-33 N	Z-33 SPS
0.0	$\bar{X}$	8	12.38	7	17.00	5	16.40
	SE		2.53		5.08		5.46
0.50	$\bar{X}$	6	4.50	6	3.52	7	8.14
	SE		1.71		1.08		3.79
0.99	$\bar{X}$	5	2.00	6	2.64	5	1.16
	SE		0.71		1.47		0.57
1.98	$\bar{X}$	6	0.62	5	3.17	5	2.14
	SE		0.48		1.78		1.51

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	723.16	14.40***
RAT (R)	2	18.88	0.38
C X R	6	19.58	0.39
ERROR	59	50.20	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 6 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	1.98	0.99	0.50	0.00
MEANS	1.89	1.98	5.53	15.00

Any two means not underscored by the same line are significantly different at $P < 0.05$.

left lever rate for secondary reinforcement. The data and analyses are presented in Table 7. Further analysis of this effect showed all concentrations of amphetamine solutions produced a significant decrease ($P < 0.05$) when compared to water. The consequential left lever rate decreased progressively with increasing concentrations and analysis by DMRT showed the highest concentration (1.98mM) produced a significantly lower ($P < 0.05$) left lever rate than the lowest concentration (0.50mM) but the middle concentration (0.99mM) was not significantly different ($P > 0.05$) from either the lowest or highest concentrations. According to ANOVA, the rats did not differ significantly ($P > 0.05$) among themselves nor was the interaction between concentration and rats significant ($P > 0.05$). The effect of amphetamine on consequential left lever rate in rats Z-29, Z-30 and Z-33 is presented graphically in Figure 7 along with the effects on inconsequential left lever rate under self-produced stimulus.

Inconsequential Left Lever Pressing For Secondary Reinforcement

As can be seen from Figure 7, the substitution of solutions of amphetamine for water resulted in a marked increase in inconsequential left lever pressing for secondary reinforcement during self-produced stimulus conditions. Apparently due to large variability in the data, this effect was not statistically significant ($P > 0.05$) according to ANOVA. The data and analysis are presented in Table 8. There was a significant difference ($P < 0.05$) between the rates under the two stimulus conditions and the data clearly indicates the rates were higher under self-produced than programmed stimulus conditions. There was no significant difference ($P > 0.05$) among

TABLE 7

EFFECT OF AMPHETAMINE SELF-INGESTION ON CONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED STIMULUS (SPS) IN NORMAL RATS Z-29, 30, 33.

CONC(mM)		Z-29 N	Z-29 SPS	Z-30 N	Z-30 SPS	Z-33 N	Z-33 SPS
0.0	$\bar{X}$	8	9.17	7	12.37	5	11.58
	SE		1.44		1.61		2.06
0.50	$\bar{X}$	6	3.55	6	3.68	7	4.96
	SE		0.83		1.00		2.21
0.99	$\bar{X}$	5	2.95	6	3.19	5	1.54
	SE		0.69		1.91		0.27
1.98	$\bar{X}$	6	1.18	5	0.99	5	0.92
	SE		0.21		0.28		0.24

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	351.84	30.10***
RAT (R)	2	5.45	0.47
C X R	6	7.29	0.62
ERROR	59	11.69	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 7 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	1.98	0.99	0.50	0.00
MEANS	1.04	2.60	4.18	10.89

Any two means not underscored by the same line are significantly different at $P < 0.05$.

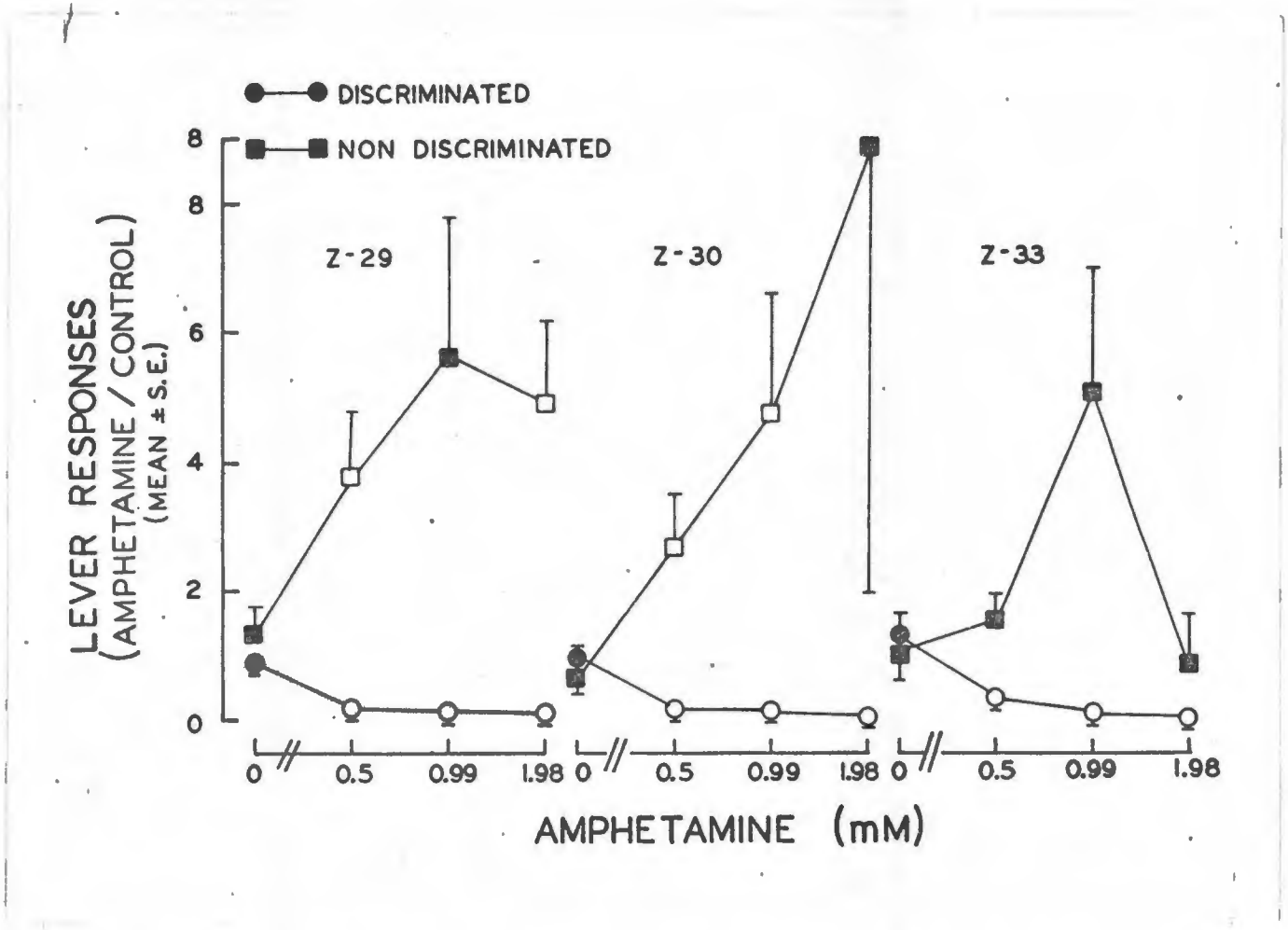

Figure 7. Effect of amphetamine self-ingestion on discriminated and non-discriminated left lever pressing rate (amphetamine/predrug) for secondary reinforcement during self-produced stimulus segments in Rats Z-29, Z-30, Z-33.

TABLE 8

EFFECT OF AMPHETAMINE SELF-INGESTION ON INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN NORMAL RATS Z-29, 30, 33.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	8	1.81	0.44	7	0.73	0.11	5	40.83	0.0
	SE		0.38	0.14		0.18	0.06		40.32	0.0
0.50	$\bar{X}$	6	6.93	0.06	6	4.78	2.18	7	1.83	0.36
	SE		1.58	0.06		1.86	1.80		0.24	0.15
0.99	$\bar{X}$	5	7.41	0.06	6	4.35	0.31	5	5.27	1.52
	SE		2.48	0.06		1.61	0.31		1.16	0.82
1.98	$\bar{X}$	6	10.70	1.26	5	3.97	2.07	5	1.06	0.0
	SE		2.40	0.73		2.03	2.07		0.71	0.0

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	88.33	0.31
STIMULUS SEGMENT	(S)	1	1350.64	4.77*
RAT	(R)	2	160.50	0.57
C X S		3	129.90	0.46
C X R		6	458.45	1.62
S X R		2	213.35	0.75
C X S X R		6	446.25	1.57
ERROR		118	284.94	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 8 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.50	1.98	0.99	0.00	0.00	0.99	0.50	1.98
MEANS	4.37	5.58	5.60	11.19	0.21	0.61	0.84	1.12

Any two means not underscored by the same line are significantly different at $P < 0.05$.

the rats nor did any of the possible interactions show significant relationships ($P > 0.05$).

Effect of Chronic Amphetamine Injection on Amphetamine Licking

The same three rats Z29, Z-30 and Z-33 as used in the previous experiment to determine the effects of amphetamine self-ingestion were used to determine the effects of a daily intraperitoneal injection of amphetamine (5mg/kg) given four hours after the daily amphetamine licking sessions. On days prior to the start of the experiment, these rats were also injected daily with 5mg/kg of amphetamine.

Consequential Licking

The effect of increasing concentrations of amphetamine solutions on consequential licking rate in these amphetamine treated rats is presented graphically in Figure 8. Increasing concentrations produced decreased licking rates, but the major difference between this experiment and the previous one was that concentrations required were considerably lower; 0.125, 0.25 and 0.50mM versus 0.50, 0.99 and 1.98mM of the previous experiment. A comparison of these results is presented graphically in Figure 9. According to ANOVA, the licking rates were significantly affected ($P < 0.001$) when increasing concentrations of amphetamine solutions were substituted for water. The data and analyses are presented in Table 9. Further analysis by DMRT showed that licking rates under all concentrations of amphetamine were significantly decreased ($P < 0.05$) when compared to water. Under self-produced stimulus, the licking rates were not significantly different ($P > 0.05$) under any of the amphetamine

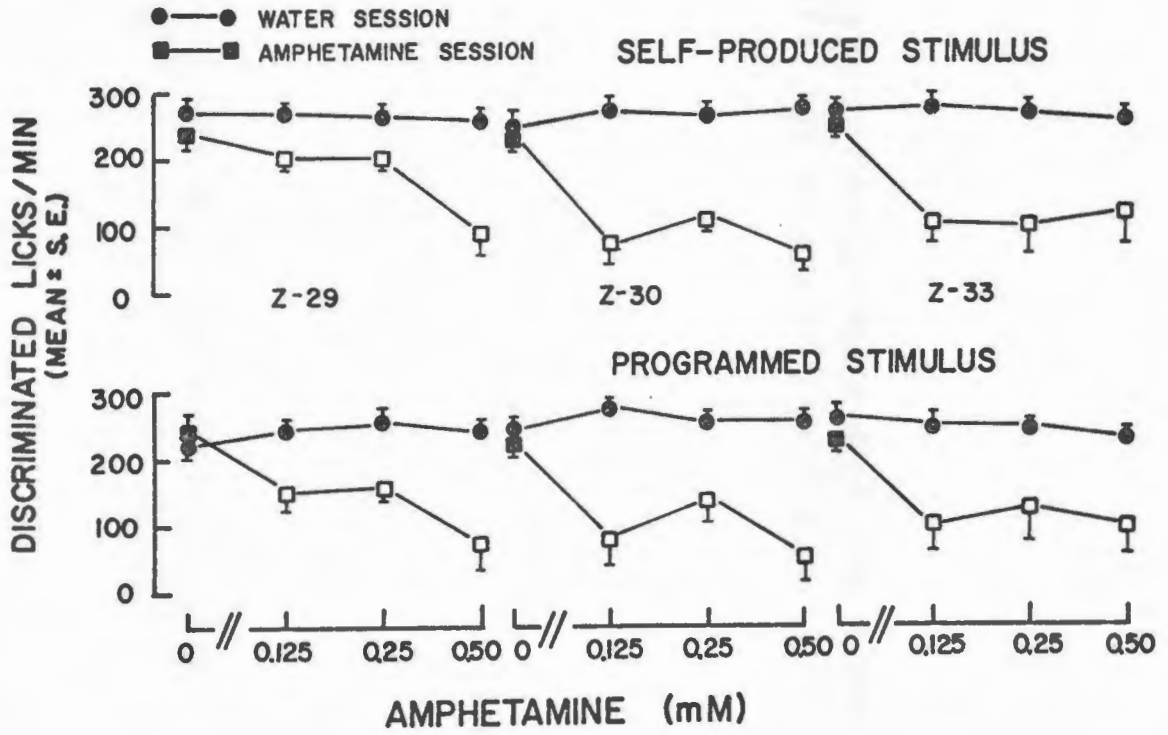

Figure 8. Effect of amphetamine self-ingestion on consequential licking rate under self-produced and programmed stimulus in rats Z-29, Z-30, Z-33 which were chronically injected with 5 mg/kg, i.p. of amphetamine, 4 hours after the amphetamine session. Clear squares represent significant difference ($P < 0.05$) between amphetamine and corresponding predrug sessions (circles).

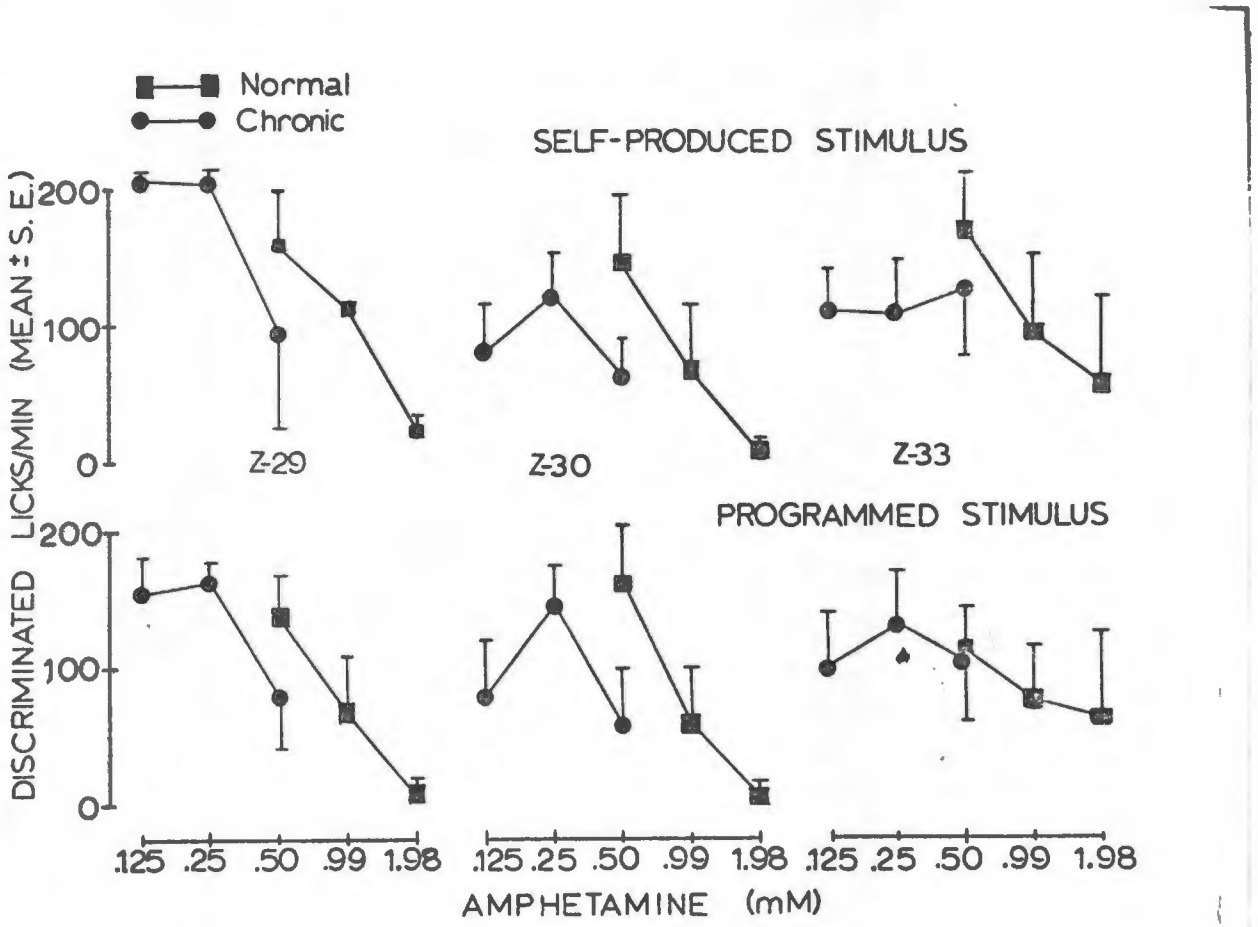

Figure 9. Effect of amphetamine self-ingestion on consequential licking rate under self-produced and programmed stimulus in Rats Z-29, Z-30, Z-33 when they were normal and after chronic injections of amphetamine.

TABLE 9

EFFECT OF AMPHETAMINE SELF-INGESTION ON CONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN CHRONICALLY INJECTED RATS Z-29,30,33.

		Z-29			Z-30			Z-33	
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	7	241.57	247.00	6	245.67	228.17	5	258.40	238.80
	SE		17.54	26.61		7.05	8.24		11.60	19.66
0.125	$\bar{X}$	7	206.29	153.43	7	79.00	80.29	7	109.86	100.38
	SE		7.86	24.93		37.56	38.70		30.29	38.78
0.25	$\bar{X}$	5	203.00	162.40	6	121.33	146.17	6	106.67	130.50
	SE		11.80	16.94		27.35	33.81		41.15	34.22
0.50	$\bar{X}$	7	95.29	77.14	6	60.50	58.67	6	125.33	104.67
	SE		45.28	40.39		28.84	37.11		48.08	42.69

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	163902.20	25.65***
STIMULUS SEGMENT	(S)	1	3904.87	0.61
RAT	(R)	2	29352.76	4.59*
C X S		3	995.92	0.16
C X R		6	10962.14	1.72
S X R		2	2499.10	0.39
C X S X R		6	1718.10	0.27
ERROR		126	6390.70	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 9 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.50	0.125	0.25	0.00	0.50	0.125	0.25	0.00
MEANS	94	132	140	248	80	111	145	238

Any two means not underscored by the same line are significantly different at P< 0.05.

concentrations while under programmed stimulus a significant difference ($P < 0.05$) occurred between the 0.125 and 0.25mM concentrations. According to ANOVA, there was no significant difference ($P > 0.05$) between the stimulus conditions and the rats differed significantly ($P < 0.05$) among themselves. None of the possible interactions showed any significant relationships ($P > 0.05$).

According to ANOVA, the substitution of increasing concentrations of amphetamine for water resulted in a significant effect ($P < 0.001$) on the amount of time spent in licking. The data and analyses are presented in Table 10. Further analysis of this effect by DMRT showed that the amount of time spent in licking under either stimulus condition was significantly reduced ($P < 0.05$) when compared to water. Under both stimulus conditions, the amount of time spent in licking at the 0.50mM concentration of amphetamine was significantly less ($P < 0.05$) than at the 0.25mM concentration. The 0.125mM concentration effect was not significantly different ($P > 0.05$) from the other two. According to ANOVA, there was a significant difference ($P < 0.05$) between the two stimulus conditions and data of Table 10 indicates more time was spent in licking under the programmed stimulus than the self-produced stimulus. The rats differed significantly ($P < 0.01$) among themselves and the interaction between concentration and rats showed a significant ($P < 0.01$) relationship. A graphical comparison of time spent in licking by these rats during the experiment prior to the one in which they received daily injections of amphetamine is presented in Figure 10. Although the concentrations used for licking were considerably lower, the amount of time spent in licking was also generally less when the rats were receiving

TABLE 10

EFFECT OF AMPHETAMINE SELF-INGESTION ON TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN CHRONICALLY INJECTED RATS Z-29,30,33.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	7	11.27	12.18	6	11.35	13.70	5	11.66	13.77
	SE		0.50	0.96		0.50	0.46		0.38	0.40
0.125	$\bar{X}$	7	6.23	7.44	7	3.80	4.25	7	3.17	3.41
	SE		0.90	0.93		1.46	1.89		0.90	1.41
0.25	$\bar{X}$	5	6.33	7.81	6	5.46	6.51	6	3.66	4.55
	SE		0.64	0.87		1.06	1.25		0.64	0.92
0.50	$\bar{X}$	7	3.52	3.41	6	1.44	1.81	6	3.89	5.06
	SE		1.14	1.49		0.77	1.18		0.96	1.33

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	580.88	79.13***
STIMULUS SEGMENT	(S)	1	34.48	4.70*
RAT	(R)	2	35.43	4.83**
C X S		3	3.05	0.42
C X R		6	26.30	3.58**
S X R		2	0.18	0.02
C X S X R		6	1.41	0.19
ERROR		126	7.34	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 10 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.50	0.125	0.25	0.00	0.50	0.125	0.25	0.00
MEANS	2.98	4.40	5.08	11.40	3.43	5.03	6.20	13.13

Any two means not underscored by the same line are significantly different at $P < 0.05$.

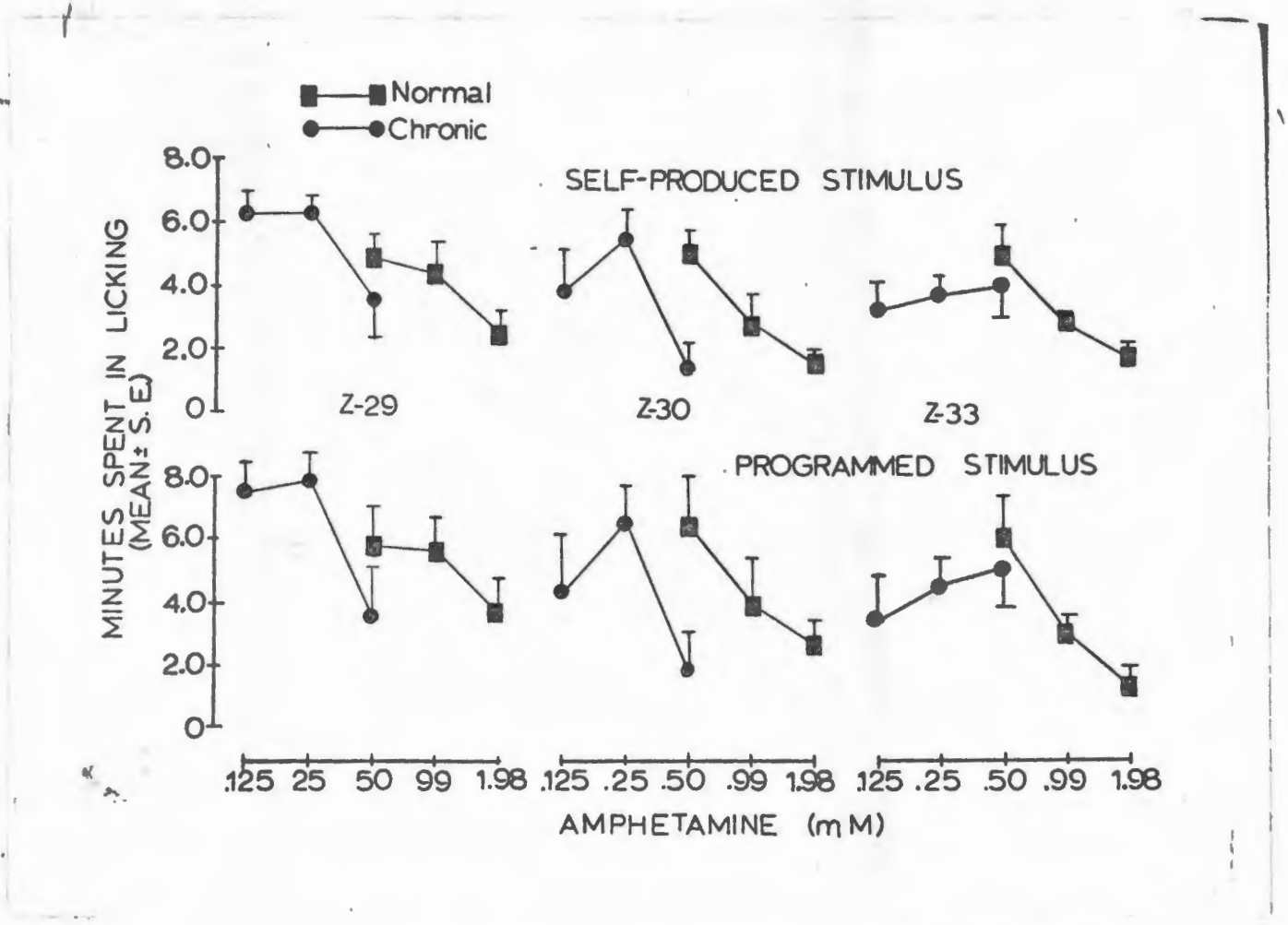

Figure 10. Effect of amphetamine self-ingestion on amount of time in minutes spent in consequential licking during 30 minute sessions under self-produced and programmed stimulus in Rats Z-29, Z-30, Z-33 when they were normal and after chronic injections of amphetamine.

daily injections of amphetamine.

According to ANOVA, the substitution of increasing concentrations of amphetamine for water resulted in a significant effect ($P < 0.05$) on the milligrams of amphetamine sulfate ingested by the rats. The data and analyses are presented in Table 11. Further analysis of this effect by DMRT showed progressively more amphetamine was ingested with successively increasing concentrations and the amount ingested at the lowest concentration (0.125mM) was statistically lower ($P < 0.05$) than at the highest concentration (0.50mM) under both stimulus conditions. The amount ingested at 0.25mM concentration was not statistically different ($P > 0.05$) from either the 0.125 or 0.50mM concentrations. According to ANOVA, there was no significant difference ($P > 0.05$) between the two stimulus conditions nor among the rats in amounts of amphetamine ingested. None of the possible interactions showed significant ($P > 0.05$) relationships. A graphical comparison between the amount of amphetamine injection experiments is presented in Figure 11. Here a clear distinction between decreasing amount of amphetamine ingested before, and increasing amount of amphetamine ingested during amphetamine injection can be seen.

Inconsequential Licking

According to ANOVA, the substitution of increasing concentrations of amphetamine for water resulted in a significant effect ($P < 0.001$) on inconsequential licking rates. The data and analyses are presented in Table 12. Further analysis of this effect by DMRT showed all concentrations of amphetamine produced a significant decrease ($P < 0.05$) in inconsequential licking rate when compared to water. Although each increasing concentration of amphetamine produced a progressive

TABLE 11

DOSE OF AMPHETAMINE (MG) DELIVERED DURING SELF-INGESTION UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN CHRONICALLY INJECTED RATS Z-29,30,33.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	-	-	-	-	-	-	-	-	-
	SE	-	-	-	-	-	-	-	-	-
0.125	$\bar{X}$	7	0.70	0.61	7	0.38	0.41	7	0.25	0.25
	SE		0.11	0.23		0.21	0.21		0.09	0.10
0.25	$\bar{X}$	5	1.43	1.36	6	0.86	1.16	6	0.55	0.72
	SE		0.22	0.16		0.26	0.33		0.28	0.29
0.50	$\bar{X}$	7	1.32	1.28	6	0.42	0.69	6	1.50	1.72
	SE		0.68	0.74		0.25	0.45		0.82	0.99

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	2	5.79	4.74*
STIMULUS SEGMENT	(S)	1	0.20	0.16
RAT	(R)	2	1.95	1.59
C X S		2	0.09	0.07
C X R		4	1.92	1.57
S X R		2	0.17	0.14
C X S X R		4	0.02	0.01
ERROR		96	1.22	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 11 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.00	0.125	0.25	0.50	0.00	0.125	0.25	0.50
MEANS	-	0.44	0.92	1.09	-	0.42	1.07	1.23

Any two means not underscored by the same line are significantly different at $P < 0.05$.

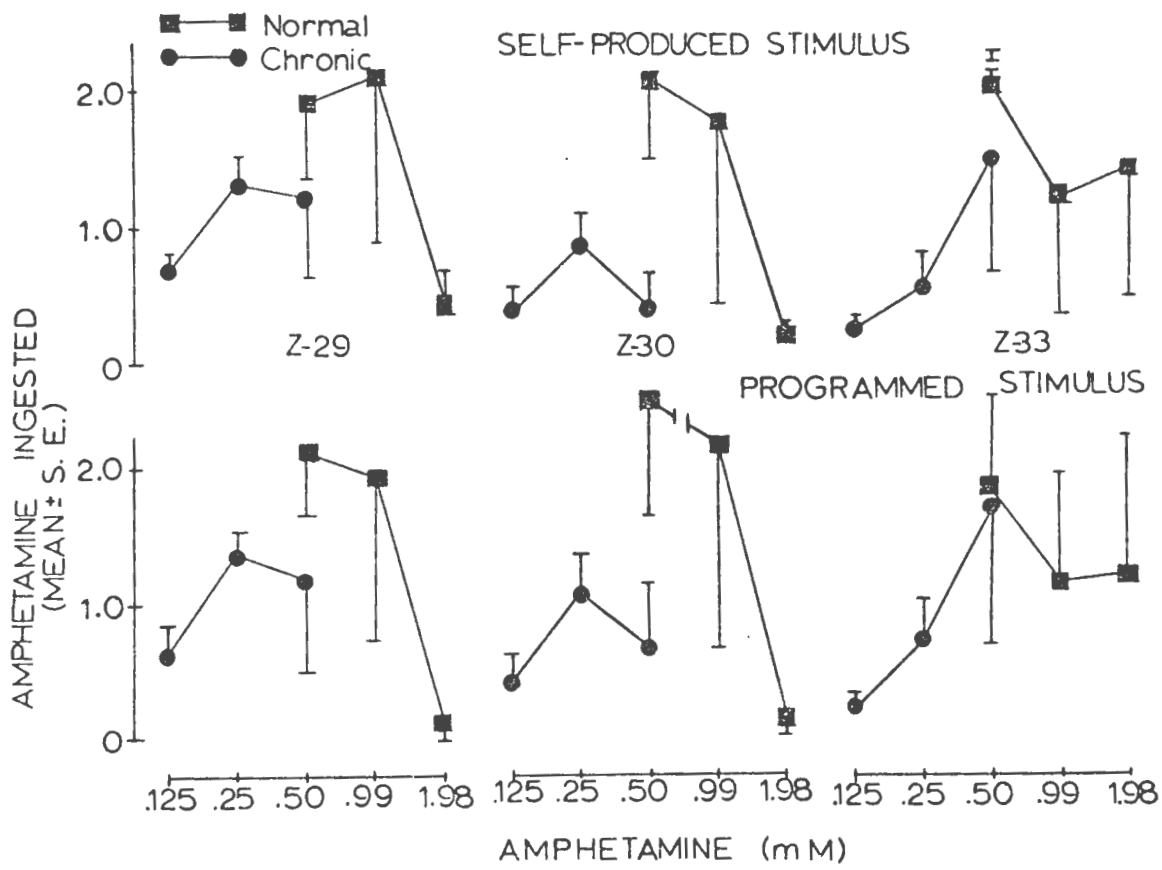

Figure 11. Effect of amphetamine self-ingestion on amount of amphetamine (mg) ingested during 30 minute sessions under self-produced and programmed stimulus in Rats Z-29, Z-30, Z-33 when they were normal and after chronic injestions of amphetamine.

TABLE 12

EFFECT OF AMPHETAMINE SELF-INGESTION ON INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED STIMULUS(SPS) IN CHRONICALLY INJECTED RATS Z-29, 30, 33.

		Z-29		Z-30		Z-33	
CONC(mM)		N	SPS	N	SPS	N	SPS
0.0	$\bar{X}$	7	31.60	6	21.87	5	41.00
	SE		10.26		5.72		10.43
0.125	$\bar{X}$	7	6.57	7	3.30	7	4.06
	SE		1.46		1.90		1.71
0.25	$\bar{X}$	5	5.60	6	3.33	6	4.17
	SE		0.93		1.50		1.66
0.50	$\bar{X}$	7	3.43	6	0.83	6	4.17
	SE		1.76		0.40		2.09

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	3348.98	25.21***
RAT	(R)	2	199.89	1.51
C X R		6	112.97	0.85
ERROR		63	132.85	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 12 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	0.50	0.25	0.125	0.00
MEANS	2.84	4.29	4.64	30.97

Any two means not underscored by the same line are significantly different at $P < 0.05$.

decrease in inconsequential licking rate, these effects were not statistically significant ($P > 0.05$) from each other. According to ANOVA, there was no significant difference ($P > 0.05$) among the rats nor in the interaction between concentration and rats.

Consequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, the substitution of increasing concentrations of amphetamine for water resulted in a significant effect ($P < 0.001$) on consequential left lever pressing for secondary reinforcement. The data and analyses are presented in Table 13. Further analysis of this effect by DMRT showed all concentrations of amphetamine produced a significant decrease ($P < 0.05$) in consequential left lever pressing when compared to water. None of the effects produced by the amphetamine concentrations were significantly different ($P > 0.05$) from each other. This effect is presented graphically for rats Z-29, Z-30 and Z-33 in Figure 12. According to ANOVA, there was no significant difference ($P \geq 0.05$) among the rats nor in the interaction between concentration and rats.

Inconsequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, the substitution of increasing concentrations of amphetamine for water had no significant effect ($P > 0.05$) on inconsequential left lever pressing for secondary reinforcement. The data and analysis are presented in Table 14. The inconsequential left lever rates under self-produced stimulus are presented graphically in Figure 12. The rates were significantly different ($P < 0.001$) under the two stimulus conditions and the data in Table 14 clearly shows the

TABLE 13

EFFECT OF AMPHETAMINE SELF-INGESTION ON CONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED STIMULUS(SPS) IN CHRONICALLY INJECTED RATS Z-29,30,33.

		Z-29		Z-30		Z-33	
CONC(mM)		N	SPS	N	SPS	N	SPS
0.0	$\bar{X}$	7	33.41	6	25.36	5	46.77
	SE		10.81		5.40		13.79
0.125	$\bar{X}$	7	6.19	7	4.13	7	2.46
	SE		1.26		2.41		0.97
0.25	$\bar{X}$	5	5.80	6	4.83	6	2.41
	SE		1.64		1.66		0.72
0.50	$\bar{X}$	7	2.97	6	1.01	6	3.50
	SE		1.33		0.57		1.70

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	4332.13	26.61***
RAT	(R)	2	111.91	0.68
C X R		6	187.68	1.15
ERROR		63	162.80	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 13 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	0.50	0.125	0.25	0.00
MEANS	2.52	4.26	4.27	34.44

Any two means not underscored by the same line are significantly different at P< 0.05.

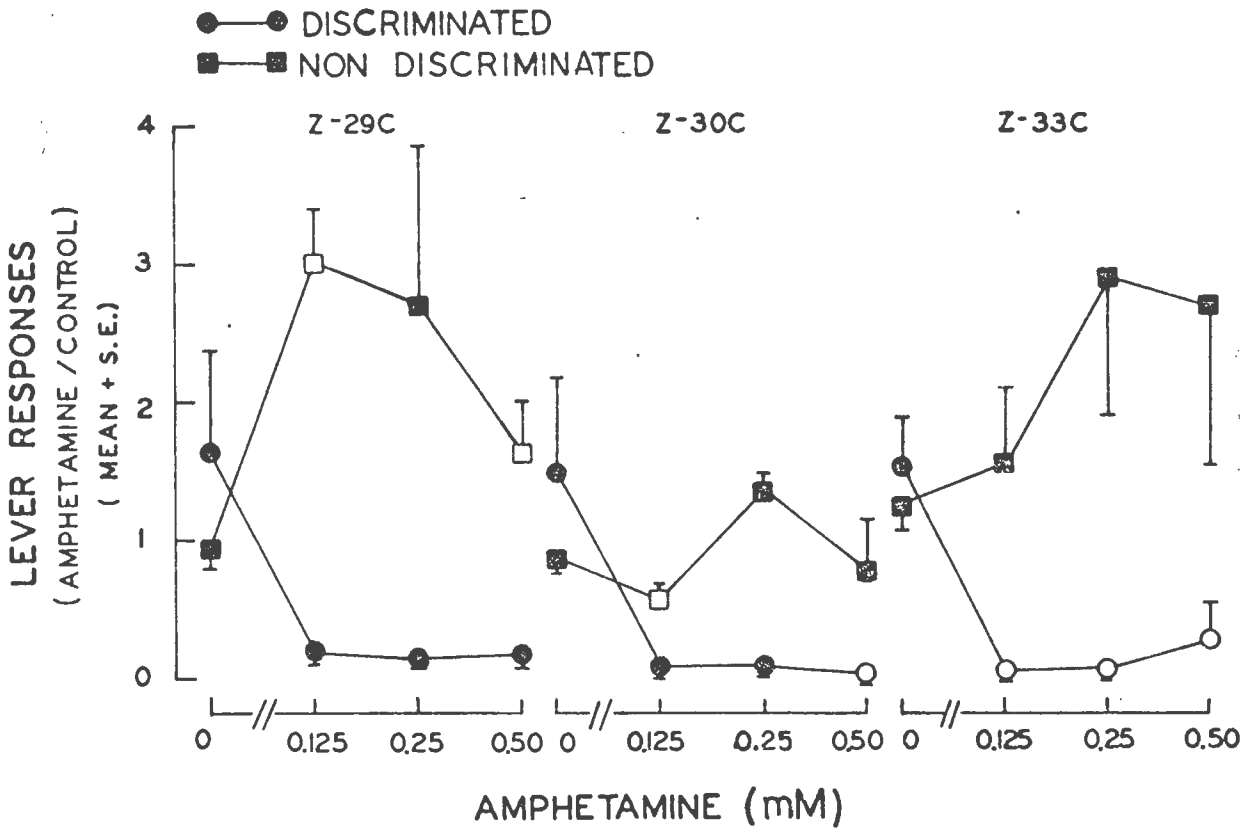

Figure 12. Effect of amphetamine self-ingestion on discriminated and non-discriminated left lever pressing rate (amphetamine/predrug) for secondary reinforcement during self-produced stimulus in Rats Z-29, Z-30, Z-33 which were chronically injected with 5 mg/kg, i.p. of amphetamine, 4 hours after the amphetamine sessions.

TABLE 14

EFFECT OF AMPHETAINE SELF-INGESTION ON INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN CHRONICALLY TREATED RATS Z-29,30,33.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.0	$\bar{X}$	7	2.60	0.17	6	3.94	0.11	5	1.50	0.00
	SE		0.26	0.11		0.21	0.04		0.09	0.00
0.125	$\bar{X}$	7	6.79	0.68	7	2.54	0.00	7	3.01	0.28
	SE		1.53	0.37		0.54	0.00		1.43	0.25
0.25	$\bar{X}$	5	4.87	1.15	6	4.42	0.17	6	5.14	0.34
	SE		1.05	0.18		0.69	0.15		1.55	0.22
0.50	$\bar{X}$	7	3.68	0.12	6	2.23	0.00	6	4.99	1.29
	SE		0.74	0.02		1.06	0.00		1.84	0.69

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	10.13	2.58
STIMULUS SEGMENT (S)	1	455.32	116.12***
RAT (R)	2	8.06	2.06
C X S	3	4.96	1.26
C X R	6	11.33	2.89**
S X R	2	2.67	0.68
C X S X R	6	5.84	1.49
ERROR	126	3.93	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 14 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.50	0.125	0.25	0.00	0.00	0.125	0.50	0.25
MEANS	0.07	0.10	0.15	0.48	0.10	0.32	0.41	0.52

Any two means not underscored by the same line are significantly different at $P < 0.05$.

rates were greater under self-produced stimulus. The rats did not differ significantly ($P > 0.05$) among themselves and the only interaction which shows a significant relationship ($P < 0.01$) was between concentration and rats.

Barbiturate Narcosis

In order to test whether any changes in metabolism or central nervous system sensitivity occurred as a result of injecting rats daily over about a 40 day period with amphetamine, two groups of nontrained rats were given a daily intraperitoneal injection of either normal saline or amphetamine (mg/kg). The results of barbiturate narcosis studies on these rats are presented in Table 15. After ten days of treatment, there was no significant difference ($P > 0.20$) between the two groups in duration narcosis induced by 120mg/kg, i.p. of hexobarbital. After 24 days of treatment, there was still no significant difference ($P > 0.30$) in duration of narcosis induced by 130mg/kg, i.p. of hexobarbital. After 30 days of treatment, the effect of combining a dose of amphetamine (5mg/kg, i.p.) with hexobarbital (130mg/kg, i.p.) was tested with no significant difference ($P > 0.10$) in duration of narcosis. After 40 days of treatment, the effect of barbital (200mg/kg, i.p.) was tested with no significant difference ($P > 0.30$) in duration of narcosis.

Effect of Chlorpromazine Pretreatment on Amphetamine Licking

Chlorpromazine, (0.5mg/kg, i.p.) injected 30 minutes before amphetamine licking sessions, produced a marked increase in licking rate for amphetamine solution (Table 16). In three rats, Z-29, Z-30 and Z-33 offered a 0.50mM solution of amphetamine. The increased licking rate was significant ($P < 0.05$) for rat Z-29 under self-produced

TABLE 15

EFFECT OF DAILY AMPHETAMINE INJECTION ON DURATION OF BARBITURATE NARCOSIS.

Days of Amphetamine Injection [a]	Narcosis, (Min) Mean ± S.E. (N) Saline Treated [b]	Amphetamine Treated [c]	P [d]
	Hexobarbital (120 mg/kg)		
10	15.80 ± 2.08(5)	19.40 ± 2.04 (5)	> 0.20
	Hexobarbital (130 mg/kg)		
24	30.00 ± 6.09(6)	23.00 ± 4.69 (4)	> 0.30
	Amphetamine (5mg/kg)[e] & Hexobarbital (130 mg/kg)		
30	49.40 ± 5.39(5)	39.83 ± 3.65 (6)	> 0.10
	Barbital (200 mg/kg)		
40	298 ± 53.5 (4)	222 ± 58.8 (4)	> 0.30

a Days of pretreatment prior to narcosis determination, last injection 24 hrs. before hexobarbital
b Saline, 1 ml/kg, i.p. daily
c Amphetamine, 5 mg/kg, i.p. daily
d Probability value based on students t test
e Immediately before hexobarbital

TABLE 16

EFFECT OF CHLORPROMAZINE PRETREATMENT ON SUBSEQUENT AMPHETAMINE SELF-INGESTION.

Stimulus Segment [a]	Licks / Minute (Mean ± S.E. (N) None	Chlorpromazine [b]	P [e]
	RAT Z-29 [c]		
SPS	1.63 ± 1.24 (7)	47.85 ± 19.69 (7)	<0.05
PS	0.0 0.0 (7)	43.41 ± 23.55 (7)	>0.05
	RAT Z-30 [c]		
SPS	2.76 ± 2.55 (6)	142.33 ± 32.28 (6)	>0.05
PS	5.48 ± 5.30 (6)	130.50 ± 40.77 (6)	>0.05
	RAT Z-33 [c]		
SPS	42.92 ±26.54 (7)	20.92 ± 9.40 (7)	>0.50
PS	42.57 ±23.90 (7)	66.28 ± 40.43 (7)	>0.50
	RAT Z-50 [d]		
SPS	34.17 ±11.61 (6)	110.43 ± 21.56 (6)	<0.05
PS	66.67 ±26.35 (6)	97.86 ± 97.86 (6)	>0.05
	RAT Z-51 [d]		
SPS	26.80 ±16.44 (5)	144.82 ± 58.53 (5)	>0.05
PS	14.40 ±11.18 (5)	203.00 ± 84.86 (5)	>0.05
	RAT Z-52 [d]		
SPS	12.67 ± 6.33 (6)	57.33 ± 31.33 (6)	>0.05
PS	7.67 ± 5.07 (6)	52.67 ± 25.17 (6)	>0.05

a SPS Self-produced stimulus; PS programmed stimulus segment.
b Chlorpromazine, 1/2 mg/kg, injected 30 min. before amphetamine session.
c Ingested 0.5 mM amphetamine solution.
d Ingested 1.0 mM amphetamine solution.
e Probability value based on student's t test.

stimulus and for rat Z-30 under both stimulus conditions. In another three rats, Z-50, Z-51 and Z-52 offered a 1.0mM solution of amphetamine, chlorpromazine produced a marked increase in licking rate for amphetamine but the effect was significant ($P < 0.05$) only for rat Z-50 under self-produced stimulus. In this experiment, only the effect of chlorpromazine on consequential licking rate was considered.

Amphetamine Licking - Three Operant Schedules

Consequential Licking

The effect of increasing concentrations of amphetamine solutions on consequential licking rate in rats Z-34, Z-35 and Z-37 is presented graphically in Figure 13. These data have also been presented and analyzed in Table 17. According to ANOVA, consequential licking rate was significantly affected ($P < 0.001$) due to substitution of amphetamine solutions for water. Further analysis of this effect by DMRT showed the effect to be concentration dependent with all increasing concentrations producing progressive decreases significantly different ($P < 0.05$) from water. Under self-produced stimulus, the 0.50mM concentration produced a decrease significantly different ($P < 0.05$) from all the lower concentrations. Under programmed stimulus, there was no significant difference ($P > 0.05$) between 0.50 and 0.25mM concentrations, but both resulted in significantly greater ($P < 0.05$) decreases than 0.125 and 0.0625mM concentrations. According to ANOVA, there was a significant difference ($P < 0.001$) between the two stimulus conditions and data of Table 17 shows clearly the consequential licking rates were consistently higher under self-produced as compared to programmed stimulus. There was also a

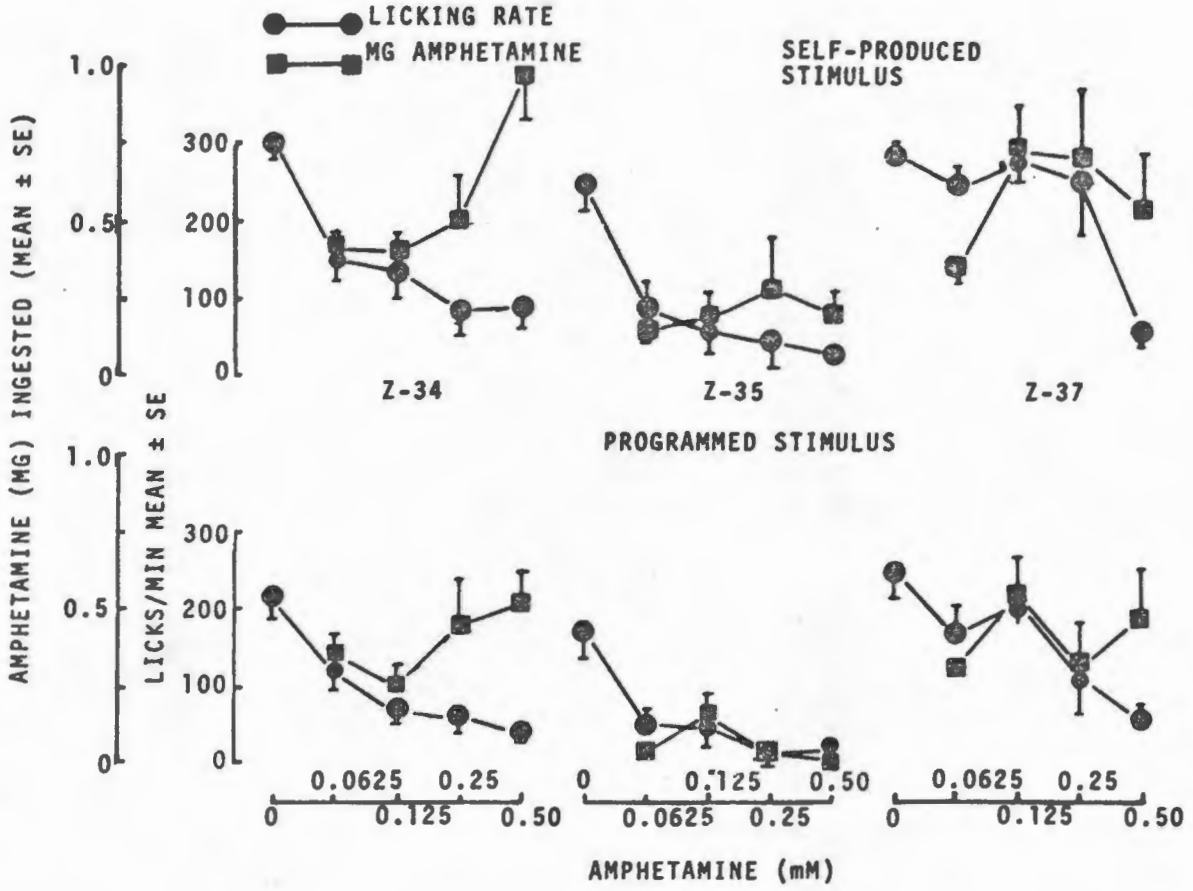

Figure 13. Effect of amphetamine self-ingestion on amount of amphetamine ingested during 30 minute sessions and on consequential licking rate under self-produced and programmed stimulus in Rats Z-34, Z-35, Z-37. Food pellets were concurrently available on FI-60" right lever pressing.

TABLE 17

EFFECT OF AMPHETAMINE SELF-INGESTION ON CONSEQUENTIAL LICKING RATS UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-34,35,37, WITH FOOD PELLETS AVAILABLE.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.00	$\bar{X}$	6	297.17	213.17	8	246.50	170.12	6	376.67	248.33
	SE		18.04	26.01		28.54	27.82		18.30	29.90
0.0625	$\bar{X}$	5	147.00	118.80	5	84.87	48.20	6	242.17	165.67
	SE		17.89	22.82		24.61	16.23		24.43	31.01
0.125	$\bar{X}$	9	137.67	67.44	9	56.56	47.93	8	277.88	207.88
	SE		30.34	13.55		23.16	23.04		24.43	23.41
0.25	$\bar{X}$	7	83.29	57.67	5	46.55	10.20	6	250.50	106.50
	SE		36.62	14.17		26.99	8.97		74.51	46.00
0.50	$\bar{X}$	12	90.25	39.08	15	29.84	12.75	13	57.23	53.74
	SE		25.55	8.79		8.35	6.10		16.39	13.56

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	306966.66	67.33***
STIMULUS SEGMENT	(S)	1	153809.38	33.74***
RAT	(R)	2	226732.32	49.73***
C X S		4	9339.24	2.05
C X R		8	23162.31	5.08***
S X R		2	7357.04	1.61
C X S X R		8	4807.40	1.05
ERROR		210	4559.17	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 17 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC (mM)	0.50	0.25	0.125	0.0625	0.00	0.50	0.25	0.125	0.0625	0.00
MEANS	57	129	153	163	301	34	61	104	114	207

Any two means not underscored by the same line are significantly different at $P < 0.05$.

significant difference ($P < 0.001$) between the rats and between the concentration and rat interaction ($P < 0.001$). None of the other possible interactions were significant ($P > 0.05$).

The milligrams of amphetamine sulfate ingested by these rats, as can be seen in Figure 13, tended to either increase, remain stable or decrease for rats Z-34, Z-35 and Z-37 respectively, with increasing concentrations of amphetamine solutions. The data and analyses are presented in Table 18. According to ANOVA, this was a significant effect ($P < 0.05$), but further analysis by DMRT showed the milligrams of amphetamine ingested were not significantly different ($P > 0.05$) from each other under the various amphetamine concentrations. According to ANOVA, there was no significant difference ($P > 0.05$) and there was a significant difference ($P < 0.001$) among the rats. None of the possible interactions showed any significant ($P > 0.05$) relationships.

According to ANOVA, the time spent in consequential licking was significantly affected ($P < 0.001$) by substitution of solutions of increasing concentrations of amphetamine for water. The data and analyses are presented in Table 19. Further analysis by DMRT showed there was a progressive decrease in time spent in licking. There was no significant difference ($P > 0.05$) between the lowest concentration (0.0625mM) and water, but all the other concentrations produced significant decreases ($P < 0.05$) when compared to water under both stimulus conditions. Under self-produced stimulus there was no significant difference ($P > 0.05$) between 0.50, 0.25 and 0.125mM concentrations, while under programmed stimulus there was a significant difference ($P < 0.05$) between 0.125 and 0.50mM but not between either

TABLE 18

MILLIGRAMS OF AMPHETAMINE DELIVERED DURING AMPHETAMINE INGESTION UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-34,35,37 WITH FOOD PELLETS AVAILABLE.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.00	$\bar{X}$	-	-	-	-	-	-	-	-	-
	SE	-	-	-	-	-	-	-	-	-
0.0625	$\bar{X}$	5	0.39	0.34	5	0.14	0.07	6	0.37	0.28
	SE		0.06	0.07		0.04	0.03		0.04	0.06
0.125	$\bar{X}$	9	0.41	0.24	9	0.16	0.13	8	0.70	0.54
	SE		0.05	0.05		0.07	0.07		0.15	0.12
0.25	$\bar{X}$	7	0.49	0.45	5	0.27	0.06	6	0.68	0.28
	SE		0.15	0.14		0.17	0.06		0.22	0.12
0.50	$\bar{X}$	12	0.97	0.52	15	0.21	0.07	13	0.56	0.44
	SE		0.17	0.11		0.08	0.03		0.18	0.14

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	0.34	2.55*
STIMULUS SEGMENT	(S)	1	1.44	10.89**
RAT	(R)	2	2.95	22.30***
C X S		4	0.07	0.51
C X R		8	0.20	1.50
S X R		2	0.08	0.64
ERROR		176	0.13	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 18 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.00	0.0625	0.125	0.25	0.50	0.00	0.0625	0.25	0.125	0.50
MEANS	-	0.30	0.41	0.49	0.55	-	0.23	0.28	0.29	0.32

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 19

EFFECT OF AMPHETAMINE SELF-INGESTION ON TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED STIMULUS IN RATS Z-34,35,37 WITH FOOD PELLETS AVAILABLE.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.00	$\bar{X}$	6	7.35	8.00	8	7.57	8.25	6	6.30	6.60
	SE		0.75	0.73		0.92	0.80		1.09	1.38
0.0625	$\bar{X}$	5	9.57	10.44	5	4.85	5.87	6	5.78	6.03
	SE		0.77	0.75		0.69	1.34		0.73	0.73
0.125	$\bar{X}$	9	6.10	6.60	9	3.85	3.75	8	4.45	4.69
	SE		0.48	0.60		0.31	0.50		0.78	0.86
0.25	$\bar{X}$	7	6.36	5.71	5	3.68	3.62	6	2.29	2.01
	SE		0.93	1.07		0.80	0.75		0.32	0.52
0.50	$\bar{X}$	12	5.74	6.03	15	2.17	1.78	13	3.36	3.26
	SE		0.58	0.61		0.37	0.45		0.44	0.49

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	142.30	37.21***
STIMULUS SEGMENT	(S)	1	1.27	0.33
RAT	(R)	2	183.98	48.10***
C X S		4	1.90	0.50
C X R		8	16.40	4.29***
S X R		2	0.35	0.09
C X S X R		8	0.41	0.11
ERROR		210	3.82	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significnat at $P < 0.001$

TABLE 19 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.50	0.25	0.125	0.0625	0.00	0.50	0.25	0.125	0.0625	0.00
MEANS	3.62	4.26	4.81	6.68	7.12	3.54	3.89	5.02	7.36	7.68

Any two means not underscored by the same line are significantly different at P< 0.05.

0.25 and 01.25 or 0.25 and 0.50mM concentrations. According to ANOVA, there was no significant difference ($P > 0.05$) between the two stimulus conditions. There was a significant difference ($P < 0.001$) among the rats and in the concentration and rat interaction ($P < 0.001$). None of the other possible interactions showed a significant ($P > 0.05$) relationship.

According to ANOVA, the number of reinforcements (drops of fluid) delivered were significantly affected ($P < 0.001$) by substitution of solutions of increasing concentrations of amphetamine for water. The data and analyses are presented in Table 20. Further analysis by DMRT showed there was a progressive decrease in number of reinforcements delivered with increasing concentrations with all concentrations significantly ($P < 0.05$) less than water. With the exception of 0.0625mM concentration under self-produced stimulus, there were no significant ($P > 0.05$) between any given concentration and the concentrations immediately adjacent to it. All other concentrations were significantly different ($P < 0.05$) from each other. According to ANOVA, there was a significant difference ($P < 0.001$) between the two stimulus conditions, and it can be seen from the data of Table 20 that more reinforcements were delivered during self-produced than programmed stimulus. There was a significant difference ($P < 0.001$) among the rats as a significant ($P < 0.01$) relationship in the rat and concentration interaction. None of the other possible interactions showed a significant ($P > 0.05$) relationship.

Inconsequential Licking

According to ANOVA, inconsequential licking rates were significantly affected ($P < 0.01$) by substitution of solutions of

TABLE 20

DROPS OF FLUID DELIVERED DURING AMPHETAMINE SELF-INGESTION UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-34,35,37, WITH FOOD PELLETS AVAILABLE.

		Z-34			Z-35			Z-37	
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.00	$\bar{X}$	6	2179.67	1793.17	8	2023.28	1508.88	6	2333.33	1767.33
	SE		259.75	363.40		322.48	284.66		397.85	422.41
0.0625	$\bar{X}$	5	1429.60	1248.80	5	509.60	263.40	6	1356.33	1011.83
	SE		232.50	262.56		134.54	103.56		158.56	232.48
0.125	$\bar{X}$	9	749.22	445.44	9	266.89	239.00	8	1279.62	988.38
	SE		100.03	97.81		114.97	125.90		268.18	222.82
0.25	$\bar{X}$	7	447.86	399.57	5	250.80	57.60	6	623.00	261.33
	SE		141.05	129.98		153.65	54.62		209.47	110.90
0.50	$\bar{X}$	12	446.33	239.25	15	98.00	33.27	13	257.62	202.62
	SE		78.49	51.28		36.83	13.97		84.63	65.02

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	21910465.17	93.56***
STIMULUS SEGMENT	(S)	1	3035925.20	12.96***
RAT	(R)	2	3606481.38	15.40***
C X S		4	260367.99	1.11
C X R		8	680652.73	2.91**
S X R		2	45042.94	0.19
C X S X R		8	56277.19	0.24
ERROR		210	234202.31	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 20 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC (mM)	0.50	0.25	0.125	0.0625	0.00	0.50	0.25	0.125	0.0625	0.00
MEANS	254	452	746	1115	2163	150	259	541	852	1672

Any two means not underscored by the same line are significantly different at $P < 0.05$.

increasing concentrations of amphetamine for water. The data and analyses are presented in Table 21. Further analysis by DMRT showed there was a progressive decrease in inconsequential licking rates with increasing concentrations with a significant decrease ($P < 0.05$) under all concentrations of amphetamine when compared to water. None of the concentrations were significantly different ($P > 0.05$) from each other. According to ANOVA, there was no significant difference ($P > 0.05$) among the rats nor in the concentration and rat interaction.

Consequential Left Lever Pressing For Secondary Reinforcement

Consequential left lever pressing rate for secondary reinforcement decreased with increasing concentrations of amphetamine as can be seen in Figure 14. According to ANOVA, this was a significant effect ($P < 0.001$). The data and analyses are presented in Table 22. Further analysis by DMRT, showed there was a progressive decrease in consequential left lever rate with all concentrations except the lowest (0.0625mM) significantly decreased ($P < 0.05$) as compared to water. There was no significant difference ($P > 0.05$) between the remaining amphetamine concentrations. According to ANOVA, there was a significant difference ($P < 0.001$) among the rats as well as in the concentration and rat interaction ($P < 0.001$).

Inconsequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, the inconsequential left lever rates for secondary reinforcement were significantly affected ($P < 0.01$) by substitution of solutions of amphetamine for water. The data and

TABLE 21

EFFECT OF AMPHETAMINE SELF-INGESTION ON INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED (SPS) STIMULUS IN RATS Z-34,35,37 WITH FOOD PELLETS AVAILABLE.

		Z-34		Z-35		Z-37	
CONC(mM)		N	SPS	N	SPS	N	SPS
0.00	$\bar{X}$	6	18.50	8	28.88	6	8.67
	SE		9.21		21.50		1.84
0.0625	$\bar{X}$	5	11.20	5	3.39	6	4.33
	SE		1.98		1.04		1.14
0.125	$\bar{X}$	9	3.44	9	1.13	8	7.00
	SE		0.47		0.30		2.02
0.25	$\bar{X}$	7	3.29	5	1.88	6	2.83
	SE		1.04		1.40		1.05
0.50	$\bar{X}$	12	3.83	15	0.49	13	1.90
	SE		0.75		0.10		0.64

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	1180.20	4.25**
RAT	(R)	2	63.62	0.23
C X R		8	213.92	0.77
ERROR		105	277.80	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 21 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	0.50	0.25	0.125	0.0625	0.00
MEANS	1.95	2.74	3.74	6.18	19.70

Any two means not underscored by the same line are significantly different at $P < 0.05$.

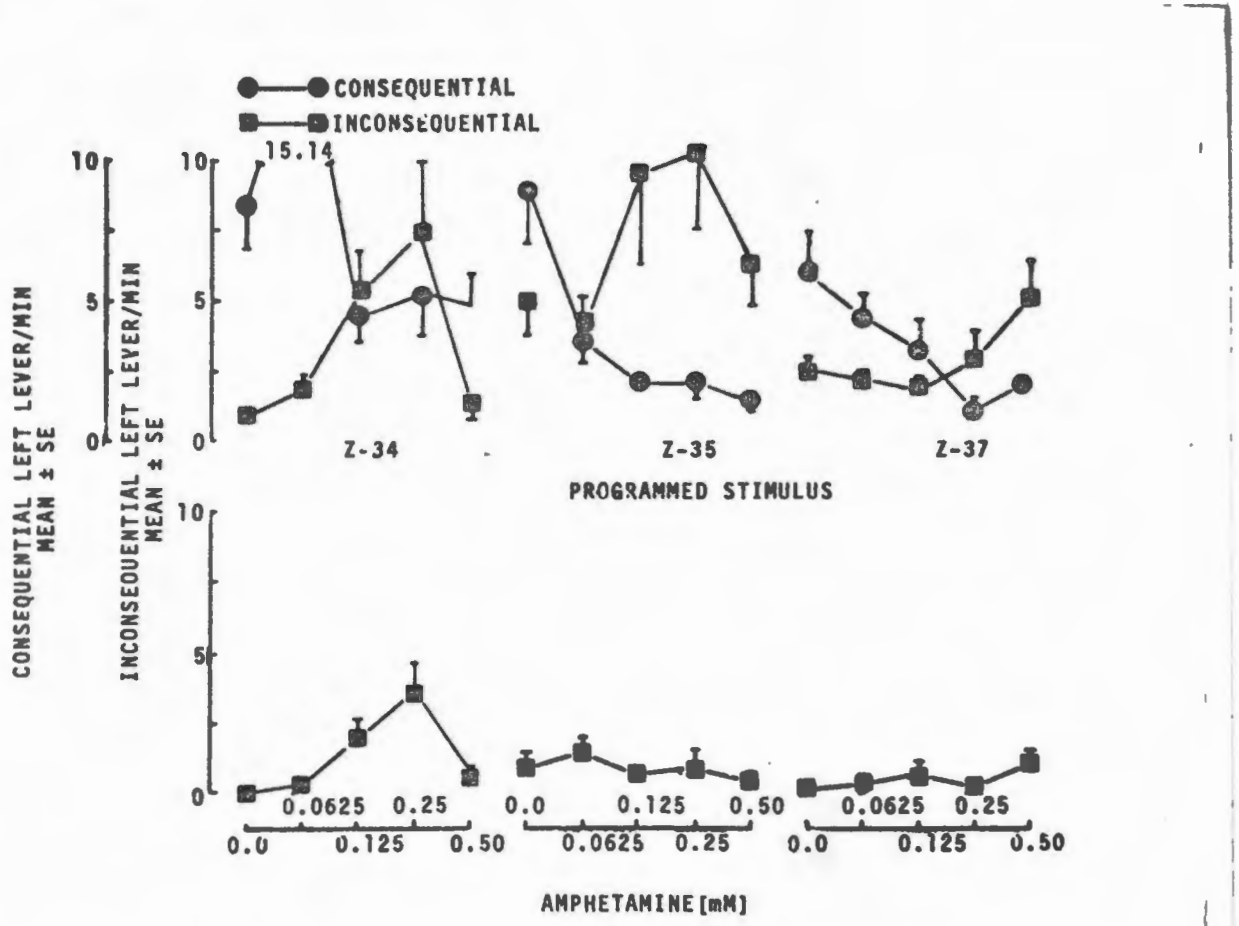

Figure 14. Effect of amphetamine self-ingestion on consequential and inconsequential left lever pressing for secondary reinforcement during self-produced and programmed stimulus in Rats Z-34, Z-35, Z-37. Food pellets were concurrently available on FI-60" right lever pressing.

TABLE 22

EFFECT OF AMPHETAMINE SELF-INGESTION ON CONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) STIMULUS IN RATS Z-34,25,27 WITH FOOD PELLETS AVAILABLE.

		Z-34		Z-35		Z-37	
CONC(mM)		N	SPS	N	SPS	N	SPS
0.00	$\bar{X}$	6	8.41	8	8.93	6	5.98
	SE		1.64		1.79		1.59
0.0625	$\bar{X}$	5	15.14	5	3.46	6	4.38
	SE		3.88				0.87
0.125	$\bar{X}$	9	4.49	9	2.14	8	3.23
	SE		0.85		0.26		0.98
0.25	$\bar{X}$	7	5.27	5	2.13	6	1.19
	SE		1.37		0.58		0.23
0.50	$\bar{X}$	12	4.92	15	1.34	13	1.86
	SE		0.90		0.26		0.29

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	152.52	16.07***
RAT	(R)	2	166.13	17.51***
C X R		8	36.37	3.83***
ERROR		105	9.49	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 22 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	0.50	0.25	0.125	0.0625	0.00
MEANS	2.59	3.04	3.29	7.45	7.89

Any two means not underscored by the same line are significantly different at $P < 0.05$.

analyses are presented in Table 23. The rats differed significantly ($P < 0.01$) among themselves in this respect and this can be seen graphically in Figure 14. Further analysis of this effect by DMRT, showed the effects of amphetamine were not concentration-related. According to ANOVA, there was a significant difference ($P < 0.001$) between the stimulus conditions and data of Table 23 clearly shows the rates were higher under self-produced stimulus than under programmed stimulus. There were significant relationships in the concentration and rat interaction ($P < 0.05$) and in the stimulus segment and rat interaction ($P < 0.001$). None of the other interactions showed a significant relationship ($P < 0.05$).

Right Lever Pressing For Food Pellets

The effect of amphetamine self-ingestion on the third operant response in this study, right lever pressing for food pellets is presented graphically in Figure 15. The data is expressed as consequential lever pressing and total lever pressing. This graph indicates that total right lever pressing increased with increasing amphetamine concentrations while consequential lever pressing was relatively unaffected. According to ANOVA, this observation is substantiated in that total right lever rates were significantly affected ($P < 0.001$) by amphetamine. The data and analyses are presented in Table 24. The consequential right lever rates were not significantly affected ($P > 0.05$) by amphetamine. The data and analyses are presented in Table 25. Further analysis of the effect of amphetamine on total right lever rates by DMRT showed a progressive increase in lever pressing rate with increasing concentrations of amphetamine. Significant increases ($P < 0.05$) between sets of

TABLE 23

EFFECT OF AMPHETAMINE SELF-INGESTION ON INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-34,35,37, WITH FOOD PELLETS AVAILABLE.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.00	$\bar{X}$	6	0.82	0.09	8	4.98	0.86	6	2.54	0.10
	SE		0.20	0.04		1.17	0.50		0.50	0.08
0.0625	$\bar{X}$	5	1.80	0.25	5	4.07	1.32	6	2.24	0.32
	SE		0.64	0.16		1.09	0.54		0.37	0.19
0.125	$\bar{X}$	9	5.22	1.88	9	9.47	0.31	8	1.84	0.60
	SE		1.41	0.62		3.26	0.15		0.34	0.46
0.25	$\bar{X}$	7	7.43	3.38	5	10.05	0.83	6	2.65	0.17
	SE		2.59	1.11		2.96	0.47		0.99	0.17
0.50	$\bar{X}$	12	2.23	0.50	12	6.23	0.38	13	5.10	0.98
	SE		0.34	0.20		1.54	0.21		1.30	0.42

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	44.13	3.77**
STIMULUS SEGMENT	(S)	1	877.57	74.89***
RAT	(R)	2	76.09	6.49**
C X S		4	17.64	1.51
C X R		8	24.57	2.10*
S X R		2	96.78	8.26***
C X S X R		8	11.21	0.96
ERROR		210	11.72	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 23 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.0625	0.00	0.50	0.125	0.25	0.00	0.0625	0.50	0.125	0.25
MEANS	2.67	3.00	4.67	6.00	6.56	0.40	0.60	0.61	0.94	1.60

Any two means not underscored by the same line are significantly different at $P < 0.05$.

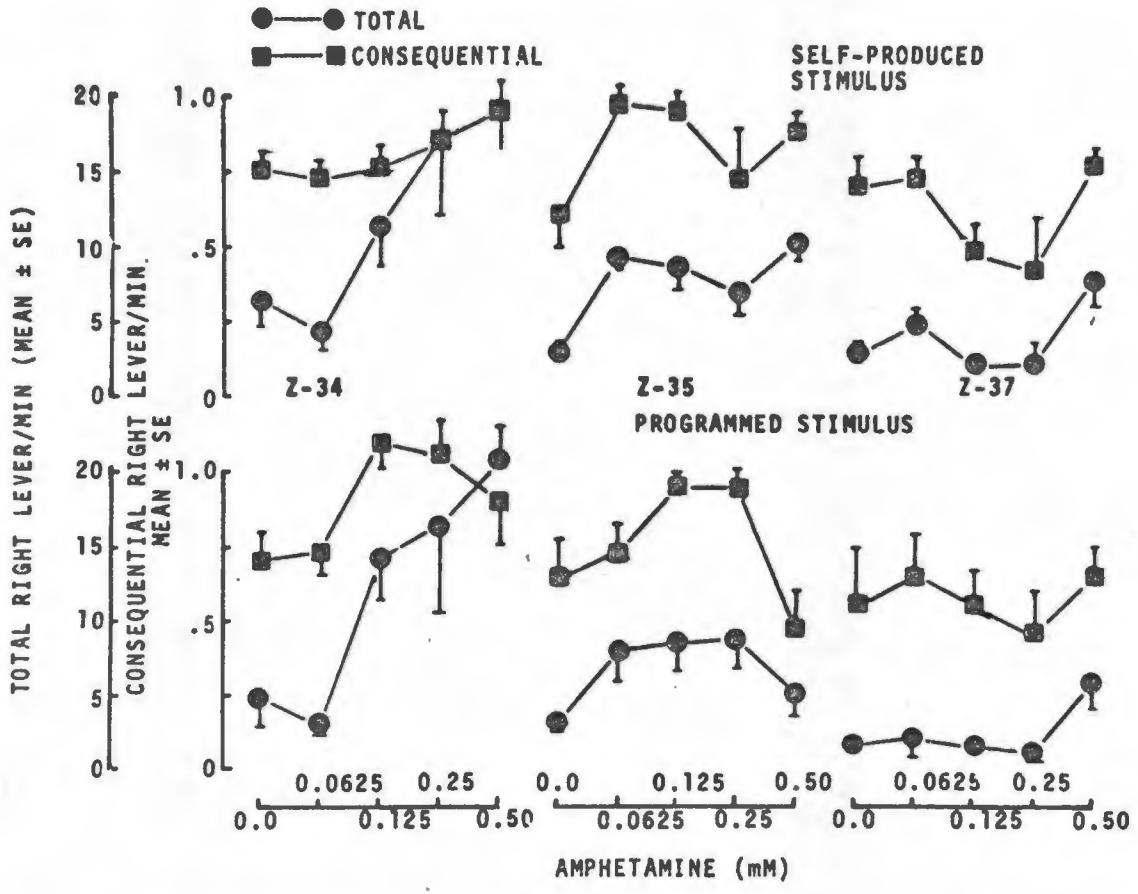

Figure 15. Effect of amphetamine self-ingestion on total (consequential and inconsequential) and consequential right lever pressing for food pellets under self-produced and programmed stimulus in Rats Z-34, Z-35, Z-37.

TABLE 24

EFFECT OF AMPHETAMINE SELF-INGESTION ON RIGHT LEVER PRESSING FOR FOOD PELLETS UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-34,35,37.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.00	$\bar{X}$	6	6.22	4.93	8	2.91	3.02	6	2.60	1.66
	SE		1.54	1.47		0.39	0.50		0.63	0.69
0.0625	$\bar{X}$	5	4.27	2.97	5	9.21	7.80	6	4.92	2.15
	SE		0.78	0.32		0.74	2.06		1.17	0.86
0.125	$\bar{X}$	9	11.42	14.18	9	8.60	8.50	8	1.96	1.47
	SE		2.79	3.36		1.36	1.44		0.64	0.45
0.25	$\bar{X}$	7	16.96	16.24	5	6.95	8.86	6	2.34	1.08
	SE		5.15	5.97		1.61	1.86		1.35	0.54
0.50	$\bar{X}$	12	19.42	20.70	15	10.16	5.05	13	7.61	5.84
	SE		2.74	3.60		0.90	1.40		1.46	1.63

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	465.46	11.02***
STIMULUS SEGMENT	(S)	1	50.22	1.19
RAT	(R)	2	1896.96	44.92***
C X S		4	18.18	0.43
C X R		8	220.75	5.23***
S X R		2	31.01	0.73
C X S X R		8	16.44	0.39
ERROR		210	42.23	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 24 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC (mM)	0.00	0.0625	0.125	0.25	0.50	0.00	0.0625	0.125	0.25	0.50
MEANS	3.81	6.06	7.53	9.31	12.11	3.19	4.17	8.30	9.14	10.00

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 25

EFFECT OF AMPHETAMINE SELF-INGESTION ON CONSEQUENTIAL RIGHT LEVER PRESSING FOR FOOD PELLETS UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-34,35,37.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0.00	$\bar{X}$	6	0.74	0.68	8	0.59	0.66	6	0.68	0.54
	SE		0.08	0.11		0.09	0.13		0.09	0.19
0.0625	$\bar{X}$	5	0.70	0.73	5	0.98	0.72	6	0.72	0.65
	SE		0.07	0.07		0.06	0.09		0.08	0.15
0.125	$\bar{X}$	9	0.76	1.10	9	0.94	0.95	8	0.44	0.54
	SE		0.08	0.08		0.05	0.05		0.10	0.09
0.25	$\bar{X}$	7	0.85	1.07	5	0.72	0.95	6	0.40	0.42
	SE		0.14	0.13		0.17	0.05		0.18	0.15
0.50	$\bar{X}$	12	0.96	0.90	15	0.82	0.46	13	0.77	0.65
	SE		0.11	0.15		0.07	0.12		0.06	0.11

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	0.13	1.21
STIMULUS SEGMENT	(S)	1	0.04	0.40
RAT	(R)	2	1.47	13.80***
C X S		4	0.30	2.81*
C X R		8	0.35	3.30***
S X R		2	0.24	2.21
C X S X R		8	0.064	0.60
ERROR		210	0.11	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 25 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC (mM)	0.25	0.00	0.125	0.0625	0.50	0.00	0.50	0.0625	0.25	0.125
MEANS	0.66	0.66	0.72	0.80	0.84	0.63	0.65	0.70	0.82	0.88

Any two means not underscored by the same line are significantly different at $P < 0.05$.

concentrations occurred as the concentrations increased. According to ANOVA, there was no significant difference ($P > 0.05$) between stimulus conditions in either total right lever rates or consequential right-lever rates. There was a significant difference ($P < 0.001$) among the rats in total and consequential right lever rates. For total right lever rates, there was a significant relationship ($P < 0.001$) in the concentration and rat interaction, while for consequential right lever rates there was a significant relationship in the concentration and stimulus condition interaction ($P < 0.05$) as well as in the concentration and rat interaction ($P < 0.001$). None of the other possible interactions were significant ($P > 0.05$).

Effect of Amphetamine Injection on Water Self-Ingestion Consequential Licking

The effect of amphetamine injections can be seen from cumulative records for rat Z-19 in Figure 16. The cumulative records on the left side are of predrug sessions where responding was at a high rate and consistent for all the sessions. On the right are the corresponding drug sessions. When either no injection was made or normal saline was injected, there were no apparent differences between predrug and drug sessions. The injection of increasing doses of amphetamine produced increasing disruption of responding to where it was totally abolished at the 2.0mg/kg dose.

The effect of amphetamine injections to decrease consequential licking rate in rats Z-19, Z-20 and Z-22 is presented graphically in Figure 17. According to ANOVA, consequential licking rates were significantly affected ($P < 0.001$) by amphetamine injections. The data and analyses are presented in Table 26. Further analysis of

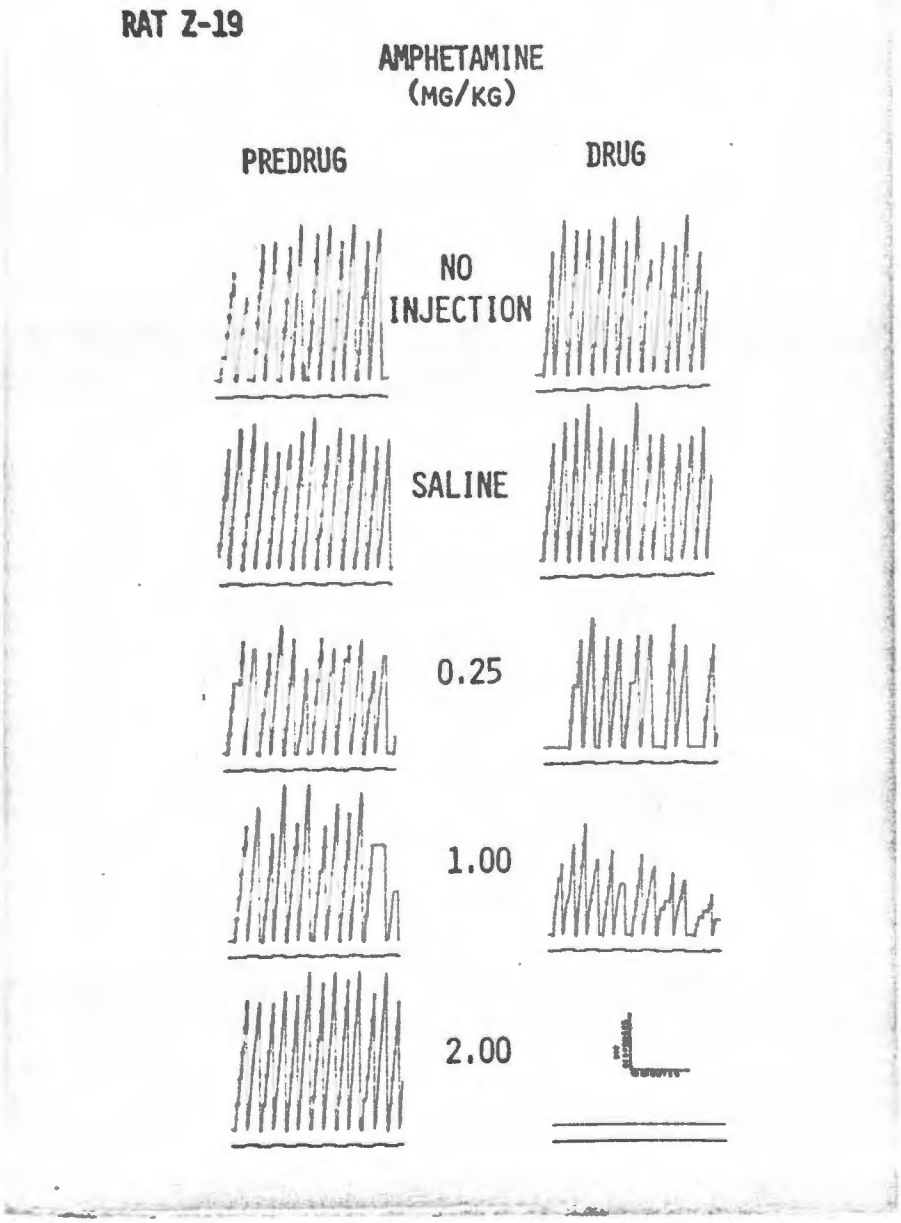

Figure 16. Effect of amphetamine injection on licking for water and lever pressing in Rat Z-19. Daily predrug (water) sessions are on left and corresponding amphetamine sessions are on right. Complete explanation of the cumulative record is presented in Figure 4.

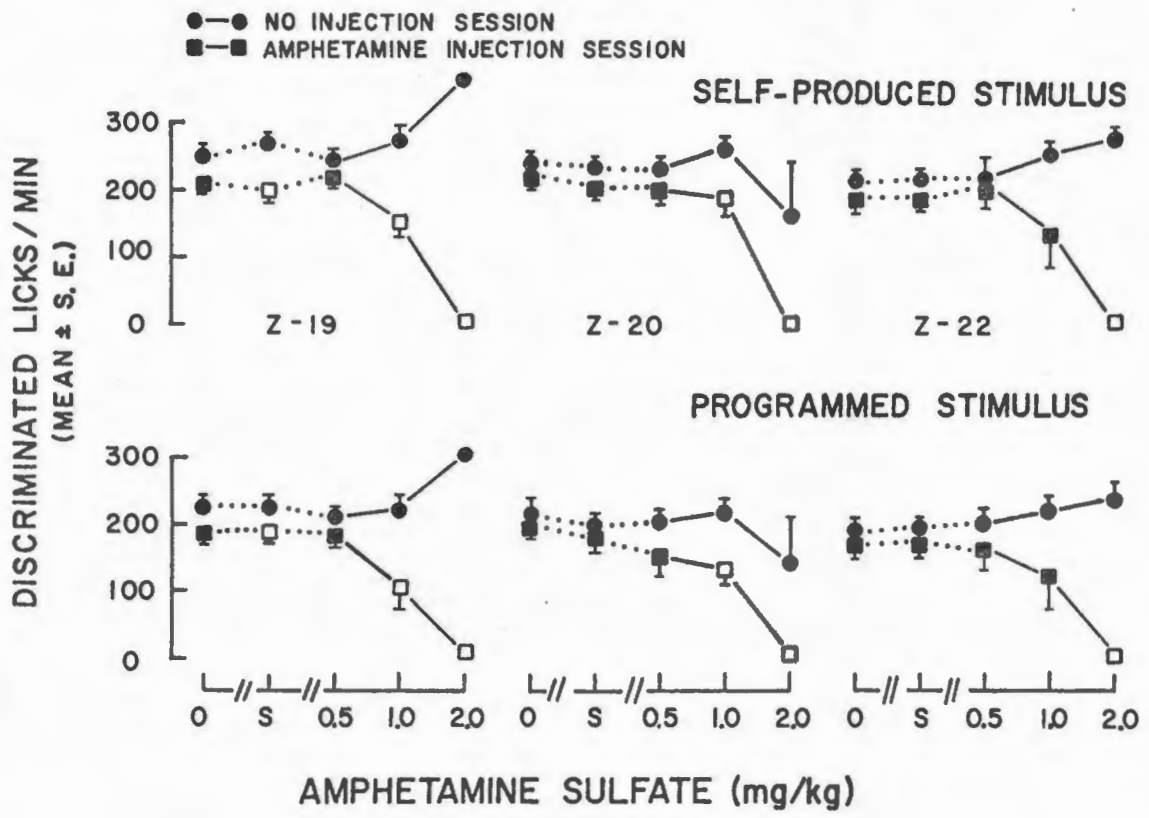

Figure 17. Effect of amphetamine injection on consequential licking rates for water during self-produced and programmed stimulus in Rats Z-19, Z-20, Z-22. Clear squares indicate significant differences ($P < 0.05$) between amphetamine sessions and corresponding predrug sessions (circles).

TABLE 26

EFFECT OF AMPHETAMINE INJECTION ON CONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN NORMAL RATS Z-19,20,22.

		Z-19			Z-20			Z-22	
DOSE(MG/KG)		N	SPS	PS	N	SPS	PS	N	SPS	PS
SALINE	$\bar{X}$	5	245.00	219.80	6	230.33	240.83	4	211.00	214.50
	SE		13.03	11.60		25.99	20.68		13.84	25.04
0.25	$\bar{X}$	5	223.80	182.40	4	231.00	159.00	4	183.50	173.75
	SE		22.82	20.56		35.94	45.00		27.96	15.95
0.50	$\bar{X}$	6	218.17	134.17	4	224.25	125.00	2	265.50	242.00
	SE		9.72	14.20		23.37	40.33		40.51	10.00
1.00	$\bar{X}$	3	111.67	114.33	4	171.25	89.50	5	192.20	134.00
	SE		44.84	12.12		38.82	35.45		13.04	16.38
2.00	$\bar{X}$	3	0.00	0.00	3	9.47	0.00	3	11.37	10.00
	SE		0.00	0.00		9.47	0.00		11.37	10.00

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	158193.82	67.60***
STIMULUS SEGMENT	(S)	1	38722.15	16.55***
RAT	(R)	2	10.80	0.05
D X S		4	6292.88	2.69*
D X R		8	4140.36	1.77
S X R		2	1692.93	0.72
D X S X R		8	1613.73	0.69
ERROR		92	2160.40	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 26 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
DOSE	2.00	1.00	0.25	0.50	SALINE	2.00	1.00	0.50	0.25	SALINE
MEANS	7	165	214	228	230	3	114	149	173	227

Any two means not underscored by the same line are significantly different at $P < 0.05$.

this effect by DMRT showed there was a progressive decrease in consequential licking rates with increasing doses of amphetamine with no significant difference ($P > 0.05$) from saline injection under self-produced stimulus until the 1.0mg/kg dose. There was a significant difference ($P < 0.05$) between the 1.0 and 2.0mg/kg doses. Under programmed stimulus all doses of amphetamine produced a significant decrease ($P < 0.05$) when compared to saline injections. The 1.0mg/kg dose produced a decrease significantly lower ($P < 0.05$) than the 0.25 mg/kg dose and the 2.0mg/kg dose was significantly lower ($P < 0.05$) than all the other doses. According to ANOVA, there was a significant difference ($P < 0.001$) between the two stimulus conditions, and data of Table 26 indicates the consequential licking rates were greater under self-produced stimulus. There was no significant difference ($P > 0.05$) among the rats. The interaction between dose and stimulus segment was significant ($P < 0.05$), but none of the other interactions showed any significant relationships ($P > 0.05$).

According to ANOVA, the time, in minutes, spent in consequential licking was significantly affected ($P < 0.001$) by different doses of amphetamine. The data and analyses are presented in Table 27. Further analysis of this effect by DMRT showed there was no significant difference ($P > 0.05$) between saline injections, and the 0.25, 0.50 and 1.0mg/kg doses. The 2.0mg/kg dose resulted in a significantly lowered ($P < 0.05$) time spent in licking as compared to saline injection and the other three doses of amphetamine. According to ANOVA, there was a significant difference ($P < 0.05$) between the two stimulus conditions and data of Table 27 indicates more time was spent under programmed stimulus than self-produced stimulus.

TABLE 27

EFFECT OF AMPHETAMINE INJECTION ON TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN NORMAL RATS Z-19,20,22.

		Z-19			Z-20			Z-22	
DOSE(MG/KG)		N	SPS	PS	N	SPS	PS	N	SPS	PS
SALINE	$\bar{X}$	5	6.87	8.50	6	8.28	9.72	4	8.58	10.47
	SE		2.08	2.89		1.44	2.13		0.72	0.78
0.25	$\bar{X}$	5	9.33	11.48	4	10.42	12.72	4	6.42	7.32
	SE		1.25	1.52		0.80	0.78		0.82	1.36
0.50	$\bar{X}$	6	6.39	7.86	4	8.25	12.48	2	8.66	10.85
	SE		1.58	1.87		2.12	0.54		0.47	0.00
1.00	$\bar{X}$	3	9.44	12.34	4	8.08	9.76	5	7.13	8.62
	SE		0.56	0.74		2.25	2.58		1.61	2.03
2.00	$\bar{X}$	3	0.00	0.00	3	0.22	0.00	3	3.44	3.62
	SE		0.00	0.00		0.22	0.00		3.11	3.62

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	236.58	17.44***
STIMULUS SEGMENT	(S)	1	82.94	6.11*
RAT	(R)	2	12.20	0.90
D X S		4	4.27	0.32
D X R		8	28.59	2.11*
S X R		2	0.99	0.07
D X S X R		8	1.55	0.12
ERROR		92	13.56	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 27 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
DOSE	2.00	0.50	SALINE	1.00	0.25	2.00	SALINE	0.50	1.00	0.25
MEANS	1.22	7.39	7.89	8.03	8.77	1.21	9.51	9.90	9.93	10.58

Any two means not underscored by the same line are significantly different at $P < 0.05$.

There was no significant difference ($P > 0.05$) among the rats. There was a significant ($P < 0.05$) interaction between dose and rats, but none of the other interactions showed any significant relationships ($P > 0.05$).

According to ANOVA, the number of drops of water delivered was significantly affected ($P < 0.001$) by amphetamine injections. The data and analyses are presented in Table 28. Further analysis of this effect by DMRT, showed there was a general decrease in water consumption with increasing doses of amphetamine, but the only significant decrease ($P < 0.05$) occurred at the 2.0mg/kg dose with the only other exception of a significant decrease ($P < 0.05$) between the 1.0mg/kg dose and saline under programmed stimulus. According to ANOVA, there were no significant differences ($P > 0.05$) between stimulus conditions, among the rats or in any of the interactions.

Inconsequential Licking

According to ANOVA, inconsequential licking rates were significantly affected ($P < 0.05$) by amphetamine injections. The data and analyses are presented in Table 29. Further analysis of this effect by DMRT, showed there was no dose dependent effect, but the 2.0mg/kg dose produced the greatest decrease which was significantly less ($P < 0.05$) than saline and 0.25 and 1.0mg/kg doses. The 0.50mg/kg dose produced a significant decrease ($P < 0.05$) when compared to saline. According to ANOVA, there was no significant difference ($P > 0.05$) among the rats or in the dose and rat interaction.

TABLE 28

EFFECT OF AMPHETAMINE INJECTION ON DROPS OF FLUID DELIVERED UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN NORMAL RATS Z-19,20,22.

		Z-19			Z-20			Z-22	
DOSE(MG/KG)		N	SPS	PS	N	SPS	PS	N	SPS	PS
SALINE	$\bar{X}$	5	1794.40	1873.40	6	2063.00	2427.50	4	1813.50	2250.50
	SE		608.30	634.55		500.55	656.60		197.62	344.10
0.25	$\bar{X}$	5	2104.20	2131.60	4	2492.25	2115.50	4	1148.00	1230.75
	SE		400.10	431.44		532.76	654.73		178.00	194.14
0.50	$\bar{X}$	6	1406.83	1117.00	4	1948.75	1549.75	2	2290.00	2624.00
	SE		342.07	302.10		539.99	517.78		263.04	107.02
1.00	$\bar{X}$	3	1689.33	1420.67	4	1282.00	1121.75	5	1435.60	1150.80
	SE		266.59	213.45		478.12	478.93		348.38	238.13
2.00	$\bar{X}$	3	0.00	0.00	3	6.33	0.00	3	110.00	108.33
	SE		0.00	0.00		6.33	0.00		110.00	108.33

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	13030488.12	15.20***
STIMULUS SEGMENT	(S)	1	42274.11	0.05
RAT	(R)	2	793828.67	0.93
D X S		4	322996.87	0.38
D X R		8	1329419.61	1.55
S X R		2	78605.81	0.09
D X S X R		8	81068.00	0.09
ERROR		92	857266.39	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 28 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	2.00	1.00	0.50	SALINE	0.25	2.00	1.00	0.50	0.25	SALINE
MEANS	39	1448	1735	1907	1929	36	1209	1512	1850	2196

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 29

EFFECT OF AMPHETAMINE INJECTION ON INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) STIMULUS IN NORMAL RATS Z-19,20,22.

DOSE(MG/KG)		Z-19 N	Z-19 SPS	Z-20 N	Z-20 SPS	Z-22 N	Z-22 SPS
SALINE	$\bar{X}$	5	14.60	6	19.50	4	16.25
	SE		7.02		6.77		6.22
0.25	$\bar{X}$	5	17.80	4	11.50	4	5.50
	SE		6.49		2.22		2.25
0.50	$\bar{X}$	6	6.67	4	7.75	2	6.00
	SE		2.90		3.12		0.00
1.00	$\bar{X}$	3	17.00	4	10.38	5	16.60
	SE		4.04		5.25		8.42
2.00	$\bar{X}$	3	0.07	3	0.00	3	2.59
	SE		0.05		0.00		2.56

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	464.39	3.54*
RAT	(R)	2	4.76	0.04
D X R		8	62.37	0.48
ERROR		46	132.31	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 29 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
DOSE	2.00	0.50	0.25	1.00	SALINE
MEANS	0.88	6.92	12.08	14.62	17.00

Any two means not underscored by the same line are significantly different at $P < 0.05$.

Consequential Left Lever Pressing For Second Reinforcement

According to ANOVA, amphetamine injections had no significant effect ($P > 0.05$) on consequential left lever rate for secondary reinforcement. The data and analyses are presented in Table 30. Further analysis of this data by DMRT showed there was no dose dependent relationship, but that the 2.0mg/kg dose produced a significant decrease ($P < 0.05$) when compared to saline and the other doses of amphetamine. According to ANOVA, there was no significant difference ($P > 0.05$) among the rats or in the dose and rat interaction.

Inconsequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, inconsequential left lever rates for secondary reinforcement were significantly affected ($P < 0.05$) by amphetamine injections. The data and analyses are presented in Table 31. Further analysis of this data by DMRT showed there was no dose dependent relationship, but under self-produced stimulus, the 2.0mg/kg dose produced an increase significantly greater ($P < 0.05$) than that produced by the other doses while under programmed stimulus the 1.0mg/kg dose produced an increase significantly greater ($P < 0.05$) than that produced by either saline or other doses of amphetamine. According to ANOVA, there was a significant difference ($P < 0.01$) in the stimulus segments and from the mean values used in DMRT, it can be seen the values for every dose including saline are greater under self-produced stimulus. ANOVA, there was a significant difference ($P < 0.001$) among the rats as well as a significant relationship ($P < 0.001$) in all of the possible interactions.

TABLE 30

EFFECT OF AMPHETAMINE INJECTION ON CONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) STIMULUS IN NORMAL RATS Z-19,20,22.

		Z-19		Z-20		Z-22	
DOSE(MG/KG)		N	SPS	N	SPS	N	SPS
SALINE	$\bar{X}$	5	21.49	6	19.52	4	12.75
	SE		11.23		7.31		2.73
0.25	$\bar{X}$	5	24.79	4	27.12	4	6.50
	SE		8.59		6.93		1.87
0.50	$\bar{X}$	6	11.41	4	14.41	2	23.74
	SE		5.28		6.52		10.93
1.00	$\bar{X}$	3	18.30	4	17.60	5	11.70
	SE		3.38		6.98		4.61
2.00	$\bar{X}$	3	0.00	3	0.16	3	6.30
	SE		0.00		0.16		6.13

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	485.12	2.42
RAT	(R)	2	179.15	0.90
D X R		8	164.85	0.82
ERROR		46	199.94	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 30 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
DOSE	2.00	0.50	1.00	SALINE	0.25
MEANS	2.15	14.65	15.32	18.37	19.88

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 31

EFFECT OF AMPHETAMINE INJECTION ON INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN NORMAL RATS Z-19,20,22.

		Z-19			Z-20			Z-22	
DOSE(MG/KG)		N	SPS	PS	N	SPS	PS	N	SPS	PS
SALINE	$\bar{X}$	5	0.63	0.24	6	1.66	0.30	4	5.35	0.00
	SE		0.22	0.20		0.68	0.20		3.26	0.00
0.25	$\bar{X}$	5	0.62	0.40	4	0.81	0.52	4	2.02	0.18
	SE		0.18	0.26		0.37	0.28		1.05	0.15
0.50	$\bar{X}$	6	1.51	0.52	4	1.81	0.86	2	1.29	0.00
	SE		0.66	0.35		1.04	0.32		0.51	0.00
1.00	$\bar{X}$	3	0.68	1.67	4	1.30	4.46	5	1.65	4.17
	SE		0.68	0.34		0.47	1.05		0.49	1.46
2.00	$\bar{X}$	3	0.00	0.00	3	0.00	0.00	3	19.25	1.69
	SE		0.00	0.00		0.00	0.00		8.02	1.69

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	21.90	3.05*
STIMULUS SEGMENT	(S)	1	49.88	6.94**
RAT	(R)	2	85.11	11.85***
D X S		4	49.68	6.92***
D X R		8	41.53	5.78***
S X R		2	46.37	6.45***
D X S X R		8	29.40	4.09***
ERROR		92	7.18	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 31 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
DOSE	0.25	1.00	0.50	SALINE	2.00	SALINE	0.25	0.50	2.00	1.00
MEANS	1.11	1.29	1.57	2.30	6.42	0.20	0.37	0.54	0.56	3.64

Any two means not underscored by the same line are significantly different at $P < 0.05$.

ETHANOL

Ethanol Licking - Two Operant Schedules

Consequential Licking

The effect of substitution of increasing concentrations of ethanol for water to decrease consequential licking rate in rats Z-25, Z-26, Z-27 and Z-28 is presented graphically in Figure 18. According to ANOVA, the substitution of ethanol solutions for water had a significant effect ($P < 0.001$) on consequential licking rate. The data and analyses are presented in Table 32. Further analysis of this data by DMRT showed the effect was concentration dependent with increasing concentrations of ethanol producing progressive decreases in consequential licking rate. There was no significant difference ($P > 0.05$) between the 10% or 20% concentrations and water or themselves, but the 40% and 80% concentrations produced rates significantly lower ($P < 0.05$) than either 10% or 20% concentrations or water. The rate under 80% was significantly lower ($P < 0.05$) than under 40%. According to ANOVA, there was a significant difference ($P < 0.001$) between the stimulus conditions and data of Table 32 shows the rates were greater under self-produced than programmed stimulus. There was a significant difference ($P < 0.001$) among the rats and a significant relationship ($P < 0.001$) in the concentration and rat interaction. None of the other interactions were significant.

According to ANOVA, the time, in minutes, spent in consequential licking was significantly affected by ethanol solutions. The data and analyses are presented in Table 33. Further analysis of the data by DMRT showed a progressive decrease in time spent in licking with increasing ethanol concentrations. There was no significant

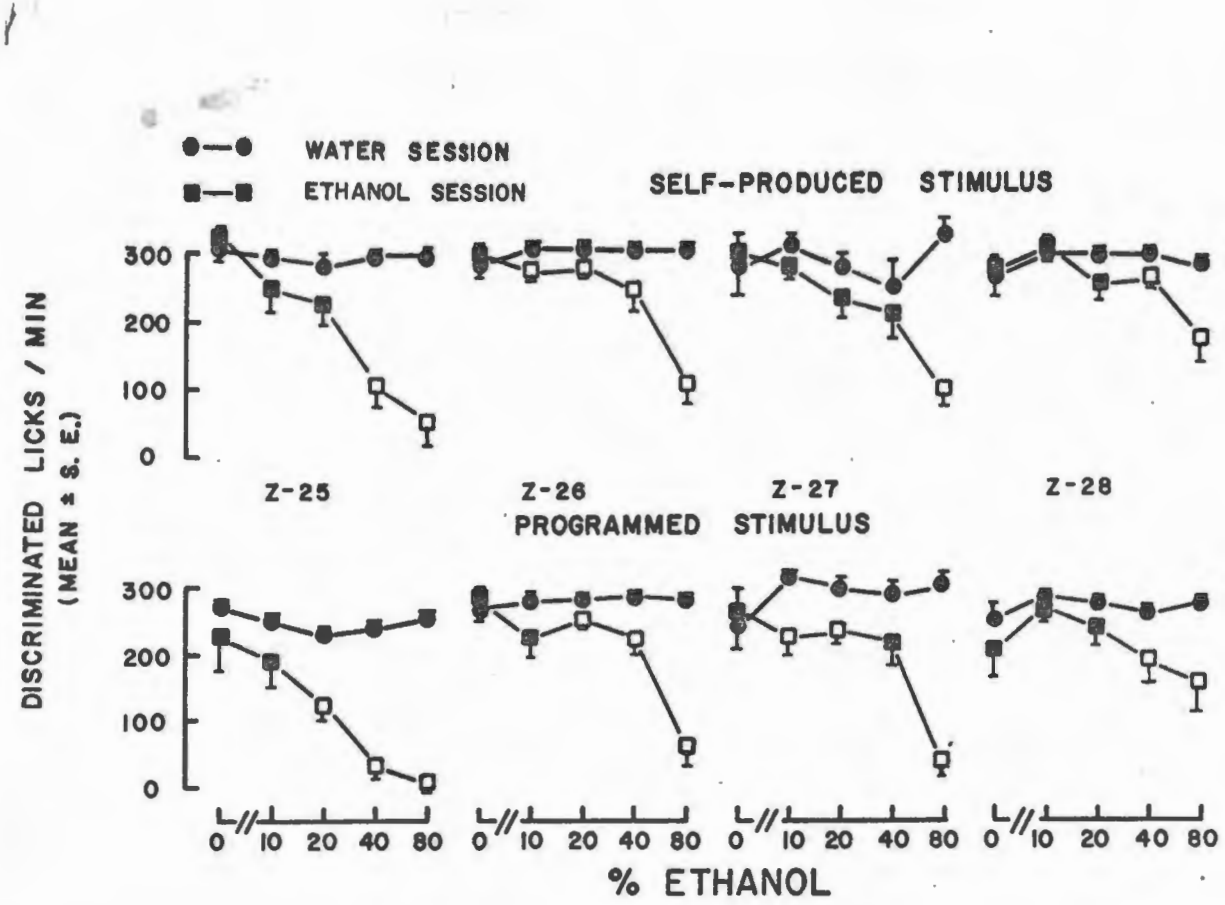

Figure 18. Effect of ethanol self-ingestion on consequential licking rate during self-produced and programmed stimulus in Rats Z-25, Z-26, Z-27, Z-28. Clear Squares indicate significant difference ($P < 0.05$) between ethanol sessions and corresponding predrug (water) sessions (circles).

TABLE 32

EFFECT OF ETHANOL SELF-INJESTION ON CONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN NORMAL RATS Z-25,26,27,28.

CONC(%V/V)		Z-25 N	Z-25 SPS	Z-25 PS	Z-26 N	Z-26 SPS	Z-26 PS
0	$\bar{X}$	4	325.50	285.75	7	300.29	278.30
	SE		6.45	7.04		12.69	9.08
10	$\bar{X}$	6	261.17	186.83	6	283.67	225.50
	SE		37.80	41.12		11.05	27.44
20	$\bar{X}$	10	229.90	125.90	10	290.50	259.40
	SE		31.28	27.48		6.43	4.45
40	$\bar{X}$	7	106.86	31.86	6	255.83	228.83
	SE		35.18	17.02		22.17	20.63
80	$\bar{X}$	6	57.00	4.33	6	11.50	64.67
	SE		34.65	3.35		30.02	31.78

TABLE 32 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
0	$\bar{X}$	5	301.60	260.32	4	284.25	227.92
	SE		32.07	40.50		5.56	31.14
10	$\bar{X}$	6	287.17	227.67	6	312.83	273.83
	SE		11.25	24.20		8.47	15.24
20	$\bar{X}$	10	238.10	238.50	10	260.40	243.40
	SE		21.66	20.66		24.93	25.41
40	$\bar{X}$	6	216.83	219.67	6	269.33	189.67
	SE		34.65	35.54		8.68	29.64
80	$\bar{X}$	6	100.67	37.33	6	173.83	156.67
	SE		24.96	1.76		29.78	38.07

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	273538.60	63.82***
STIMULUS SEGMENT	(S)	1	129784.49	30.28***
RAT	(R)	3	109868.97	25.64***
C X S		4	810.94	0.19
C X R		12	18248.93	4.26***
S X R		3	7400.84	1.73
C X S X R		12	2604.67	0.61
ERROR		226	4285.72	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 32 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	40	20	10	0	80	40	20	10	0
MEANS	111	208	255	286	288	66	162	217	228	253

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 33

EFFECT OF ETHANOL SELF-INGESTION ON TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-25,26,27,28.

CONC(%V/V)		Z-25			Z-26		
		N	SPS	PS	N	SPS	PS
0	$\bar{X}$	4	8.00	9.69	7	11.45	13.60
	SE		0.89	1.34		0.18	0.89
10	$\bar{X}$	6	5.61	6.20	6	8.39	10.25
	SE		1.10	1.06		1.13	1.51
20	$\bar{X}$	10	5.06	6.39	10	8.94	10.85
	SE		1.00	1.50		0.74	0.91
40	$\bar{X}$	7	1.38	1.24	6	6.00	7.03
	SE		0.32	0.64		1.18	1.67
80	$\bar{X}$	6	1.84	2.17	6	4.00	4.65
	SE		0.40	0.56		1.15	1.50

TABLE 33 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
0	$\bar{X}$	5	9.13	10.97	4	5.83	7.21
	SE		0.67	0.79		1.08	1.13
10	$\bar{X}$	6	9.50	11.68	6	7.56	9.40
	SE		0.85	1.11		0.86	0.72
20	$\bar{X}$	10	8.69	10.85	10	7.89	9.61
	SE		0.68	0.79		0.63	0.82
40	$\bar{X}$	6	6.66	8.68	6	6.06	7.60
	SE		0.80	1.12		0.70	0.93
80	$\bar{X}$	6	3.78	4.96	6	3.89	4.70
	SE		0.51	0.84		0.76	1.04

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	298.15	46.64***
STIMULUS SEGMENT	(S)	1	137.18	21.46***
RAT	(R)	3	258.59	40.45***
C X S		4	2.80	0.44
C X R		12	20.76	3.25***
S X R		3	3.98	0.62
C X S X R		12	0.44	0.07
ERROR		226	6.93	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 33 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	40	20	10	0	80	40	10	20	0
MEANS	3.38	4.88	7.64	7.76	8.63	4.12	5.94	9.38	9.42	10.36

Any two means not underscored by the same line are significantly different at $P < 0.05$.

difference ($P > 0.05$) between the 10% or 20% concentration and water or themselves. The 40% and 80% concentrations were significantly lower ($P < 0.05$) than either the 10% or 20% concentrations or water but were not significantly different ($P > 0.05$) from each other. According to ANOVA, there was a significant difference ($P < 0.001$) between the stimulus conditions and data of Table 33 shows more time was spent under programmed stimulus than under self-produced stimulus. There was a significant difference ($P < 0.001$) among the rats as well as a significant relationship ($P < 0.001$) in the concentration and rat interaction. None of the other interactions showed a significant interaction ($P > 0.05$).

According to ANOVA, the drops of fluid delivered were significantly affected ($P < 0.001$) by ethanol solutions. The data and analyses are presented in Table 34. Further analysis by DMRT showed a progressive decrease in fluid consumption with increasing ethanol concentrations. There was no significant difference ($P > 0.05$) between the 10% concentration and water or 20% concentration, but all other concentrations of ethanol were significantly different ($P < 0.05$) from water and from each other. According to ANOVA, there was no significant difference ($P > 0.05$) between the stimulus conditions. There was a significant difference ($P < 0.001$) among the rats as well as in the concentration and rat interaction ($P < 0.001$). There was no significant relationship ($P > 0.05$) in any of the other interactions.

According to ANOVA, there was a significant difference ($P < 0.001$) in grams of absolute ethanol ingested under the various ethanol concentrations. The data and analyses are presented in Table 35.

TABLE 34

DROPS OF FLUID DELIVERED DURING ETHANOL SELF-INGESTION UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-25,26,27,28.

CONC(%V/V)		Z-25 N	Z-25 SPS	Z-25 PS	Z-26 N	Z-26 SPS	Z-26 PS
0	$\bar{X}$	4	2595.75	2794.50	7	3220.71	3698.43
	SE		270.04	443.46		241.69	280.15
10	$\bar{X}$	6	1655.67	1356.50	6	2413.67	2317.50
	SE		426.53	396.40		389.65	471.57
20	$\bar{X}$	10	1376.00	1093.80	10	2610.70	2805.90
	SE		308.14	282.98		247.73	229.83
40	$\bar{X}$	6	188.71	83.71	6	1592.17	1597.17
	SE		66.81	41.65		342.80	421.01
80	$\bar{X}$	6	95.67	9.83	6	444.50	451.50
	SE		57.84	7.10		130.89	281.02

TABLE 34 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
0	$\bar{X}$	5	2789.00	3065.20	4	1649.50	1618.25
	SE		410.71	442.25		273.14	259.79
10	$\bar{X}$	6	2733.17	2578.00	6	2349.67	2588.67
	SE		282.73	289.67		250.08	278.67
20	$\bar{X}$	10	2109.10	2661.80	10	2009.30	2235.30
	SE		278.40	357.35		240.03	257.67
40	$\bar{X}$	6	1575.00	1946.00	6	1636.33	1394.83
	SE		372.70	368.68		206.56	217.29
80	$\bar{X}$	6	385.17	166.83	6	704.50	782.33
	SE		112.47	74.01		215.21	290.62

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	41036745.59	70.47***
STIMULUS SEGMENT	(S)	1	318126.32	0.55
RAT	(R)	3	18718800.82	32.14***
C X S		4	259896.47	0.45
C X R		12	2340235.61	4.02***
S X R		3	408010.35	0.70
C X S X R		12	184163.02	0.32
ERROR		226	582648.94	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 34 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	40	20	10	0	80	40	20	10	0
MEANS	408	1206	2026	2288	2546	353	1209	2199	2210	2803

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 35

GRAMS OF ABSOLUTE ETHANOL INGESTED UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-25,26,27,28.

		Z-25			Z-26		
CONC(%V/V)		N	SPS	PS	N	SPS	PS
0	$\bar{X}$	-	-	-	-	-	-
	SE	-	-	-	-	-	-
10	$\bar{X}$	6	0.56	0.46	6	0.82	0.78
	SE		0.14	0.13		0.13	0.16
20	$\bar{X}$	10	0.95	0.75	10	1.79	1.93
	SE		0.21	0.19		0.17	0.16
40	$\bar{X}$	7	0.26	0.11	6	2.18	2.19
	SE		0.09	0.06		0.47	0.58
80	$\bar{X}$	6	0.26	0.02	6	1.22	1.24
	SE		0.16	0.02		0.36	0.77

TABLE 35 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
0	$\bar{X}$	-	-	-	-	-	-
	SE	-	-	-	-	-	-
10	$\bar{X}$	6	0.94	0.90	6	0.80	0.89
	SE		0.10	0.10		0.09	0.10
20	$\bar{X}$	10	1.38	1.83	10	1.38	1.54
	SE		0.17	0.24		0.16	0.18
40	$\bar{X}$	6	2.16	2.66	6	2.24	1.91
	SE		0.51	0.50		0.28	0.30
80	$\bar{X}$	6	1.06	0.46	6	1.94	2.15
	SE		0.31	0.20		0.59	0.80

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	8.38	13.25***
STIMULUS SEGMENT	(S)	1	0.008	0.01
RAT	(R)	3	16.40	25.88***
C X S		4	0.31	0.50
C X R		12	1.67	2.64**
S X R		3	0.02	0.04
ERROR		194	0.63	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 35 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0	10	80	20	40	0	10	80	20	40
MEANS	-	0.78	1.12	1.37	1.65	-	0.76	0.97	1.51	1.65

Any two means not underscored by the same line are significantly different at $P < 0.05$.

Further analysis by DMRT showed a trend for greater amounts of ethanol to be consumed up to the 40% concentration with a decreased amount consumed at the 80% concentration. There was a significantly greater ($P < 0.05$) amount of ethanol consumed at the 20% and 40% concentrations than at the 10% concentration. Under programmed stimulus the same also is true for 80%. There were no significant differences ($P > 0.05$) between the 10% and 80% and between the 20% and 40% concentrations under both stimulus conditions. According to ANOVA, there was no significant difference ($P > 0.05$) between the two stimulus conditions and there was a significant difference ($P < 0.001$) among the rats. There was a significant relationship ($P < 0.01$) in the concentration and rat interaction. None of the other concentrations showed any significant relationship ($P > 0.05$). A comparison between grams of ethanol consumed with minutes spent in licking is presented in Figure 19. Here the trend toward increased ethanol consumption with increasing concentrations is compared with the trend toward spending less time in licking with increasing concentrations of ethanol.

Inconsequential Licking

According to ANOVA, inconsequential licking rates were significantly affected ($P < 0.001$) by ethanol solutions. The data and analyses are presented in Table 36. Further analysis of this effect by DMRT showed a trend toward decreases in inconsequential licking rate with increasing concentrations of ethanol. There was a decrease although not significant ($P > 0.05$) with 10% and 20% as compared to water. The 40% and 80% concentrations produced significant decreases ($P < 0.05$) when compared to 10%, 20% and water. There

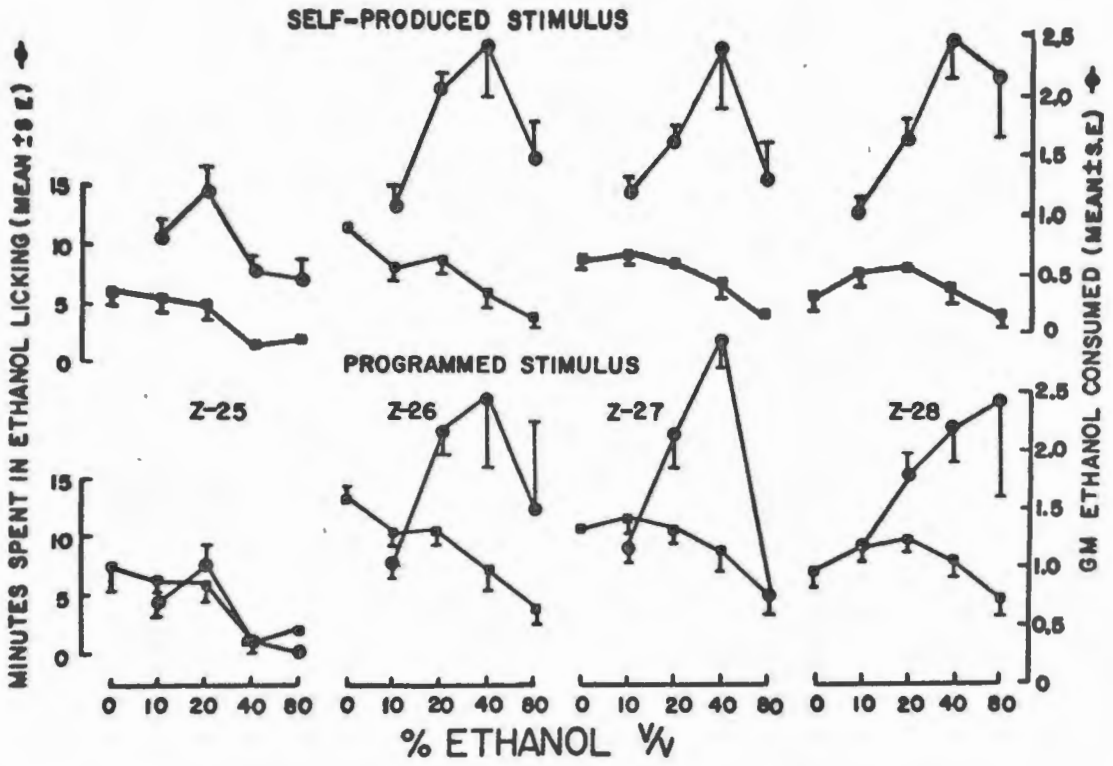

Figure 19. Effect of ethanol self-ingestion on minutes spent in consequential licking and grams of absolute ethanol consumed during 30 minute sessions under self-produced and programmed stimulus in Rats Z-25, Z-26, Z-27, Z-28.

TABLE 36

EFFECT OF ETHANOL SELF-INGESTION ON INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) STIMULUS IN RATS Z-25,26,27,28.

		Z-25		Z-26		Z-27		Z-28	
CONC(%V/V)		N	SPS	N	SPS	N	SPS	N	SPS
0	$\bar{X}$	4	12.56	7	33.53	5	17.10	4	26.56
	SE		3.95		9.37		4.86		11.72
10	$\bar{X}$	6	6.58	6	13.67	6	18.00	6	26.00
	SE		1.89		4.01		4.60		6.19
20	$\bar{X}$	10	4.11	10	16.70	10	21.40	10	22.90
	SE		0.99		3.90		5.25		3.63
40	$\bar{X}$	7	0.81	6	7.50	6	16.00	6	11.33
	SE		0.25		2.95		4.76		2.46
80	$\bar{X}$	6	1.75	6	3.71	6	8.50	6	8.83
	SE		0.72		1.23		2.78		2.23

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	1093.12	8.21***
RAT	(R)	3	1401.23	10.52***
C X R		12	153.95	1.16
ERROR		113	133.19	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 36 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	80	40	10	20	0
MEANS	5.70	8.60	16.10	16.30	22.60

Any two means not underscored by the same line are significantly different at $P < 0.05$.

was the most marked decrease seen at 80%, but it was not significantly less ($P > 0.05$) than at 40%. According to ANOVA, there was a significant difference ($P < 0.001$) among the rats and the interaction between concentration and rats was not significant ($P > 0.05$)

Consequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, consequential left lever rates were significantly affected ($P < 0.001$) by ethanol solutions. The data and analyses are presented in Table 37. Further analysis of this effect by DMRT showed there was a concentration dependent decrease in consequential left lever rates with increasing concentrations of ethanol. All concentrations of ethanol produced a significant decrease ($P < 0.05$) when compared to water. There was no significant differences ($P > 0.05$) between 10% and 20% and between 40% and 80% but both 40% and 80% were significantly lower ($P < 0.05$) than 10% and 20%. According to ANOVA, there was a significant difference ($P < 0.001$) among the rats and a significant relationship ($P < 0.01$) in the rat and concentration interaction. The effect of ethanol on consequential left lever rates in rats Z-25, Z-26, Z-27 and Z-28 is presented graphically in the upper portion of Figure 20.

Inconsequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, inconsequential left lever rates were not significantly affected ($P > 0.05$) by ethanol. The data and analysis are presented in Table 38. The data is also presented graphically for self-produced stimulus in the lower portion of Figure 20. There was a significant difference ($P < 0.001$) between the stimulus conditions

TABLE 37

EFFECT OF ETHANOL SELF-INGESTION ON CONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) STIMULUS IN RATS Z-25,26,27,28.

		Z-25		Z-26		Z-27		Z-28	
CONC(%V/V)		N	SPS	N	SPS	N	SPS	N	SPS
0	$\bar{X}$	4	10.99	7	40.52	5	15.91	4	9.04
	SE		3.36		8.80		4.52		3.83
10	$\bar{X}$	6	5.25	6	17.02	6	18.43	6	9.55
	SE		1.45		5.96		4.01		1.92
20	$\bar{X}$	10	5.40	10	18.81	10	16.04	10	9.09
	SE		1.47		4.83		4.56		1.40
40	$\bar{X}$	7	0.79	6	7.58	6	7.50	6	5.55
	SE		0.20		2.92		1.49		1.12
80	$\bar{X}$	6	1.05	6	2.89	6	2.93	6	2.88
	SE		0.30		0.94		0.55		0.88

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	1159.10	12.52***
RAT	(R)	3	1264.44	13.66***
C X R		12	216.29	2.34**
ERROR		113	92.54	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 37 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	80	40	20	10	0
MEANS	2.44	5.17	12.34	12.56	21.11

Any two means not underscored by the same line are significantly different at P <0.05.

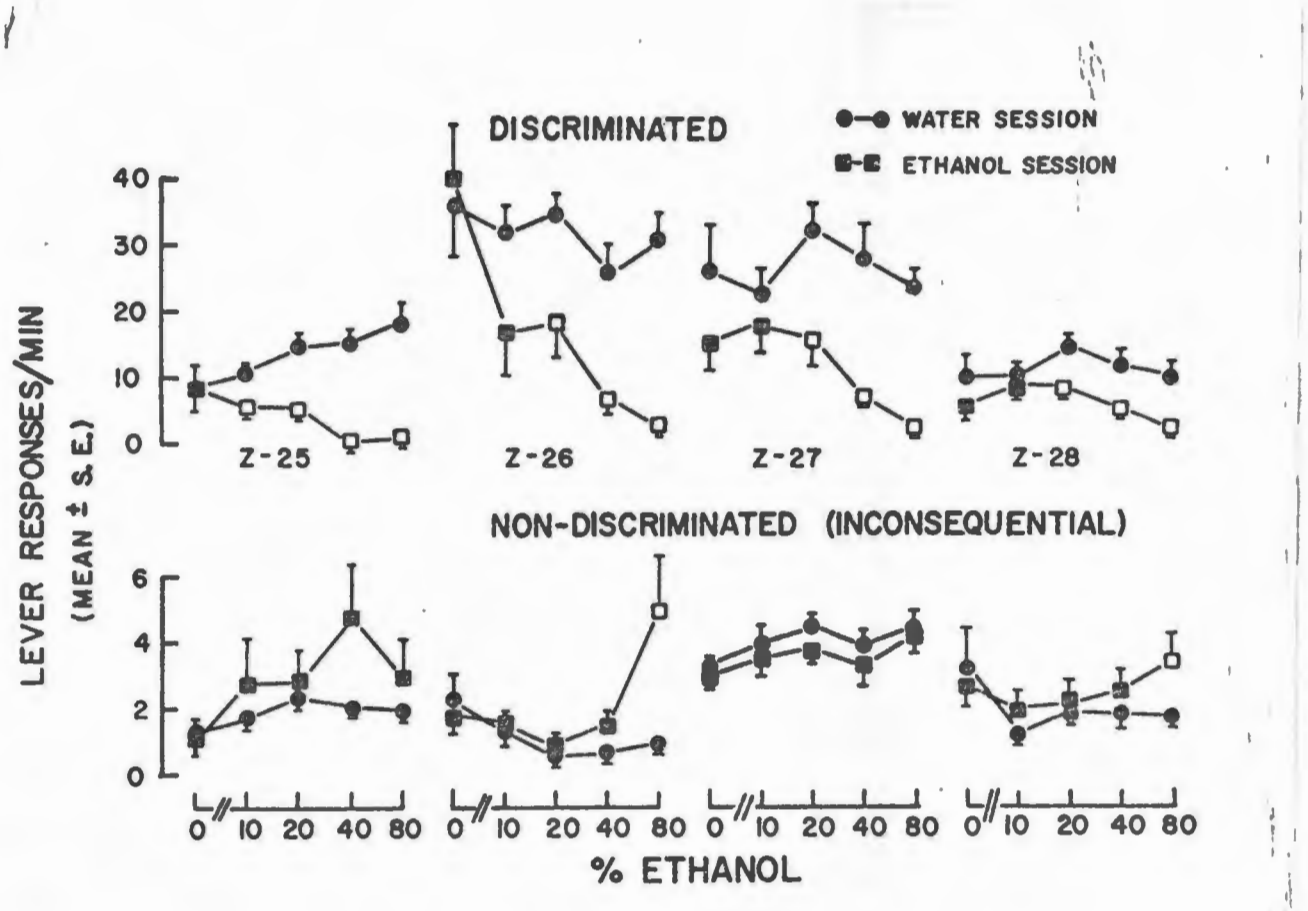

Figure 20. Effect of ethanol self-ingestion on discriminated and non-discriminated left lever pressing for secondary reinforcement during self-produced stimulus in Rats Z-25, Z-26, Z-27, Z-28. Clear squares indicate significant difference ($P < 0.05$) between ethanol sessions and corresponding predrug water sessions (circles).

and from Table 38, the rates under self-produced stimulus can be seen to be greater than under programmed stimulus. There was a significant difference ($P < 0.05$) among the rats and a significant relationship ($P < 0.05$) in the stimulus segment and rat interaction. None of the other interactions showed any significant relationships ($P > 0.05$).

Ethanol Licking - Three Operant Schedules

Consequential Licking

According to ANOVA, consequential licking rates were significantly affected ($P < 0.001$) by ethanol solutions. The data and analyses are presented in Table 39. Further analysis by DMRT showed there was a progressive decrease in consequential licking rates under self-produced stimulus with increasing concentrations. All concentrations, but 10%, were significantly lower ($P < 0.05$) than water. There was no significant difference ($P > 0.05$) between 10%, 20% and 40% and while the 80% concentration was significantly lower ($P < 0.05$) than all the other concentrations. Under programmed stimulus all concentrations of ethanol produced rates significantly lower ($P < 0.05$) than water. There was no significant difference ($P > 0.05$) between the 10%, 20% and 40% concentrations, while the 80% concentration was significantly lower ($P < 0.05$) than all others. According to ANOVA, there was a significant difference ($P < 0.001$) between stimulus segments and from Table 39 the rates under self-produced stimulus are greater than under programmed stimulus. There was no significant difference ($P > 0.05$) among the rats nor in any of the possible interactions.

TABLE 38

EFFECT OF ETHANOL SELF-INGESTION ON LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-25,26,27,28.

		Z-25			Z-26		
CONC(%V/V)		N	SPS	PS	N	SPS	PS
0	$\bar{X}$	4	1.28	0.03	7	1.77	0.85
	SE		0.42	0.03		0.41	0.85
10	$\bar{X}$	6	5.91	0.44	6	1.42	0.31
	SE		3.22	0.42		0.50	0.21
20	$\bar{X}$	10	2.84	0.90	10	0.90	0.01
	SE		0.91	0.73		0.17	0.01
40	$\bar{X}$	7	4.65	0.00	6	1.46	0.49
	SE		1.66	0.00		0.33	0.44
80	$\bar{X}$	6	2.87	1.15	6	4.97	0.84
	SE		1.09	0.66		1.72	0.61

TABLE 38 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
0	$\bar{X}$	5	9.52	1.09	4	2.63	0.56
	SE		6.69	1.08		0.26	0.24
10	$\bar{X}$	6	3.45	0.14	6	1.94	0.06
	SE		0.59	0.09		0.48	0,02
20	$\bar{X}$	10	3.85	0.18	10	2.02	0.68
	SE		0.28	0.10		0.82	0.61
40	$\bar{X}$	6	3.23	0.10	6	2.50	0.48
	SE		0.54	0.05		0.60	0.28
80	$\bar{X}$	6	4.30	0.30	6	3.51	0.31
	SE		0.63	0.17		0.69	0.19

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	8.52	1.04
STIMULUS SEGMENT	(S)	1	483.00	58.91***
RAT	(R)	3	22.27	2.72*
C X S		4	4.49	0.55
C X R		12	12.51	1.53
S X R		3	25.36	3.09*
C X S X R		12	9.18	1.12
ERROR		226	8.20	-

*Significant at P < 0.05
**Significant at P < 0.01
***Significant at P < 0.001

TABLE 38 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	20	40	10	0	80	10	40	20	80	0
MEANS	2.40	3.03	3.18	3.60	3.91	0.23	0.26	0.44	0.65	0.66

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 39

EFFECT OF ETHANOL SELF-INGESTION ON CONSEQUENTIAL LICKING RATE DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-41,42,43, WITH FOOD PELLETS AVAILABLE.

		Z-41			Z-42			Z-43	
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0	$\bar{X}$	9	284.67	274.00	8	290.62	231.25	8	273.00	210.88
	SE		31.30	24.03		10.01	25.02		38.77	24.53
10	$\bar{X}$	5	309.20	112.00	7	238.71	166.14	7	178.14	106.14
	SE		24.90	32.53		31.82	32.40		45.55	32.47
20	$\bar{X}$	5	165.80	179.20	7	268.86	185.14	7	235.14	150.14
	SE		46.55	49.83		29.55	21.92		35.54	24.43
40	$\bar{X}$	7	232.57	165.86	6	254.83	154.00	6	181.67	162.33
	SE		14.28	29.48		24.44	15.67		39.35	23.06
80	$\bar{X}$	7	168.00	65.86	7	169.71	70.14	5	142.20	108.40
	SE		13.86	24.64		18.18	22.10		11.96	16.15

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	112190.01	20.13***
STIMULUS SEGMENT	(S)	1	239052.48	42.89***
RAT	(R)	2	11982.18	2.15
C X S		4	5989.38	1.08
C X R		8	5292.38	0.95
S X R		2	2720.75	0.49
C X S X R		8	8366.95	1.50
ERROR		172	5574.10	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 39 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	40	20	10	0	80	10	40	20	0
MEANS	162	224	229	235	283	79	130	161	171	240

Any two means not underscored by the same line are significantly different at $P < 0.05$.

According to ANOVA, the time spent in consequential licking was significantly affected ($P < 0.001$) by ethanol solutions. The data and analyses are presented in Table 40. Further analysis by DMRT showed a progressive decrease in time spent in consequential licking with increasing concentrations of ethanol. All concentrations produced a significant reduction ($P < 0.05$) when compared to water. There was no significant difference ($P > 0.05$) between 10%, 20% and 40%. Under self-produced stimulus, the 80% concentration produced a rate significantly lower ($P < 0.05$) than 10% while under programmed stimulus the 80% concentration produced a rate significantly lower ($P < 0.05$) than 10% and 20%. According to ANOVA, there was no significant difference ($P > 0.05$) between stimulus conditions. There was a significant difference ($P < 0.001$) among the rats and in the concentration and rat interaction ($P < 0.001$). None of the other interactions showed any significant relationships ($P > 0.05$).

According to ANOVA, drops of fluid delivered was significantly affected ($P < 0.001$) by ethanol solutions. The data and analyses are presented in Table 41. Further analysis of the data by DMRT shows there was a progressive decrease in drops of fluid delivered as increasing concentrations of ethanol were substituted for water. The drops of fluid delivered at all concentrations of ethanol were significantly lower ($P < 0.05$) than for water. There was no significant difference ($P > 0.05$) between the 10%, 20% and 40% concentrations. The 80% concentration was significantly lower ($P < 0.05$) than the 10% and 20% concentration effects. According to ANOVA, there was a significant difference ($P < 0.01$) between the two stimuli and the data of Table 41 shows values under self-produced stimulus are

TABLE 40

EFFECT OF ETHANOL SELF-INGESTION ON TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-41,42,43, WITH FOOD PELLETS AVAILABLE.

		Z-41			Z-42			Z-43		
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0	$\bar{X}$	9	8.20	7.99	8	9.46	9.53	8	8.77	9.21
	SE		0.61	1.04		0.68	0.92		0.91	0.99
10	$\bar{X}$	5	4.09	4.40	7	8.77	9.56	7	4.01	4.02
	SE		0.87	0.81		0.66	0.86		0.78	0.88
20	$\bar{X}$	5	4.26	4.42	7	6.33	7.22	7	5.01	5.50
	SE		1.17	1.94		0.90	1.06		1.10	1.06
40	$\bar{X}$	7	3.01	3.17	6	5.70	6.68	6	4.78	5.34
	SE		0.35	0.41		0.85	0.98		0.98	1.11
80	$\bar{X}$	7	2.78	2.60	7	2.82	2.41	5	6.34	7.09
	SE		0.53	0.73		0.22	0.26		0.79	0.67

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	169.71	32.96***
STIMULUS SEGMENT	(S)	1	4.38	0.85
RAT	(R)	2	83.84	16.28***
C X S		4	0.62	0.12
C X R		8	36.08	7.01***
S X R		2	1.02	0.20
C X S X R		8	0.53	0.10
ERROR		172	5.15	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 40 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	40	20	10	0	80	40	20	10	0
MEANS	3.73	4.20	5.30	5.78	8.78	3.71	4.96	5.85	6.16	8.88

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 41

DROPS OF FLUID DELIVERED DURING ETHANOL SELF-INGESTION UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-41,42,43, WITH FOOD PELLETS AVAILABLE.

		Z-41			Z-42			Z-43	
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0	$\bar{X}$	9	2261.11	2073.11	8	2726.25	2164.12	8	2263.25	1883.38
	SE		265.93	336.64		200.85	262.11		355.03	276.74
10	$\bar{X}$	5	1250.00	843.80	7	2154.00	1649.86	7	855.14	523.57
	SE		267.38	305.30		362.10	373.34		318.45	208.30
20	$\bar{X}$	5	663.00	765.60	7	1675.71	1264.14	7	1211.43	924.57
	SE		184.80	326.45		275.91	194.51		347.53	266.06
40	$\bar{X}$	7	684.43	490.43	6	1407.17	961.67	6	765.17	788.67
	SE		62.68	104.91		253.41	183.14		200.57	150.02
80	$\bar{X}$	7	498.14	271.14	7	478.71	182.86	5	912.40	809.60
	SE		119.50	154.85		62.80	77.55		150.17	172.04

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	19485921.86	44.35***
STIMULUS SEGMENT	(S)	1	4322492.08	9.84**
RAT	(R)	2	3716302.79	8.46***
C X S		4	93301.77	0.21
C X R		8	1367296.04	3.11**
S X R		2	329573.44	0.75
C X S X R		8	60164.96	0.14
TOTAL		172	439366.90	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 41 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	40	20	10	0	80	40	20	10	0
MEANS	600	938	1238	1438	2411	380	733	1008	1023	2042

Any two means not underscored by the same line are significantly different at $P < 0.05$.

greater than under programmed stimulus. There was a significant difference ($P < 0.001$) among the rats. The interaction between concentration and rat was significant ($P < 0.01$) but none of the other interactions had a significant relationship ($P > 0.05$).

According to ANOVA, the grams of absolute ethanol ingested was significantly affected ($P < 0.001$) by the various concentrations of ethanol. The data and analyses are presented in Table 42. Further analysis by DMRT showed a progressive increase in grams of ethanol consumed with increasing concentrations of ethanol solutions. Under self-produced stimulus, there was no significant difference ($P > 0.05$) between the 10% and 20% concentrations nor between the 40% and 80% concentrations but both 40% and 80% were significantly greater ($P < 0.05$) than the two lower concentrations, 10% and 20%. Under programmed stimulus, there was no significant difference ($P > 0.05$) between the 10% and 20% concentrations nor between the 20%, 40% and 80% concentrations but both the 40% and 80% concentrations were significantly greater ($P < 0.05$) than the 10% concentration. According to ANOVA, there was a significant difference ($P < 0.01$) between the two stimulus conditions and according to the data of Table 42, more ethanol was consumed under the self-produced stimulus than the programmed stimulus. There was a significant difference ($P < 0.05$) among the rats. There was a significant relationship ($P < 0.001$) in the concentration and rat interaction. None of the other interactions showed any significant relationship ($P > 0.05$).

Inconsequential Licking

According to ANOVA, inconsequential licking rates were significantly affected ($P < 0.001$) by the substitution of ethanol

TABLE 42

GRAMS OF ETHANOL INGESTED UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-41,42,43, WITH FOOD PELLETS AVAILABLE.

CONC(%V/V)		Z-41 N	Z-41 SPS	Z-41 PS	Z-42 N	Z-42 SPS	Z-42 PS	Z-43 N	Z-43 SPS	Z-43 PS
0	$\bar{X}$	-	-	-	-	-	-	-	-	-
	SE	-	-	-	-	-	-	-	-	-
10	$\bar{X}$	5	0.43	0.29	7	0.74	0.57	7	0.29	0.18
	SE		0.09	0.10		0.12	0.13		0.11	0.07
20	$\bar{X}$	5	0.45	0.53	7	1.15	0.87	7	0.83	0.63
	SE		0.13	0.22		0.19	0.13		0.24	0.18
40	$\bar{X}$	7	0.94	0.67	6	1.93	1.32	6	1.05	1.08
	SE		0.08	0.14		0.35	0.25		0.28	0.21
80	$\bar{X}$	7	1.37	0.75	7	1.32	0.50	5	2.51	2.24
	SE		0.33	0.42		0.17	0.21		0.41	0.47

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	5.60	16.58***
STIMULUS SEGMENT	(S)	1	3.33	9.87**
RAT	(R)	2	1.43	4.24*
C X S		4	0.22	0.64
C X R		8	1.86	5.50***
S X R		2	0.98	2.92
TOTAL		128	0.34	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 42 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0	10	20	40	80	0	10	20	40	80
MEANS	-	0.49	0.85	1.29	1.65	-	0.35	0.69	1.01	1.04

Any two means not underscored by the same line are significantly different at $P < 0.05$.

solutions for water. The data and analyses are presented in Table 43. Further analysis by DMRT showed a progressive decrease in inconsequential licking rates with increasing concentrations of ethanol. All concentrations of ethanol produced a significant decrease ($P < 0.05$) in inconsequential licking rates as compared to water. None of the effects produced by the ethanol solutions were significantly different ($P > 0.05$) from each other. According to ANOVA, there was no significant difference ($P > 0.05$) among the rats nor in the concentration and rat interaction.

Consequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, consequential left lever pressing for secondary reinforcement was significantly affected ($P < 0.001$) by the substitution of ethanol solutions for water. The data and analyses are presented in Table 44. Further analysis by DMRT showed decreased rates with increased ethanol solutions. All solutions produced a significant decrease ($P < 0.05$) in rates when compared to water. None of the effects produced by the ethanol solutions were significantly different ($P > 0.05$) from each other. According to ANOVA, there was a significant difference ($P < 0.01$) among the rats and non significant relationship ($P > 0.05$) in the interaction between concentration and rats.

Inconsequential Left Lever Pressing For Secondary Reinforcement

According to ANOVA, inconsequential left lever pressing rates were not significantly affected ($P > 0.05$) by the substitution

TABLE 43

EFFECT OF ETHANOL SELF-INGESTION ON INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED STIMULUS(SPS) IN RATS Z-41,42,43, WITH FOOD PELLETS AVAILABLE.

CONC(%V/V)		Z-41 N	Z-41 SPS	Z-42 N	Z-42 SPS	Z-43 N	Z-43 SPS
0	$\bar{X}$	9	17.22	8	14.88	8	12.12
	SE		3.68		4.03		3.11
10	$\bar{X}$	5	6.80	7	9.29	7	3.35
	SE		2.13		1.52		0.96
20	$\bar{X}$	5	4.20	7	4.14	7	7.29
	SE		1.24		0.99		1.67
40	$\bar{X}$	7	3.35	6	4.33	6	3.00
	SE		0.36		0.67		0.58
80	$\bar{X}$	7	2.57	7	2.71	5	5.20
	SE		0.78		0.42		1.83

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	520.10	15.06***
RAT	(R)	2	10.83	0.31
C X R		8	35.27	1.02
ERROR		86	34.53	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 43 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	80	40	20	10	0
MEANS	3.32	3.55	5.32	6.44	14.84

Any two means not underscored by the same line are significantly different at P <0.05.

TABLE 44

EFFECT OF ETHANOL SELF-INGESTION ON INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED STIMULUS(SPS) IN RATS Z-41,42,43, WITH FOOD PELLETS AVAILABLE.

		Z-41		Z-42		Z-43	
CONC(%V/V)		N	SPS	N	SPS	N	SPS
0	$\bar{X}$	9	8.30	8	15.55	8	13.28
	SE		1.35		4.55		2.69
10	$\bar{X}$	5	2.94	7	9.66	7	2.26
	SE		0.80		1.66		0.88
20	$\bar{X}$	5	1.69	7	6.29	7	7.50
	SE		0.37		2.07		2.95
40	$\bar{X}$	7	1.73	6	4.48	6	4.24
	SE		0.24		1.15		1.41
80	$\bar{X}$	7	1.88	7	1.69	5	5.43
	SE		0.58		0.21		1.47

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	334.02	11.19***
RAT	(R)	2	156.01	5.23**
C X R		8	38.53	1.29
ERROR		86	29.85	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 44 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	80	40	10	20	0
MEANS	2.74	3.39	5.17	5.52	12.21

Any two means not underscored by the same line are significantly different at $P < 0.05$.

of solutions of ethanol for water. The data and analysis are presented in Table 45. There was a significant difference ($P < 0.001$) between the two stimulus conditions and according to the data of Table 45, the rates were higher under self-produced stimulus than programmed stimulus. There was no significant difference ($P > 0.05$) among the rats. A significant relationship ($P < 0.05$) exists in the concentration and rat interaction, but all other possible interactions were not significant ($P > 0.05$).

Right Lever Pressing For Food Pellets

According to ANOVA, the substitution of solutions of ethanol for water had a significant effect ($P < 0.001$) on the total right lever rate for food pellets. Food pellets were available on a FI-60 second schedule so these rates reflect all responding on the right lever, both inconsequential and consequential. The data and analyses are presented in Table 46. Further analysis by DMRT showed there was no significant difference ($P > 0.05$) in responding between the ethanol concentrations and water under self-produced stimulus, while under programmed stimulus the only significant difference ($P < 0.05$) was in a higher rate under 80% ethanol as compared to water. According to ANOVA, there was no significant difference ($P > 0.05$) between stimulus conditions. There was a significant difference ($P < 0.001$) among the rats and in the interaction between concentration and rat ($P < 0.05$). None of the other possible interactions showed any significant relationships ($P > 0.05$).

When just consequential right lever responses were considered, there was no significant effect ($P > 0.05$) in rates when ethanol was

TABLE 45

EFFECT OF ETHANOL SELF-INGESTION ON INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED(SPS) AND PROGRAMMED STIMULUS(PS) IN RATS Z-41,42,43, WITH FOOD PELLETS AVAILABLE.

		Z-41			Z-42			Z-43	
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0	$\bar{X}$	9	3.49	0.61	8	2.46	0.63	8	1.98	0.00
	SE		0.68	0.38		0.40	0.52		0.31	0.00
10	$\bar{X}$	5	1.24	0.45	7	5.16	0.46	7	4.63	1.29
	SE		0.32	0.30		1.28	0.35		3.10	1.29
20	$\bar{X}$	5	1.35	1.72	7	4.23	0.84	7	0.78	0.07
	SE		0.23	1.42		1.10	0.37		0.37	0.07
40	$\bar{X}$	7	2.06	0.43	6	4.53	0.05	6	0.46	0.00
	SE		0.47	0.39		1.26	0.05		0.16	0.00
80	$\bar{X}$	7	2.41	0.11	7	2.07	0.00	5	3.84	0.40
	SE		0.37	0.07		0.27	0.00		1.89	0.40

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	6.87	1.35
STIMULUS SEGMENT	(S)	1	266.73	52.34***
RAT	(R)	2	9.50	1.86
C X S		4	3.83	0.75
C X R		8	10.71	2.10*
S X R		2	11.56	2.26
C X S X R		8	6.82	1.34
ERROR		172	5.10	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 45 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	20	40	80	0	10	80	40	0	10	20
MEANS	2.20	2.33	2.66	2.68	3.93	0.14	0.17	0.42	0.76	0.79

Any two means not underscored by the same line are significantly different at $P \leq 0.05$.

TABLE 46

EFFECT OF ETHANOL SELF-INGESTION ON RIGHT LEVER PRESSING FOR FOOD PELLETS [DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS] IN RATS Z-41,42,43.

		Z-41			Z-42			Z-43		
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0	$\bar{X}$	9	1.78	0.63	8	5.86	5.75	8	3.00	2.38
	SE		0.35	0.27		1.19	1.01		0.49	0.62
10	$\bar{X}$	5	2.58	0.73	7	7.23	6.31	7	2.29	2.35
	SE		0.32	0.36		1.07	1.24		0.57	0.68
20	$\bar{X}$	5	3.27	3.20	7	10.81	9.42	7	1.99	1.09
	SE		1.20	1.78		2.24	2.38		0.67	0.57
40	$\bar{X}$	7	2.42	0.92	6	9.24	9.94	6	2.86	2.54
	SE		0.52	0.45		2.00	3.02		0.80	0.68
80	$\bar{X}$	7	3.51	2.15	7	9.18	13.23	5	4.48	2.72
	SE		0.47	0.98		1.51	3.01		0.73	0.88

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	52.09	4.70***
STIMULUS SEGMENT	(S)	1	12.58	1.13
RAT	(R)	2	936.52	84.46***
C X S		4	2.30	0.21
C X R		8	24.01	2.16*
S X R		2	10.23	0.92
C X S X R		8	6.36	0.57
ERROR		172	11.09	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 46 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0	10	40	20	80	0	10	40	20	80
MEANS	3.47	4.19	4.71	5.57	6.09	2.83	3.38	4.28	4.72	6.38

Any two means not underscored by the same line are significantly different at $P < 0.05$.

substituted according to ANOVA. The data and analysis is presented in Table 47. As with total right lever rates there was no significant difference ($P > 0.05$) between the two stimulus conditions. There was a significant difference ($P < 0.001$) among the rats as well. There was a significant effect ($P < 0.05$) in the stimulus and rat interaction, but none of the possible interactions showed any significant ($P > 0.05$) relationships.

Effects of Oral Ethanol Injections

The three rats, Z-53, Z-54 and Z-55, selected for the study of effects of ethanol injections were trained in the usual manner on three operant schedules. Once trained, the rats were allowed ad lib access to a 20% v/v solution of ethanol in their home cages for the duration of the experiments of about 30 days. During this time, the rats were given access to either water or a solution of ethanol 40% v/v for licking in the behavior boxes and superimposed on this, the rats were randomly injected orally with a dose of 12ml/kg of a 50% v/v ethanol solution, 15 minutes before drug session. The results of this experiment have been analyzed in the following manner:

Comparison of water or ethanol licking without ethanol injections.

Comparison of the effects of ethanol injections on water licking.

Comparison of the effects of ethanol injections on ethanol licking.

Comparison of the effects of ethanol injections on water and ethanol licking.

TABLE 47

EFFECT OF ETHANOL SELF-INGESTION ON CONSEQUENTIAL RIGHT LEVER RATE FOR FOOD PELLETS UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN RATS Z-41,42,43.

		Z-41			Z-42			Z-43	
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
0	$\bar{X}$	9	0.31	0.27	8	0.64	0.86	8	0.69	0.57
	SE		0.10	0.10		0.10	0.11		0.08	0.14
10	$\bar{X}$	5	0.57	0.31	7	0.85	0.85	7	0.58	0.71
	SE		0.05	0.09		0.04	0.08		0.09	0.15
20	$\bar{X}$	5	0.31	0.40	7	0.71	1.02	7	0.49	0.33
	SE		0.14	0.20		0.10	0.05		0.17	0.13
40	$\bar{X}$	7	0.43	0.39	6	0.58	0.94	6	0.46	0.68
	SE		0.12	0.13		0.16	0.10		0.13	0.11
80	$\bar{X}$	7	0.72	0.55	7	0.82	0.88	5	0.65	0.48
	SE		0.05	0.20		0.14	0.21		0.16	0.16

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	0.16	1.52
STIMULUS SEGMENT	(S)	1	0.05	0.43
RAT	(R)	2	2.72	25.27***
C X S		4	0.10	0.88
C X R		8	0.13	1.19
S X R		2	0.34	3.15*
C X S X R		8	0.07	0.63
ERROR		172	0.11	-

*Significant at P < 0.05
**Significant at P < 0.01
***Significant at P < 0.001

TABLE 47 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	40	20	0	10	80	0	20	80	40	10
MEANS	0.49	0.53	0.54	0.68	0.74	0.55	0.60	0.65	0.66	0.67

Any two means not underscored by the same line are significantly different at $P < 0.05$.

Effect of Water or Ethanol Licking Without Ethanol Injection

The results for all variables for the three rats combined are presented and analyzed by Students t Test in Table 48. Total right lever pressing (consequential and inconsequential) for food pellets and increased significantly ($P < 0.01$) under self-produced stimulus during ethanol ingestion. There was no significant difference ($P > 0.05$) under programmed stimulus. There was no significant effect ($P > 0.05$) on consequential right lever pressing for food pellets under either stimulus condition. During ethanol ingestion, there was a significant decrease ($P < 0.001$) in consequential left lever pressing for second reinforcement under self-produced stimulus while inconsequential left lever pressing was not significantly affected ($P > 0.05$) by ethanol during either stimulus condition. Ethanol produced a significant reduction ($P < 0.001$) in consequential licking rates, amount of time spent in licking and amount of fluid consumed under both stimulus conditions. The inconsequential licking rate was likewise significantly reduced ($P < 0.001$) by ethanol.

Effects of Ethanol Injection on Water Licking

The results for all variables for the three rats combined are presented and analyzed by Students t Test in Table 49. With the exception of total right lever pressing, all variables were significantly reduced at a probability value between ($P < 0.025$ - $P < 0.001$) by ethanol pretreatment. Total right lever pressing for food pellets was not significantly affected ($P > 0.05$) by ethanol pretreatment.

TABLE 48

EFFECTS OF SELF-INGESTION OF WATER AND ETHANOL (40% V/V). COMBINED DATA FOR RATS Z-53, Z-54, Z-55 IS EXPRESSED AS MEANS, STANDARD ERROR AND TOTAL NUMBER OF SESSIONS.

Stimulus Condition	RESPONSES / MINUTE: Water Ingestion	Ethanol Ingestion	p [a]
	Total Right Lever		
SPS [b]	1.88±0.40(18)	3.37±0.60(21)	<0.01
PS [c]	1.80±0.46(18)	1.67±0.62(21)	>0.05
	Consequential Right Lever		
SPS	0.75±0.05(18)	0.83±0.04(21)	>0.05
PS	0.62±0.10(18)	0.55±0.11(21)	>0.05
	Consequential Left Lever		
SPS	9.20±1.28(18)	1.10±0.17(21)	<0.001
	Inconsequential Left Lever		
SPS	4.41±0.79(18)	3.70±0.82(21)	>0.05
PS	1.18±0.35(18)	0.47±0.28(21)	>0.05
	Consequential Licking		
SPS	149.56±8.96(18)	5.24±1.27(21)	<0.001
PS	123.39±10.96(18)	3.95±3.08(21)	<0.001
	Minutes		
SPS	8.40±0.41(18)	2.18±0.30(21)	<0.001
PS	9.32±0.49(18)	1.64±0.36(21)	<0.001

TABLE 48 - CONTINUED

	Drops		
SPS	1263±87(18)	13.14±3.63(21)	<0.001
PS	1168±121(18)	8.62±6.14(21)	<0.001
	Inconsequential Licking		
SPS	9.06±1.06(18)	3.59±1.00(21)	<0.001

a Probability value based on student's t test
b SPS - Self Produced Stimulus
c PS - Programmed Stimulus

TABLE 49

EFFECTS OF ORAL INJECTIONS OF ETHANOL (12 ML/KG, OF A 50% V/V SOLUTION, 15 MINUTE PRETREATMENT) ON SELF-INGESTION OF WATER. COMBINED DATA FOR RATS Z-53, Z-54, Z-55 IS EXPRESSED AS MEANS, STANDARD ERROR AND TOTAL NUMBER OF SESSIONS.

Stimulus Condition	RESPONSES / MINUTE: No Injection	Ethanol Injection	p [a]
	Total Right Lever		
SPS [b]	1.88±0.40(18)	1.76±0.67(13)	>0.05
PS [c]	1.80±0.46(18)	1.60±0.80(13)	>0.05
	Consequential Right Lever		
SPS	0.75±0.05(18)	0.52±0.11(13)	<0.025
PS	0.62±0.10(18)	0.27±0.11(13)	<0.025
	Consequential Left Lever		
SPS	9.20±1.28(18)	3.32±1.86(13)	<0.01
	Inconsequential Left Lever		
SPS	4.41±0.79(18)	1.52±0.50(13)	<0.005
PS	1.18±0.35(18)	0.09±0.05(13)	<0.01
	Consequential Licking		
SPS	149.56±8.96(18)	72.38±24.31(13)	<0.005
PS	123.39±10.96(18)	67.08±26.08(13)	<0.025
	Minutes		
SPS	8.40±0.41(18)	2.89±1.02(13)	<0.001
PS	9.32±0.49(18)	2.97±1.10(13)	<0.001

TABLE 49 - CONTINUED

	Drops		
SPS	1263±87(18)	479±203(13)	<0.001
PS	1168±121(18)	521±260(13)	<0.01
	Inconsequential Licking		
SPS	9.06±1.06(18)	4.08±2.05(13)	<0.025

a Probability value based on students t test

b SPS - Self Produced Stimulus

c PS - Programmed Stimulus

Effects of Ethanol Injection on Ethanol Licking

The results for the three rats combined are presented and analyzed by Students t Test in Table 50. With the exception of consequential right lever pressing under self-produced stimulus and inconsequential licking rates under self-produced stimulus, there were no significant differences ($P > 0.05$) in any of the variables before or after ethanol injection with ethanol was available for licking. Consequential right lever pressing for food pellets during self-produced stimulus was significantly reduced ($P < 0.01$) as was inconsequential licking ($P < 0.05$) by ethanol injections.

Effects of Ethanol Injection on Water and Ethanol Licking

The results for the three rats combined are presented and analyzed by Students t Test in Table 51. With the exception of consequential licking rate and drops of fluid delivered, there were no significant differences ($P > 0.05$) in any of the other variables between ethanol injection sessions when water or ethanol was available for licking. Consequential licking rates were significantly lower during ethanol licking in the self-produced stimulus ($P < 0.01$) and the programmed stimulus ($P < 0.025$). Drops of fluid delivered were also significantly lower during ethanol licking in the self-produced stimulus ($P < 0.025$) and the programmed stimulus ($P < 0.05$).

Disulfiram Effects on Ethanol Ingestion

The effect of disulfiram on ingestion of ethanol (20% v/v) in rats Z-59, 60, 61 is seen in Figure 21. The cumulative records on

TABLE 50

EFFECTS OF ORAL INJECTIONS OF ETHANOL (12 ML/KG, OF A 50% V/V SOLUTION, 15 MINUTE PRETREATMENT) ON SELF-INGESTION OF ETHANOL (40% V/V). COMBINED DATA FOR RATS Z-53, Z-54, Z-55 IS EXPRESSED AS MEANS, STANDARD ERROR AND TOTAL NUMBER OF SESSIONS.

Stimulus Condition	RESPONSES / MINUTE: No Injection	Ethanol Injection	p [a]
	Total Right Lever		
SPS [b]	3.37±0.60(21)	2.78±1.09(11)	NS [d]
PS [c]	1.67±0.62(21)	1.81±0.76(11)	NS
	Consequential Right Lever		
SPS	0.83±0.04(21)	0.61±0.09(11)	<0.01
PS	0.55±0.11(21)	0.45±0.09(11)	NS
	Consequential Left Lever		
SPS	1.10±0.17(21)	0.67±0.27(11)	NS
	Inconsequential Left Lever		
SPS	3.70±0.82(21)	4.63±1.65(11)	NS
PS	0.47±0.28(21)	0.36±0.21(11)	NS
	Consequential Licking		
SPS	5.24±1.27(21)	2.82±0.78(11)	NS
PS	3.93±3.08(21)	0.27±0.14(11)	NS
	Minutes		
SPS	2.18±0.30(21)	1.35±0.45(11)	NS
PS	1.64±0.36(21)	1.28±0.56(11)	NS

TABLE 50 - CONTINUED

	Drops		
SPS	13.14±3.63(21)	4.73±1.69(11)	NS
PS	8.62±6.14(21)	0.91±0.55(11)	NS
	Grams of Absolute Ethanol		
SPS	0.018±0.005(21)	0.006±0.002(11)	NS
PS	0.012±0.008(21)	0.001±0.001(11)	NS
	Inconsequential Licking		
SPS	3.59±1.00(21)	1.00±0.38(11)	<0.05

a Probability value based on students t test.

b SPS-Self Produced Stimulus

c PS - Programmed Stimulus

d Probability value of >0.05.

TABLE 51

EFFECTS OF ORAL INJECTIONS OF ETHANOL (12 ML/KG, OF A 50% V/V SOLUTION, 15 MINUTE PRETREATMENT) ON SELF-INGESTION OF ETHANOL (40% V/V) AND WATER. COMBINED DATA FOR RATS Z-53, Z-54, Z-55 IS EXPRESSED AS MEANS, STANDARD ERROR AND TOTAL SESSIONS.

Stimulus Condition	RESPONSES / MINUTE: Water Ingestion	Ethanol Ingestion	p [a]
	Total Right Lever		
SPS [b]	1.76±0.67(13)	2.78±1.09 (11)	NS [d]
PS [c]	1.60±0.80(13)	1.81±0.76(11)	NS
	Consequential Right Lever		
SPS	0.52±0.11(13)	0.61±0.09(11)	NS
PS	0.27±0.11(13)	0.45±0.08(11)	NS
	Consequential Left Lever		
SPS	3.32±1.86(13)	0.67±0.26(11)	NS
	Inconsequential Left Lever		
SPS	1.52±0.50(13)	4.63±1.65(11)	NS
PS	0.09±0.05(13)	0.36±0.21(11)	NS
	Consequential Licking		
SPS	72.38±24.31(13)	2.82±0.78(11)	<0.01
PS	67.08±26.08(13)	0.78±0.14(11)	<0.025
	Minutes		
SPS	2.89±1.02(13)	1.35±0.45(11)	NS
PS	2.97±1.10(13)	1.28±0.56(11)	NS

TABLE 51 - CONTINUED

	Drops		
SPS	478.54±202.56(13)	4.73±1.68(11)	<0.025
PS	520.85±259.82(13)	0.91±0.55(11)	<0.025
	Inconsequential Licking		
SPS	4.08±2.05(13)	1.00±0.38(11)	NS

a Probability value based on students t test.

b SPS Self Produced Stimulus

c PS Programmed Stimulus

d Probability value of > 0.05.

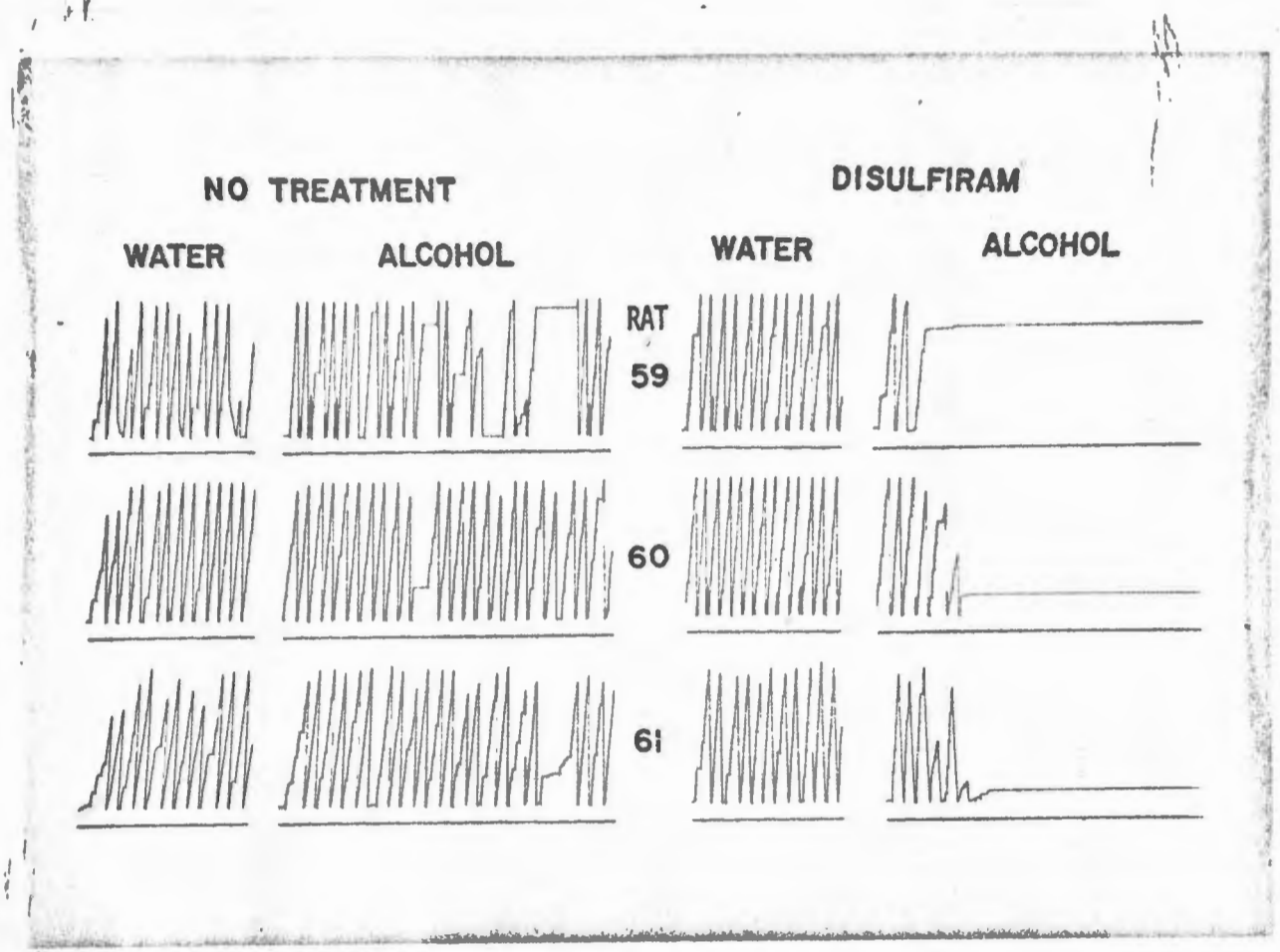

Figure 21. Effect of disulfiram injection (50 mg/kg, i.p.) given 60 minutes before alcohol session, on self-ingestion of alcohol (20% v/v) during 60 minute sessions in Rats Z-59,Z-60,Z-61. Cumulative records on the left are predrug and alcohol sessions without disulfiram, and records on the right are the alcohol sessions after disulfiram pretreatment, along with predrug session. Complete explanation of the cumulative records is presented in Figure 4.

the left under "no treatment" are of water and ethanol ingestion on the day preceeding the start of disulfiram treatment. These rats were run for five days on ethanol before the start of disulfiram treatment. The water records indicate the three rats were licking for water at a sustained high rate for the entire 30 minute session; the ethanol records likewise indicate a sustained, high licking rate for ethanol for the entire 60 minute session. On the right are records of the effect of the first injection of disulfiram (50mg/kg, i.p., 60 minutes before the ethanol session) on licking for ethanol. The three rats under the influence of disulfiram began licking for ethanol at a high rate, then ceased licking abruptly after about 15-20 minutes and did not resume for the remainder of the session. The effect of disulfiram on drops of ethanol consumed during the 60 minute sessions is presented in the lower half of Figure 22. Day 1 was the last session before disulfiram effects. Days 2 - 7 were consecutive days on which disulfiram was administered and the amount of ethanol is far below that of day 1. Days 8 - 10 were consecutive days following disulfiram treatment and the amount of ethanol consumed was similar to that when disulfiram was administered. The corresponding predrug (water) 30 minute sessions are presented in the upper half of Figure 22. The amount of water consumed in predrug sessions on days when disulfiram was administered did not vary appreciably from day 1 before the start of disulfiram; similar results were seen for the three post disulfiram days.

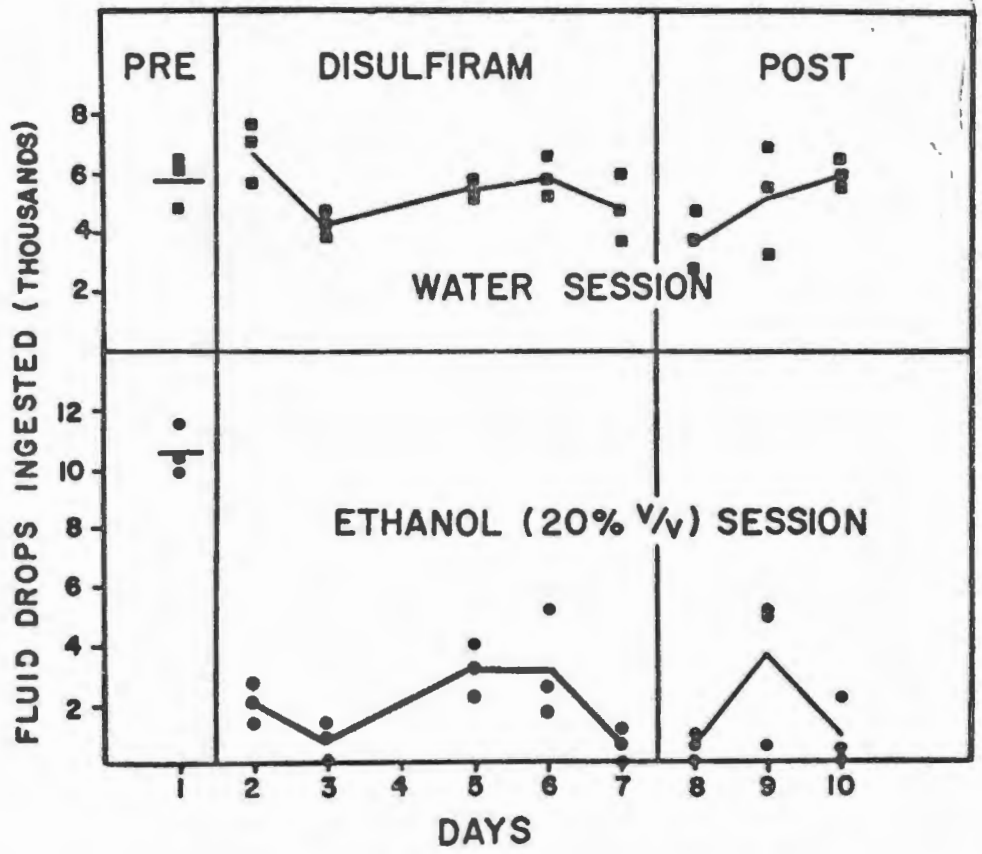

Figure 22. Effect of disulfiram (50 mg/kg, i.p.) on drops of ethanol (20% v/v) consumed during 60 minute sessions (lower half of figure) in Rats Z-59, Z-60, Z-61. Day one is last session before disulfiram, days 2-7 are consecutive days of disulfiram treatment, days 8-10 are consecutive days following disulfiram treatment. Corresponding predrug (water) sessions (30 min.) are presented in upper half of figure.

MORPHINE

Deprivation of Daily Injection

Water Self-Ingestion

The rats used in this study were maintained on a daily dose of morphine (200 mg/kg). The effect of withholding this daily injection for four days on consequential licking rates for water is presented in Figure 23 and rats Z-44, and Z-45. In each rat, there was a decrease on day 1 with a gradual increase over the next four days. A similar effect was seen in rats Z-47, Z-49 (Figure 24) which also had food pellets available on a FI-60 schedule on the right lever. When the amount of time spent in licking is considered, a marked increase appeared at 24 hours for rats Z-44 and Z-45 (Figure 25) as well as for rats Z-47 and Z-49 (Figure 26).

Amphetamine Self-Ingestion

The substitution of a solution of amphetamine (0.5mM) for water during the deprivation period produced a marked decrement as can be seen from the cumulative records for rat Z-49 at the top of Figure 27. The consequential licking rates for amphetamine are well below those for water in rats Z-44 and Z-45 (Figure 23) and in rats Z-47 and Z-49 (Figure 24). When the amount of time in licking is examined, it is lower for amphetamine than water for the first three days of deprivation, then the time spent in licking for amphetamine increases to almost the same as for water, Z-44 and Z-45, Figure 23, Z-47 and Z-49, Figure 24.

Ethanol Self-Ingestion

A solution of ethanol (80% v/v) was substituted for water during

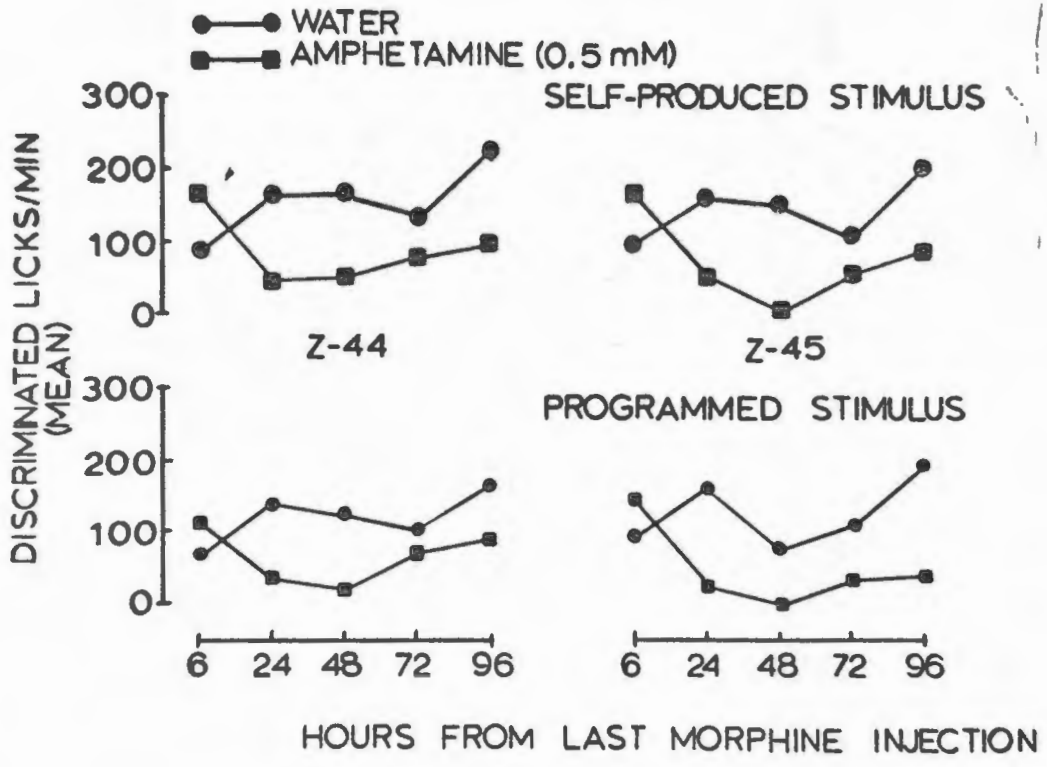

Figure 23. Effect of withholding daily morphine injection (200 mg/kg, i.p.) for four consecutive days on consequential licking rates for water and amphetamine (0.5 mM) under self-produced and programmed stimulus in morphine dependent Rats Z-44 and Z-45.

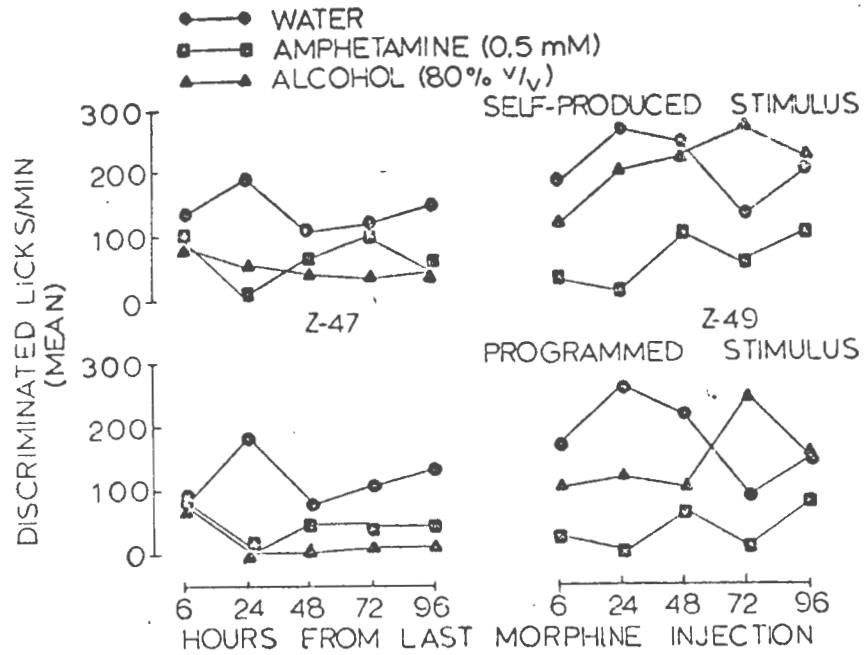

Figure 24. Effect of withholding daily morphine injection (200 mg/kg,i.p.) for four consecutive days on consequential licking rates for water, amphetamine (0.5 mM) and alcohol (80% v/v) under self-produced and programmed stimulus in morphine dependent rats Z-47 and Z-49. Food pellets were concurrently available on FI-60'' right lever pressing.

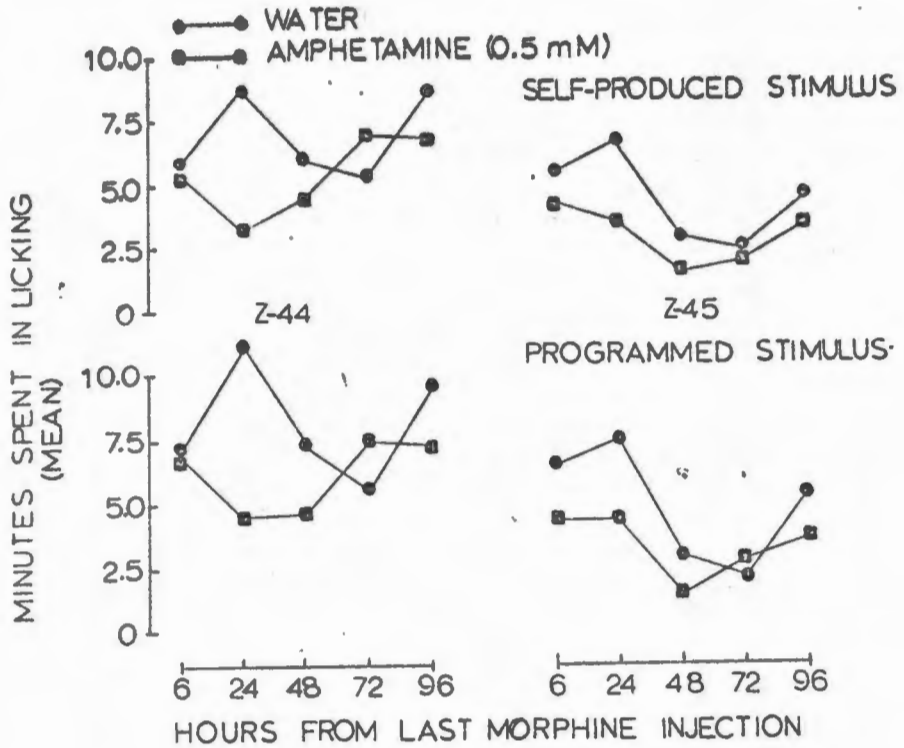

Figure 25. Effect of withholding daily morphine injection (200 mg/kg, i.p.) for four consecutive days on minutes spent in consequential licking for water and amphetamine (0.5mM) under self-produced and programmed stimulus in morphine dependent rats Z-44 and Z-45.

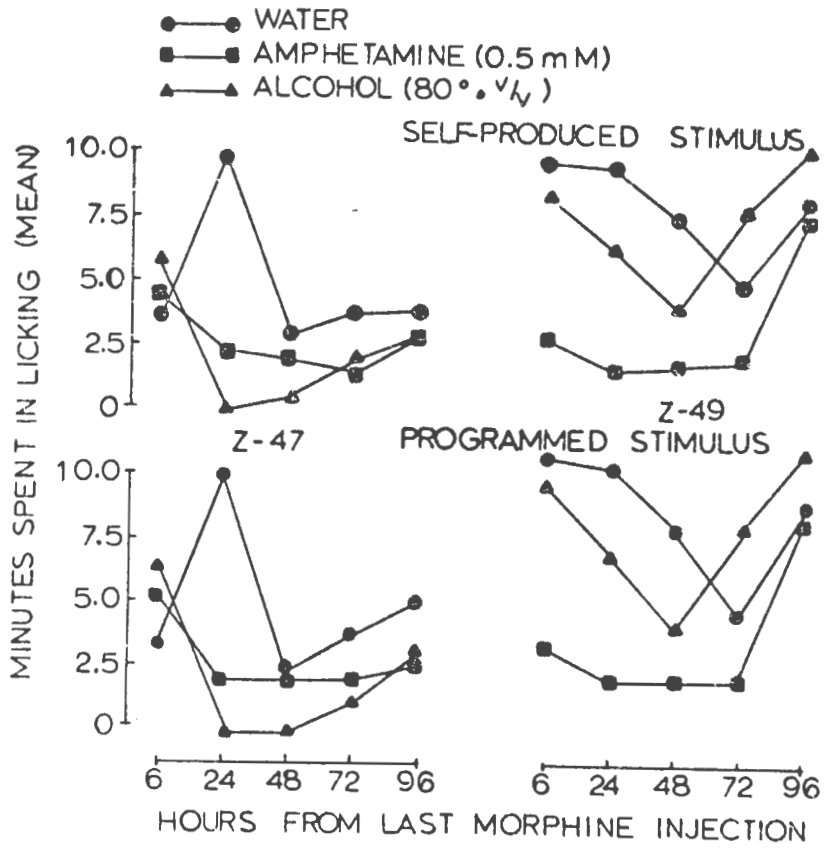

Figure 26. Effect of withholding daily morphine injection (200 mg/kg, i.p.) for four consecutive days on minutes spent in consequential licking for water, amphetamine (0.5 mM) and alcohol (80% v/v) under self-produced and programmed stimulus in morphine dependent rats Z-47 and Z-49. Food pellets were concurrently available on FI-60" right lever pressing.

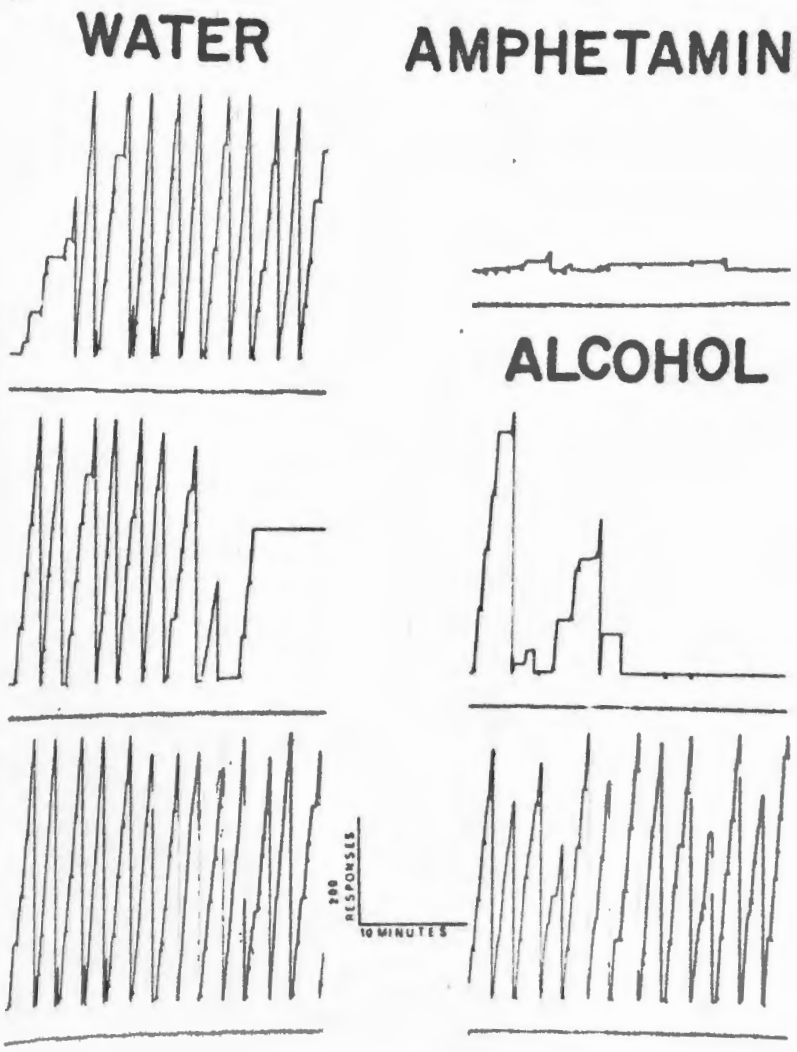

Figure 27.

Top- Effect of first day of withdrawalof daily morphine injection (200 mg/kg) on water ingestion (left side) and amphetamine (0.5mM) ingestion (right side) in morphine dependent rat Z-49.

Center- Effect of first day of withdrawal of daily morphine injection (200 mg/kg) on water ingestion (left side) and alcohol (80% v/v) ingestion (right side) in morphine dependent rat Z-49.

Bottom- Effect of second day of withdrawal of daily morphine injection (200 mg/kg) on water ingestion (left side) and alcohol (80 %) ingestion (right side) in morphine dependent rat Z-49. Complete explanation of cumulative records is presented in Figure 4.

the deprivation period in rats Z-47 and Z-49. Cumulative records for the first two days are presented in the lower two thirds of Figure 27. On the first day, the responses were very low, but greatly increased on the second day. In rat Z-47, the consequential licking rates for ethanol were lower than for either water or amphetamine (Figure 24). Similar results were observed in amount of time spent in consequential licking (Figure 26). In Z-49 however, the consequential licking rate was higher for amphetamine and by 96 hours of morphine deprivation was higher than for water (Figure 24). Similar results were observed for amount of time spent in consequential licking (Figure 26).

Effect of Nalorphine Injection

The effect of nalorphine injection was investigated in rats Z-44, Z-45, Z-47, Z-49 which were receiving a daily dose of 200mg/kg of morphine. A dose of 2mg/kg of nalorphine was ineffective in all four rats and this effect is presented for rat Z-44 in the upper half of Figure 28. The effect of 4mg/kg of nalorphine is presented for rat Z-44 in the lower half of Figure 28. At this dose, nalorphine, abolished all responding in rat Z-44. The data for the effect of 4mg/kg of nalorphine in each of the four rats is presented and analyzed by "t" test in Table 52.

In rat Z-44, nalorphine injections resulted in a significant decrease (at least $P < 0.05$) in consequential left lever rate, consequential licking rate, drops of fluid delivered, minutes spent in licking and inconsequential licking rate under self-produced stimulus. Under programmed stimulus, consequential licking rate, drops of fluid delivered and minutes spent in licking were significantly decreased ($P < 0.001$).

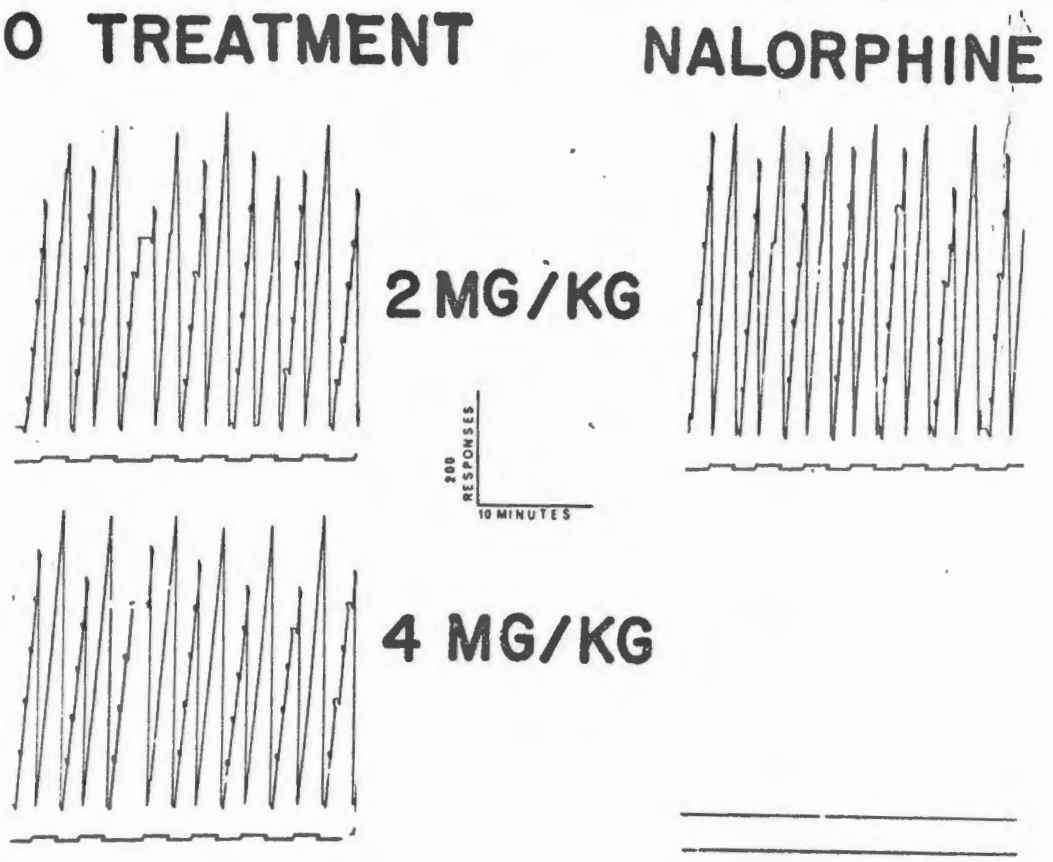

Figure 28. Effect of nalorphine injection of 2 mg/kg (upper half of figure) and 4 mg/kg (lower half of figure) made 30 minutes before drug sessions (right side) on licking and lever pressing in morphine dependent rat Z-44. Corresponding predrug sessions (left side) were obtained four hours earlier, four hours after daily morphine injection (200 mg/kg). Complete explanation of cumulative records is presented in Figure 4.

TABLE 52

EFFECT OF NALORPHINE PRETREATMENT (4 MG/KG, I.P., 60 MINUTES PRIOR TO SESSION) ON BEHAVIOR (RESPONSES/MINUTE) IN RATS Z-44, Z-45, Z-47, Z-49 WHICH WERE CHRONICALLY RECEIVING DAILY INJECTIONS OF MORPHINE (200 MG/KG, I.P.).

				RESPONSES / MINUTE							
NALORPHINE PRETREATMENT	STIMULUS CONDITION		N[a]	RL-T[b]	RL-C[c]	LL-C[d]	LL-I[e]	LIC-C[f]	DROP[g]	MIN.[h]	LIC-I[i]
						RAT Z-44[l]					
NO	SPS[j]	$\bar{X}$	8	0.03	-	21.31	1.60	200.88	2015	9.62	9.12
		SE		0.02		5.18	0.68	17.16	239	0.77	2.96
YES	"	$\bar{X}$	5	0.01	-	0.06[o]	0.57	0.00[p]	0.00[p]	0.07[p]	0.00[n]
		SE		0.01		0.04	0.57	0.00	0.00	0.07	0.00
NO	PS[k]	$\bar{X}$	8	0.04	-	0.60	0.60	169.12	1984	11.61	-
		SE		0.03			0.38	20.78	303	1.04	
YES	"	$\bar{X}$	5	0.00	-	-	0.00	0.00[p]	0.00[p]	0.00[p]	-
		SE		0.00			0.00	0.00	0.00	0.00	

TABLE 52 - CONTINUED

RAT Z-45[l]

NO	SPS	$\bar{X}$	6	0.05	-	21.87	1.48	237.83	2430	10.17	11.50
		SE		0.03		4.28	0.51	13.01	277	0.85	4.80
YES	"	$\bar{X}$	4	0.14	-	12.62	1.14	135.75	1158	6.05	15.50
		SE		0.14		9.53	0.57	60.60	620	2.43	12.93
NO	PS	$\bar{X}$	6	0.08	-	-	0.23	238.00	2746	9.92	-
		SE		0.05			0.18	11.79	279	1.72	
YES	"	$\bar{X}$	4	0.07	-	-	0.03	130.75	1319	7.04	-
		SE		0.07			0.03	58.37	738	2.88	

RAT Z-47[m]

NO	SPS	$\bar{X}$	6	1.46	0.66	12.58	1.37	232.67	1989	8.54	28.33
		SE		0.50	0.10	3.24	0.31	9.57	267	1.17	9.11
YES	"	$\bar{X}$	6	0.08[n]	0.04[p]	0.04[o]	0.00[o]	28.83[p]	9.50[p]	0.06[p]	0.08[n]
		SE		0.02	0.01	0.02	0.00	28.83	9.50	0.06	0.04
NO	PS	$\bar{X}$	6	0.27	0.38	-	0.48	226.67	2161	9.48	-
		SE		0.13	0.19		0.28	9.82	310	1.34	
YES	"	$\bar{X}$	6	0.00	0.00	-	0.00	0.00[p]	0.00[p]	0.00[p]	-
		SE		0.00	0.00		0.00	0.00	0.00	0.00	

TABLE 52 - CONTINUED

RAT Z-49[m]

NO	SPS	$\bar{X}$	9	1.01	0.39	49.72	6.25	224.44	2715	12.18	98.00
		SE		0.39	0.16	7.07	1.94	10.18	80	0.33	13.94
YES	"	$\bar{X}$	5	1.84	0.63	35.17	1.14[n]	282.60[n]	2961	10.61	83.60
		SE		0.68	0.17	11.32	0.62	18.04	434	1.49	23.30
NO	PS	$\bar{X}$	9	0.82	0.41	-	3.42	206.00	2939	14.30	-
		SE		0.47	0.19		1.27	10.51	162	0.47	
YES	"	$\bar{X}$	5	2.78	0.62	-	1.52	217.60	2596	11.83	-
		SE		1.24	0.16		0.72	22.44	490	1.50	

a Number of replicate sessions.
b RL-T Total right lever rate for food pellets.
c RL-C Consequential right lever rate for food pellets.
d LL-C Consequential left lever rate for secondary reinforcement.
e LL-I Inconsequential left lever rate for secondary reinforcement.
f LIC-C Consequential licking rate for water reinforcement.
g DROP Number of water reinforcements delivered
h MIN Minutes spent under stimulus conditions.
i LIC-I Inconsequential licking rate.
j SPS Self-produced stimulus segment.
k PS Programmed stimulus segment.
l Rats trained on two operant schedules.
m Rats trained on three operant schedules.
n Significant at probability of < 0.05.
o Significant at probability of < 0.01.
p Significant at probability of < 0.001.

In rat Z-45, nalorphine injections also resulted in decreased responding, but none of the effects were statistically significant ($P > 0.05$).

In rat Z-47, nalorphine injections also produced decreased responding or total abolition of responding and most of these effects were significant ($P < 0.05$).

In rat Z-49, the nalorphine injections were generally ineffective, with the exception of a significant decrease ($P < 0.05$) in inconsequential left lever rate under self-produced stimulus. Consequential licking rate under self-produced stimulus was even increased significantly ($P < 0.05$). Doses of 8 and 16mg/kg were also ineffective in rat Z-49.

V. DISCUSSION

Oral self-administration of drugs was studied using rats as experimental subjects. The use of experimental animals as subjects eliminated complications of psychological and personality factors which complicate studies with humans. Oral self-administration of drugs was studied since the drugs are commonly self-ingested and the results obtained could be more reliably extrapolated to human behavior. Oral self-administration via licking was selected for several reasons. Licking is a response in the rats' natural repertoire, is a rapidly acquired response and is a response which provided optimum high rates of responding. In addition, licking rates provided reliable and quantitative data with which to study oral self-administration of drugs.

Since drug use by humans is under the influence of complex controls as motivation, availability of drugs and availability of funding, the application of simultaneous multiple operants as utilized in these experiments afforded a means by which to evaluate the complex effects of self-administered drugs in the same subject. The measurement of licking behavior under two different stimulus conditions provided an indicator of motivation as well as motor ability. During the programmed stimulus phase, fluid was freely available to the rat while during the self-produced stimulus phase, the rat had to first perform five presses on the left lever in order to gain access to fluid from the licking spout. In some instances the right lever was programmed to deliver food pellets on a fixed interval schedule of one minute. Responding or lack of responding on the right lever provided data on the effects of drugs on food motivated behavior, fixed interval responding as well as motor ability. Since consequential as well as inconsequential re-

sponses were possible on licking or on either lever, the inconsequential responses were recorded as well and used as a measure of the disruptive effects of the drugs on the discriminative ability of the rats.

In order to assess the applicability of this simultaneous multiple operant design to the study of drug self-administration, several different drugs were investigated.

The first drug to be studied was dextro-amphetamine. Self-administration of solutions of amphetamine via the oral route was readily achieved in rats. Amphetamine ingestion resulted in a depression of licking following an initial period of normal licking. That licking persisted for several minutes before it was abruptly depressed is an indication that the taste of the solutions was not aversive. While oral ingestion of amphetamine produced a sudden depression in licking after a period of no effect, intraperitoneal injections of amphetamine caused a depression of behavior throughout the entire session. This suggested that a sufficient quantity of amphetamine had to be administered before pharmacological effects were exhibited.

The decrease in consequential licking rates, inconsequential licking rates and consequential left lever pressing for secondary reinforcement suggests a behavioral depression produced by amphetamine. These findings are similar with respect to response rate, to the works of Deneau et al (1969) and Pickens and Harris (1968) who studied intravenous self-administration of amphetamine in rats. When the magnitude of infusions was increased, the rate of lever pressing for intravenous infusion decreased in similar fashion to decreased response rates seen with increasing concentrations of amphetamine.

Non-discriminated aspects of responding as for secondary reinforce-

ment or food pellets increased with amphetamine. This appears to be the result possibly of motor hyperactivity and/or disruption of discrimination. A similar action of amphetamine was previously reported by Lal and Brown (1969), who demonstrated depression by amphetamine, of goal directed behavior and stimulation of irrelevant or purposeless behavior.

The complex behavioral effects of amphetamine are best evaluated by simultaneous multiple-operants as utilized in this study since the effect of amphetamine on behavior maintained by different reinforcers and different schedules of reinforcement was studied concurrently in the same subject. While amphetamine shows anorexic properties in a free eating situation (Epstein, 1959), consequential operant responding under the control of fixed-interval schedules for food pellets was unaffected by amphetamine in the present investigation. While other discriminated responses were reduced, the relevant responding on the right lever for food pellets was not so affected. Since responding on right lever was maintained by a fixed-interval schedule this observation is in agreement with that of Kelleher and Morse (1968), who reported an increased rate of lever pressing for food by amphetamine under a fixed-interval schedule, but depressed responding under fixed-ratio schedule. They concluded that the behavioral effects of amphetamine were controlled more by the contingencies of reinforcement than by the reinforcement itself.

Dews (1958) reported that amphetamine exerts its effect on schedule controlled behavior by increasing low rates of responding maintained by schedules such as the fixed interval and decreasing high rates of responding maintained by schedules such as fixed ratios. More recently Weiss (1970), has further examined the effect of amphetamine on schedule controlled behavior. Using interresponse time as the primary measure-

ment, he attributed the increased rate of responding during fixed interval schedules caused by amphetamine to decreased interresponse times early in the interval and decreased rate of responding during fixed ratio schedules to increased interresponse times during the first portion of the fixed ratio.

Drugs are rarely freely available to human addicts. More often than not, drugs are available at specific times and after completion of a specific task in order to obtain sufficient money to purchase drugs. The hypothesis that rats too will perform some task in order to gain access to drug solutions was tested in this study. The rats were required to press the left lever (FR-5 schedule) in order to attain an opportunity to obtain drug solutions. These results were then compared to the situation when fluid was freely provided. During predrug sessions when water was available for licking, the licking rates after lever pressing were always higher than when fluid was freely provided.

This effect was abolished when amphetamine was substituted for water in rats exposed to the two operant procedure both when they were normal as well as when they were chronically treated with amphetamine, but was not changed in rats which were exposed to the three operant procedure or in rats which were injected with amphetamine. In no instances were the licking rates higher when fluid was freely provided. Further examination of the data revealed that significantly more time was available for licking under the programmed stimulus than the self-produced stimulus in all groups of rats except the three operant group in which there was no difference. Also since there were no significant differences in the number of reinforcements obtained under either stimulus condition, the observed effects appear due to amphetamines effect on licking rates

rather than to some aspect of the experimental design. The interaction between concentration and stimulus was not significant when amphetamine was available for ingestion, but the interaction between dose and stimulus was significant when amphetamine was ingested, indicating that the differential dose effect depended upon the stimulus contingencies.

Inconsequential licking was decreased in all the studies with amphetamine whether it was ingested or injected. This appears to be an exception to the general rule that amphetamine increased irrelevant behavior and may be unique to the operant response of licking. Inconsequential licking could only occur during the self-produced stimulus so there is no stimulus comparison, but in no instance was there a significant interaction between either concentration or dose with rats indicating it was independent of any differences in the rats behavior.

Inconsequential left lever pressing for secondary reinforcement was consistently increased by amphetamine whether it was ingested or injected. Inconsequential left lever rates were also consistently greater under self-produced than programmed stimulus. This appears to be correlated with the fact that left lever pressing on a FR-5 schedule was an integral component of the self-produced stimulus and even during predrug sessions there was a significant increase in inconsequential responses during self-produced stimulus.

Following chronic treatment with amphetamine an apparent increased sensitivity to self-ingested amphetamine occurred in all responses. This increased sensitivity was manifested by a shift of the concentration response curves to lower concentrations. Following chronic treatment, the variability in responding between rats increased significantly indicating different degrees of animal susceptibility to chronic treat-

ment with amphetamine. A similar finding was reported by Schuster et al, (1966) for rats responding on complex schedules of reinforcement. Relatively little is know about the effects of long-term administration of amphetamine. Behavioral studies have revealed different changes in the response to stimulant drugs which develop during the course of chronic administration. These include no tolerance (Uehling, 1969) in measures of lever pressing (CRF schedule) for illumination change; tolerance (Schuster et al, 1966) as measured by lever pressing (FI or DRL schedules) for food reinforcement, and increase in magnitude of response (Kosman and Unna, 1968) as measured by spontaneous activity of rats injected chronically with d,l-amphetamine.

Inhibited metabolism of amphetamine by hepatic microsomal enzymes was ruled out as a possible mechanism for the increased sensitivity. The duration of hexobarbital narcosis was not significanlty different in control animals or rats chronically treated with amphetamine. Since hexobarbital is metabolized by hepatic microsomal enzymes (Cooper and Brodie, 1955), any changes in hepatic microsomal enzymes would have resulted in changes in the duration of hexobarbital narcosis. These results are substantiated by Lewander (1968) who found no evidence of an altered metabolic inactivation of amphetamine in chronically treated rats as measured by the pattern of distribution of urinary metabolites of injected radioactive amphetamine. Lal et al,(1970) have reported a decreased in vitro hepatic metabolism of hexobarbital by amphetamine in mice. This difference may be due to the fact that an acute rather than chronic dose of amphetamine was used. Since barbital is not metabolized (Dorfman and Goldbaum, 1947; Ebert et al, 1964) and duration of barbital narcosis was not significantly affected, there appears to be no change

in central nervous system sensitivity in these rats to barbiturates to explain the apparent increased sensitivity to ingested amphetamine. An alternate explanation might be an accumulation of amphetamine in these rats as a result of the combined oral ingestion and chronic daily injection of amphetamine.

In the present investigation, intraperitoneal injections of chlorpromazine markedly increased licking of amphetamine solutions. Since these drugs are presumed to have opposite actions on the adrenergic system, with chlorpromazine blocking (Brodie et al, 1959) and amphetamine potentiating (Hanson, 1966) the actions of catecholamines these findings of mutual antagonism might be expected. Schuster and Wilson (unpublished data) showed that chlorpromazine increased the intravenous self-administration of amphetamine by rhesus monkeys with indwelling intravenous catheters. Chlorpromazine has been reported to antagonize behavioral depression caused by amphetamine in a food reinforced operant in the rat (Brown, 1963) as well as in the pigeon (Davis, 1965). Glick and Jarvik (1969) reported an antagonism between the effects of amphetamine and chlorpromazine on delayed matching performance in monkeys. Maickel (1968) has shown that amphetamine will reverse the decrease in gross behavior and motor activity caused by chlorpromazine in rats.

Self-administration of ethanol via an oral route was also readily achieved in rats. As with amphetamine, the persistent licking for several minutes before depression of behavior suggest that the licking motivation was stronger than the aversion to taste until a high concentration of ethanol was licked. Depression of ethanol licking seemed to be due to an intoxication effect since the behavioral depression was gradual and some licking was maintained throughout the session.

In this study, rats have ingested significant amounts of ethanol in concentrations (up to 80% v/v) well above those reported in the literature to date. Myers (1968) has reported that rats will not voluntarily consume ethanol if the solutions are greater than 7-8%. By restricting the animals fluid intake exclusively to solutions of ethanol, ingestion of ethanol in concentrations up to 20% has been reported (Richter, 1953; Mardones, 1960). Using a technique similar to the one used in the present investigation, Lester (1961) reported intakes of 5.6% ethanol by rats to the point of intoxication. In the experiment reported by Lester (1961), rats obtained ethanol from a dipper after lever pressing. In the present investigation, rats obtained ethanol by an operant licking response which had the advantage of generating high response rates and utilized a response of licking for fluid which is a more natural response for the rat. Deneau et al, (1969) have demonstrated that monkeys would initiate and maintain intravenous self-administration of ehtanol, but a model by which to study ethanol self-administration via the oral route, as in the present study, is more meaningful if any findings are to be applied to the human situation since ethanol is normally ingested by man.

Licking rates (both consequential and inconsequential) for ethanol solutions decreased with increasing concentrations in a similar manner as for amphetamine solutions. The licking rates were also similarly greater during self-produced than programmed stimulus indicating this may be more related to the schedule than to drug influence. The interactions between concentration and stimulus condition were not significant indicating the actions of the ethanol were independent of stimulus condition. The rats were generally significantly different from each

other, indicating different individual susceptibility to the effects of ingested ethanol. This difference is reflected in the concentration and rat interactions which were generally significant during ethanol ingestion.

A significant difference between the effects of ethanol and amphetamine self-ingestion is reflected in the inconsequential left lever rate which was significantly increased by amphetamine, but not affected by ethanol. As discovered earlier, the ability to increase irrelevant behavior may be unique for amphetamine.

Responding on the right lever which produced food pellets was either unaffected or increased by ethanol indicating that the rats had not lost their motor ability and as a result continued to obtain food pellets in spite of decreased responding associated with ethanol ingestion.

The effects of oral injections of ethanol were similar to effects of ingested ethanol except in right lever pressing for food pellets. As with ingested ethanol, there was an increase in lever pressing for food pellets, but rather than the number of pellets delivered remaining constant, the number decreased. The injected ethanol apparently disrupted the rats temporal discrimination for fixed internal responding so while more responses were made, fewer food pellets were delivered.

The experimental design utilized in the present study provided a simple, inexpensive model by which to test the effects of disulfiram on ethanol consumption in the rat. After pretreating the rats with disulfiram, only a fraction of the normal amount of ethanol was consumed. These results supported in the rat, the findings of Hald, et al, (1948) that ethanol ingestion was terminated in humans, after a critical amount

of ethanol was consumed in the presence of disulfiram. An explanation for this effect was put forth by Hald and Jacobsen (1948) that disulfiram inhibited acetaldehyde dehydrogenase thereby resulting in an elevated acetaldehyde level in the blood. Apparently, the elevated acetaldehyde levels were toxic to the rat as in man to prevent the further intake of ethanol. A conditioned aversion to ethanol was not established in the rats since they continued to ingest ethanol on succeeding days of the disulfiram pretreatment experiment.

The applicability of the method used in this investigation to the study of morphine withdrawal was studied. During a four day withdrawal period, the ingestion of water, amphetamine and ethanol was studied. The greatest depression in behavior was seen on the first day of withdrawal with a trend gradually returning to normal over the next three days. This behavioral effect during withdrawal is well correlated with the duration of electroencephalograph changes observed during withdrawal in morphine dependent rats (Khazan, 1970). After discontinuation of morphine injections, a marked drop in high voltage, slow waves occurred and persisted for about three days.

In contrast to the ingestion of amphetamine, morphine rats ingested high concentrations of ethanol readily during the withdrawal from morphine. The mechanism for this urge to drink ethanol when morphine is not available is not known. It may be due to ethanol-induced depression of the central nervus system which is hyperexcited during morphine withdrawal (Goldstein and Goldstein, 1961). It may be also due to the conversion of ethanol in the central nervous system to a morphine-like compound (Walsh et al, 1970).

Nalorphine, a morphine antagonist, has been used to demonstrate

morphine withdrawal in addicted animals (Thompson and Schuster, 1964). In addicted rats receiving morphine by lever pressing for intravenous infusion, nalorphine increased the rate of responding proportionally to the severity of withdrawal induced. Nalorphine in a dose of 4 mg/kg reliably abolished responding in three out of four dependent rats, but in the fourth rat a dose as high as 16 mg/kg was ineffective indicating varying degrees of susceptibility to nalorphine-induced withdrawal.

Nalorphine in a dose of 4 mg/kg produced no effect or a slight increase in responding in a nonaddicted rat. McMillan and Morse (1967) have also reported increased operant responding in non-tolerant animals.

Since the mechanism of action of morphine is still unknown, it is not surprising that the mechanism of action of antagonists as nalorphine is also unclear. However, since it is generally assumed that nalorphine acts by displacing morphine from its receptor (Takemori et al, 1969), it is not surprising that this acute onset of withdrawal has a more severe effect on behavior than gradual onset of abstinence-induced withdrawal.

VI. CONCLUSIONS

(1) Oral self-ingestion by operant licking provided a reliable means by which to quantitatively study self-administration of abusive drugs in the rat.

(2) Oral self-ingestion by operant licking utilized a method to study drug self-administration which was in the rats natural repertoire, easily acquired and resulted in high rates of responding.

(3) Self-ingestion of drug solutions was not limited by taste aversion except in extremely high concentrations, but rather by the pharmacological effects of the drugs.

(4) The drugs studied in this investigation affected behavioral responses in a dose-dependent manner.

(5) Rats stopped ingesting amphetamine after ingesting a dose approximately equivalent to the dose of injected amphetamine which abolished responding.

(6) Multiple concurrent schedules provided the means by which to study the complex nature of drug self-administration in rats.

(7) Following chronic treatment of rats with amphetamine, an increased sensitivity to ingested amphetamine occurred which was manifested by the same behavioral effects of ingested amphetamine but at considerably lower concentrations.

(8) Chlorpromazine pretreatment increased the rate of amphetamine self-ingestion.

(9) The study with disulfiram offers an experimental model to test and study pharmacologically - induced aversion to ethanol ingestion.

(10) Solutions of ethanol were better substitutes for water than solutions of amphetamine during abstinence induced withdrawal in mor-

phine dependent rats.

(11) Nalorphine induced withdrawal was of greater intensity than abstinence induced withdrawal.

REFERENCES

Arvola, A. and Forsander, A.O.: Hamsters in experiments of free choice between alcohol and water. Quart. J. Stud. Alc. 24:591, 1963.

Asada, M. and Galambas, J.T.: Liver disease, hepatic alcohol dehydrogenase activity and alcohol metabolism in man. Gastroenterology, 45:67, 1963.

Aschenkenasy-Lelu, P.: Relation entre l'effect inhibiteur des oestrogenes sur la consommation d'alcool du rat et leur action genitale. Arch. Sci. Physiol. 14:165-174, 1960.

Barry, H.,III and Miller, N.E.: Effects of drugs on approach avoidance conflict tested repeatedly by means of a "telescope alley". J. Comp. Physiol. Psychol. 55:201-210, 1962.

Barry, H., III, Wagner, A.R. and Miller, N.E.: Effects of alcohol and amobarbital on performance inhibited by experimental extinction. J. Comp. Physiol. Psychol. 55:464-468, 1962.

Broadhurst, P.L. and Walgren, H.: Ethanol and the acquisition of a conditioned avoidance response in selected strains of rats. Quart. J. Stud. Alc. 25:476-489, 1964.

Brodie, B.B., Spector, S. and Shore, P.A.: Interaction of drugs with norepinepinephrine in the brain. Pharmac. Rev. 11:548-564, 1959.

Brown, H.: d-amphetamine chlorpromazine antagonism in a food reinforced operant. J. Exp. Analysis Behav. 6:395-398, 1963.

Chen, C.S.: A study of the alcohol tolerance effect and an introduction of a new behavioral technique. Psychopharmacologia, 12:433-440, 1968.

Chittal, S.M. and Sheth, U.K.: Effect of drugs on conditioned avoidance response in rats. Arch. Intern. Pharmacodyn. 144:471-480, 1963.

Cicero, T.J., Myers, R.D. and Black, W.W.: Increase in volitional ethanol consumption following interference with a learned avoidance response. Physiol. Behav. 3:657-660, 1968.

Clay, M.L.: Conditions affecting voluntary alcohol consumption in rats. Quart. J. Stud. Alc. 25:36-55, 1964.

Conger, J.J.: The effects of alcohol on conflict behavior in the albino rat. Quart. J. Stud. Alc. 12:1-29, 1951.

Connell, P.H.: The use and abuse of amphetamine. Practioner 200: 234-243, 1968.

Cooper, J.R. and Brodie, B.B.: The enzymatic metabolism of hexobarbital (Evipal) J. Pharmacol. Exp. Therap. 114:409-417, 1955.

Davis, J.L.: Antagonism of a behavioral effect of d-amphetamine by chlorpromazine in the pigeon. J. Exp. Analysis Behav. 8:325-327, 1965.

Deneau, G.A., Yanagita, T. and Seevers, M.H.: Psychogenic Dependence to a variety of drugs in the monkey. Pharmacologist, 6:182, 1964.

Deneau, G.A. and Inoki, R.: Nocotine self-administration in monkeys. Ann. N.Y. Acad. Sci., 142:277-279, 1967.

Deneau, G. Yanagita, T. and Seevers, M.H.: Self-administration by the monkey. A measure of psychological dependence. Psychopharmacologia (Berl.) 16:30-48, 1969.

Dews, P.B.: Studies on behavior. IV. Stimulant actions of methamphetamine. J. Pharmacol. Exp. Ther. 122:137-147, 1958.

Dicker, S.E.: The effects of methylpentynol on ethanol drinking and on water metabolism in rats. J. Physiol. 144:138-147, 1958.

Dixon, W.J. and Massey, F.J.: Introduction to statistical analysis. McGraw-Hill, New York, 1969. 3rd Edition.

Dorfman, A. and Goldbaum, L.R.: Detoxification of Barbiturates. J. Pharm. Exp. Therap. 90:330-337, 1947.

Duncan, D.B.: Multiple range and multiple F tests. Biometrics 11: 1-42, 1955.

Durrant, B.W.: Amphetamine Addiction. Practitioner 194:646-651, 1965.

Ebert, A.G. Yim, G.K. and Miya, T.S.: Distribution and metabolism of barbital C^{14} in tolerant and non-tolerant rats. Biochem. Pharmacol. 13:1267-1274, 1964.

Epstein, A.N.: Suppression of eating and drinking by amphetamine and other drugs in normal and hyperphagic rats. J. Comp. Physiol. Psychol. 52:37-45, 1959.

Eriksson, K.: Genetic Selection for voluntary alcohol consumption in the albino rat. Science, 159:739-741, 1968.

Eriksson, K.: Factors affecting voluntary alcohol consumption in the albino rat. Ann. Zool. Fennici. 6:227-265, 1969.

Eriksson, K. and Malmstrom, K.K.: Sex differences in consumption and elimination of alcohol in albino rats. Ann. Med. Exp. Fenn. 45: 398-392, 1967.

Essig, C.F.: Increased water consumption following forced drinking of alcohol in rats. Psychopharmacologia, 12:333-337, 1968.

Falk, J.L.: Production of polydipsia in normal rats by an intermittent food schedule. Science, 133:195-196, 1961.

Forsander, O.A.: The role of metabolism in alcohol consumption in biochemical factors in alcoholism. R.P. Maickel, Ed., Pp 7-16, New York: Pergamon Press, 1967.

Freed, E.X.: The effect of alcohol upon approach-avoidance conflict in the white rat. Quart. J. Stud. Alc. 28:236-254, 1967.

Freed, E.X.: Effect of alcohol on conflict behaviors. Psychol. Rep. 23:151-159, 1968a.

Freed, E.X. Effect of self-intoxication upon approach-avoidance conflict in the rat. Quart. J. Stud. Alc. 29:323-329, 1968b.

Glick, S.D. and Jarvik, M.E.: Amphetamine, scopolamine and chlorpromazine interactions on delayed matching performance in monkeys. Psychopharmacologia, 16:147-155, 1969.

Goldstein, D.B. and Goldstein, A.: Possible role of enzyme inhibition and repression in drug tolerance and addiction. Biochem. Pharmacol. 8:48, 1961.

Goodrick, C.L.: Alcohol preference of the male sprague-dawley albino rat as a function of age. J. Geront. 22:369-371, 1967.

Grossman, S.P. and Miller, N.E.: Control for stimulus-change in the evaluation of alcohol and chlorpromazine as fear-reducing drugs. Psychopharmacologia 2:342-351, 1961.

Hald, J. Jacobsen, E. and Larsen V.: The sensitizing effect of tetraethyl-thuiram disulphide (antabuse) to ethyl alcohol. Acta Pharmacol. Toxicol. 4:285-297, 1948.

Hald, J. and Jacobsen, E.: The formation of acetaldehyde in the organism after ingestion of antabuse (Tetraethylthuiram disulphide) and alcohol. Acta Pharmacol. Toxicol. 4:304-310, 1948.

Hanson, L.C.F.: Evidence that the central action of amphetamine is mediated via catecholamines. Psychopharmacologia 10:289-297, 1967.

Harris, R.T., Claghorn, J.L. and Schoolar, J.C.: Self-administration of minor tranquilizers as a function of conditioning. Psychopharmacologia 13:81-88, 1968.

Hausmann, M.F.: The behavior of albino rats in choosing food and stimulants. J. Comp. Psychol. 13:279-309, 1932.

Headlee, C.P. Coppock, H.W. and Nichols, J.R.: Apparatus and technique involved in a laboratory method of detecting the addictiness of drugs. J. Am. Pharm. Ass. (Sci. ed), 44:229-231, 1955.

Jarvik, M.E.: Tobacco smoking in monkeys. Ann. N.Y. Acad. Sci. 142:280-294, 1967.

Kelleher, R.T. and Morse, W.H.: Determinants of the specificity of behavioral effects of drugs. Reviews of Physiology, Biochemistry, and Experimental Pharmacology, pp 1-56, Springer-Verlag, New York, 1968.

Khazan, N.: Longitudinal EEG study of the effects of morphine injections and withdrawal in the morphine dependent rat. Reported to the committee on problems of drug dependence, NAS-NRC, 1970, pp. 6827.

Kohn, M. and Stellar, E.: Alcohol preference in normal and anosmic rats. J. Comp. Physiol. Psychol. 53:571-575, 1960.

Kosman, M.E. and Unna, K.R.: Effects of chronic administration of the amphetamines and other stimulants on behavior. Clin. Pharmacol. Therap. 9: 240-254, 1968.

Koz, G. and Mendelson, J.H.: Effects of intraventricular ethanol infusion on free choice alcohol consumption by monkeys in Biochemical Factors in Alcoholism, R.P. Maickel Ed. pp 17-24, New York: Pergamon Press, 1967.

Kumar, R., Steinberg, H. and Stolerman, I.P.: Inducing a preference for morphine in rats without premedication. Nature, 218:564-565, 1968.

Lal, H . and Brown, R.M.: Acceleration of operant responding with inconsequential contingencies by environmental stimuli: Chlorpromazine induced blockade of enhancement produced by amphetamine. Federation Proc. 28:511, 1969.

Lal, H., Puri, S.K. and Fuller, G.C.: Inhibition of hepatic hexobarbital metabolism by dextro amphetamine. Psychopharmacologia 16: 395-398, 1970.

Laties, V.G. and Weiss, B.: Effects of alcohol on timing behavior. J. Comp. Physiol. Psychol. 55:85-91, 1962.

LeBlanc, A.E., Kalant, H., Gibbons, R.J. and Berman, N.D.: Acquisition and loss of tolerance to ethanol by the rat. J. Pharmacol. Exp. Ther. 168:244-250, 1969.

Lester, D.: Self-maintenance of intoxication in the rat. Quart. J. Stud. Alc. 22:223-231, 1961.

Lewander, T.: Urinary excretion and tissue levels of catecholamines during chronic amphetamine intoxication. Psychopharmacologia 13:394-407, 1968.

Lewin, L., Phantastica: Narcotic and stimulating drugs, Dutton, New York, 355, 1964.

Light, A.B. and Torrance, E.G.: VIII The effects of intramuscular and intravenous administration of large doses of morphine to human subjects. A.M.A. Arch. Int. Med. 44:376-394, 1929.

Maickel, R.P.: Diverse central effects of chlorpromazine. Int. J. Neuropharmacol. 7:23-27, 1968.

Mardones, J.: Experimentally induced changes in the free selection of ethanol. Int. Rev. Neurobiol. 2:41-76, 1960.

Mardones, R.J., Segovia, N. and Hederra, A.: Heredity of experimental alcohol preference in rats. II. co-efficient of heredity. Quart. J. Stud. Alc. 14:1-4, 1953.

Masserman, J.H., Yum, K.S., Nicholson, M.R. and Lee, S.: Neurosis and alcohol: an experimental study. Am. J. Psychiat. 101:389-395, 1944.

Masserman, J.H. Jacques, M.G. and Nicholson, M.R.: Alcohol as a preventive of experimental neurosis. Quart. J. Stud. Alc. 6:281-299, 1945.

Masserman, J.H. and Yum, K.S.: An analysis of alcohol on experimental neuroses in cats. Psychosom. Med. 8:36-52, 1946.

McClearn, G.E. and Rodgers, D.R.: Differences in alcohol preference among inbred strains of mice. Quart. J. Stud. Alc. 20:691-695, 1959.

McMillan, D.E. and Morse, W.H.: Some effects of morphine and morphine antagonists on schedule-controlled behavior. J. Pharmacol. Exp. Therap. 157:175-184, 1967.

Mendelson, J.H.: Biologic concomitants of alcoholism. Part II. New England J. Med. 283:71-81, 1970.

Moskowitz, H. and Wapner, M.: Studies on the acquisition of behavioral tolerance to alcohol. Quart. J. Stud. Alc. 25:619-626, 1964.

Multivariate Statistical Programs. Biometric Laboratory, University of of Miami, Coral Gables, Florida, 1966.

Myers, A.K.: Alcohol choice in wistar and G-4 rats as a function of environmental temperature and alcohol concentration. J. Comp. Physiol. 55:606-609, 1962.

Myers, R.D.: Alcohol consumption in rats: Effects of Intracranial injections of ethanol. Science, 142:240-241, 1963.

Myers, R.D.: Ethyl alcohol consumption: Valid measurement in albino rats. Science 161:76-77, 1968.

Myers, R.D. and Carey, R.: Preference factors in experimental alcoholism. Science 134:469-470, 1961.

Myers, R.D. and Holman, R.B.: Failure of stress of electric shock to increase ethanol intake in rats. Quart. J. Stud. Alc. 28:132-137, 1967.

Nichols, J.R., Headlee, C.P. and Coppock, H.W.: Drug addition I. Addiction by escape training. J. Amer. Pharm. Ass. (Sci. Ed), 45:788-791, 1956.

Parisella, R.M. and Pritham, G.H.: Effects of age on alcohol preference by rats. Quart. J. Stud. Alc. 25:248-252, 1964.

Pickens, R.: Self-administration of stimulants by rats. Intern. J. A Addit. 3:215-221, 1968.

Pickens, R., Meisch, R. and McGuire, L.E.: Methamphetamine reinforcement in rats. Psychon. Sci., 8:371-372, 1967.

Pickens, R. and Harris, W.: Self-administration of d-amphetamine by rats. Psychopharmacologia 12:158-163, 1968.

Pickens, R. and Thompson, T.: Cocaine-reinforced behavior in rats: effects of reinforcement magnitude and fixed-ratio size. J. Pharmacol. Exptl. Therap. 161:122-129, 1968.

Powell, B.J., Kamano, D.K. and Martin, L.K.: Multiple factors affecting volitional consumption of alcohol in the Abrams Wistar rat. Quart. J. Stud. Alc. 27:7-15, 1966.

Richter, C.P.: Alcohol, beer and wine as foods. Quart. J. Stud. Alc. 14:525-539, 1953.

Schadewald, M., Emerson, G.A., Moore, W.T., and Moore, B.M.: Voluntary preference for alcohol of white rats after gonadectomy. Fed. Proc 12:364-365, 1953.

Schuster, C.R.: Psychological approaches to opiate dependence and self-administration by laboratory animals. Federation proc. 29: #1 pp 2-5, 1970.

Schuster, C.R., Dockens, W.S. and Woods, J.H.: Behavioral variables affecting the development of amphetamine tolerance. Psychopharmacologia 9:170-182, 1966.

Schuster, C.R. and Villarreal, J.E.: The experimental analysis of opioid dependence. In: Psychopharmacology: A review of progress, edited by D. Efron. Proc. Sixth annual meeting of the American College of Neuropsychopharmacology, San Juan, Puerto Rico, 1967, p 811.

Schuster, C.R. and Thompson, T.: Self-administration of and behavioral dependence on drugs. Ann. Rev. Pharmacol. 9:483-502, 1969.

Senter, R.J. and Sinclair, J.D.: Self-maintenance of intoxication in the rat: a modified replication. Psychon. Sic. 9:291-292, 1967.

Senter, R.J. and Persensky, J.J.: Effects of environment on ethanol consumption in rats after conditioning. Quart. J. Stud. Alc. 29:856-862, 1968.

Sidman, M.: Technique for assessing the effects of drugs on timing behavior. Science, 122:925, 1955.

Spragg, S.D.S.: Morphine addiction in chimpanzees. Comp. Psychol. Mongr. 15:#7, 1940.

Takemori, A.E., Kupferberg, H.J. and Miller, J.W.: Quantitative studies on the antagonism of morphine by nalorphine and naloxone. J. Pharmacol. Expt. Therap. 169:39-45, 1969.

Tatum, E.L., Seevers, M.H. and Collins, K.H.: Morphine addition and its physiological interpretation based on experimental evidences. J. Pharmacol. Exptl. Therap. 36:447-475, 1929.

Thompson, T. and Schuster, C.R.: Morphine self-administration, food-reinforced and avoidance behavior in rhesus monkeys. Psychopharmacologia (Berl.) 5:87-94, 1964.

Thompson, T. and Pickens, R.: Stimulant self-administration by animals: Some comparisons with opiate self-administration. Federation Proc. 29:6-12, 1970.

Uehling, B.S.: Effects of chronic d-amphetamine sulfate administration during development in rats. Int. J. Neuropharmac. 8:43-48, 1969.

Walgren, H. and Savolainen, S.: The effect of ethyl alcohol on a conditioned avoidance response in rats. Acta. Pharmacol. Toxicol. 19: 59-67, 1962.

Walsh, M.H., Davis, V.E. and Yamanaka, Y.: Tetrahydropapaneroline an alkaloid metabolite of dopamine in vitro. J. Pharmacol. Exptl. Therap. 174:388-400, 1970.

Weeks, J.R.: Experimental morphine addiction: Method for automatic intravenous injections in unrestrained rats. Science 138:143-144, 1962.

Weiss, B.: The effects of various morphine - N - allyl normorphine ratios on behavior. Arch. Int. Pharmacodyn. Therap. 105:381-388, 1956.

Weiss, B., Amphetamine and the temporal structure of behavior in Amphetamines and Related Compounds, Proceedings of the Mario Negri Institute for Pharmacological Research, Milan Italy, Edited by E. Costa and S. Garattini, Raven Press, New York, pp. 797-812, 1970.

Westerfeld, W.W.: The metabolism of alcohol. Tex. Rep. Biol. Med. 13: 559-577, 1955.

Wikler, A.P.C. Green, H.D. Smith and F.T. Pescor: Use of a benzimidazole derivative with potent morphine like properties orally as a presumptive reinforcer in conditioning of drug-seeking behavior in rats (abstract). Fed. Proc. 19:22, 1960.

Wilson, E.C.: Ethanol metabolism in mice with different levels of hepatic alcohol dehydrogenase, in Biochemical Factors in Alcoholism, R.P. Maickel, Ed., pp 115-126, New York: Pergamin Press, 1967.

Wilson, E.C., Respess, J.C., Hollifield, G. and Parson W.: Studies of alcohol metabolism in mice which perferentially consume ethanol. Gastroenterology, 40:807-808, 1961.

Woods, J. and Schuster, C.R.: Reinforcement properties of morphine, cocaine, and SPA as a function of unit dose. Intern. J. Addict. 3:231-237, 1968.

APPENDIX A

Predrug sessions for amphetamine self-ingestion in normal rats.

TABLE 53

CONSEQUENTIAL LICKING RATES DURING SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	8	249.88	203.38	7	262.71	237.14	5	266.00	213.20
	SE		14.31	8.82		37.78	30.63		9.99	10.83
(0.50	$\bar{X}$	6	285.33	222.00	6	299.83	271.50	7	305.57	242.86
	SE		2.53	7.12		11.30	5.71		5.09	8.91
(0.99)	$\bar{X}$	5	298.00	244.60	6	294.50	264.00	5	289.40	251.60
	SE		4.55	3.36		4.88	9.89		6.56	7.66
(1.98)	$\bar{X}$	6	287.17 9.33	231.83	5	288.20	285.20	5	280.40	235.40
	SE			10.77		8.40	5.36		7.59	15.81

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	10264.65	8.02***
STIMULUS SEGMENT	(S)	1	63803.52	49.86***
RAT	(R)	2	7003.70	5.47**
C X S		3	439.58	0.34
C X R		6	562.56	0.44
S X R		2	3518.65	2.75
C X S X R		6	249.12	0.20
ERROR		118	1279.56	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 53 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.00	1.98	0.99	0.50	0.00	0.50	1.98	0.99
MEANS	258	285	294	297	218	245	250	254

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 54

TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING DURING SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	8	8.25	10.04	7	8.62	10.54	5	7.73	10.24
	SE		0.50	0.79		0.69	0.78		0.64	0.76
(0.50)	$\bar{X}$	6	10.44	12.66	6	10.11	12.45	7	9.67	11.69
	SE		0.43	0.46		0.47	0.53		0.48	0.74
(0.99)	$\bar{X}$	5	10.47	12.52	6	9.06	11.58	5	9.07	10.66
	SE		0.50	0.42		0.69	0.76		0.84	1.09
(1.98)	$\bar{X}$	6	9.56	11.22	5	9.94	12.28	5	9.33	10.99
	SE		0.51	0.80		1.23	0.59		0.41	0.39

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	26.51	10.49***
STIMULUS SEGMENT	(S)	1	148.39	58.74***
RAT	(R)	2	3.92	1.55
C X S		3	0.15	0.06
C X R		6	2.31	0.91
S X R		2	0.44	0.17
C X S X R		6	0.35	0.14
ERROR		118	2.53	-

*Significant at P < 0.05
**Significant at P < 0.01
***Significant at P < 0.001

TABLE 54 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.00	0.99	1.98	0.50	0.00	1.98	0.99	0.50
MEANS	8.25	9.50	9.61	10.05	10.26	11.48	11.58	12.24

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 55

DROPS OF FLUID DELIVERED DURING SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	8	2051.88	2039.62	7	2161.00	2469.14	5	2049.00	2202.80
	SE		158.97	167.61		285.61	365.59		170.59	236.82
(0.50)	$\bar{X}$	6	2978.50	2812.83	6	3040.83	3395.67	7	2942.57	2841.74
	SE		116.52	138.51		201.99	208.88		114.50	206.68
(0.99)	$\bar{X}$	5	3111.60	3062.80	6	2669.83	3067.17	5	2636.20	2682.40
	SE		105.32	117.29		215.04	268.71		283.52	294.83
(1.98)	$\bar{X}$	6	2734.00	2567.17	5	2868.40	3403.40	5	2627.20	2708.60
	SE		118.86	128.33		207.42	193.75		173.72	137.51

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	5538478.39	21.44***
STIMULUS SEGMENT (S)	1	424395.56	1.64
RAT (R)	2	939964.23	3.64*
C X S	3	30368.10	0.12
C X R	6	287436.29	1.11
S X R	2	768222.86	2.97
C X S X R	6	26336.56	0.10
ERROR	118	258372.76	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 55 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.00	1.98	0.99	0.50	0.00	1.98	0.99	0.50
MEANS	2089	2743	2797	2985	2231	2873	2949	3008

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 56

INCONSEQUENTIAL LICKING RATE DURING SELF-PRODUCED (SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

CONC(mM)		Z-29 N	Z-29 SPS	Z-30 N	Z-30 SPS	Z-33 N	Z-33 SPS
(0.0)	$\bar{X}$	8	16.50	7	21.43	5	16.00
	SE		2.59		5.53		4.81
(0.50)	$\bar{X}$	6	24.17	6	16.83	7	19.57
	SE		4.22		3.31		3.37
(0.99)	$\bar{X}$	5	25.80	6	14.00	5	17.80
	SE		4.67		4.34		4.97
(1.98)	$\bar{X}$	6	15.50	5	14.80	5	16.20
	SE		2.11		3.41		1.66

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	70.81	0.78
RAT (R)	2	58.85	0.64
C X R	6	90.84	1.00
ERROR	59	91.25	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 56 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	1.98	0.00	0.99	0.50
MEANS	15.50	18.10	18.88	20.16

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 57

CONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED STIMULUS (SPS) IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-29		Z-30		Z-33	
CONC(mM)		N	SPS	N	SPS	N	SPS
(0.0)	$\bar{X}$	8	11.53	7	13.41	5	10.76
	SE		2.06		2.22		2.51
(0.50)	$\bar{X}$	6	24.61	6	21.66	7	19.78
	SE		4.29		3.89		4.39
(0.99)	$\bar{X}$	5	23.26	6	17.58	5	16.28
	SE		3.03		4.59		4.74
(1.98)	$\bar{X}$	6	16.29	5	20.86	5	15.41
	SE		2.25		4.27		2.10

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	356.30	4.94**
RAT (R)	2	35.82	0.50
C X R	6	32.11	0.44
ERROR	59	72.10	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 57 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	0.00	1.98	0.99	0.50
MEANS	12.00	17.45	18.95	21.90

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 58

INCONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED (SPS) AND PROGRAMMED (PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

CONC(mM)		Z-29			Z-30			Z-33		
		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	8	1.55	0.07	7	0.85	0.18	5	1.63	0.07
	SE		0.25	0.05		0.18	0.07		0.72	0.07
(0.50)	$\bar{X}$	6	2.04	0.12	6	1.68	0.04	7	1.43	0.04
	SE		0.26	0.07		0.19	0.04		0.23	0.04
(0.99)	$\bar{X}$	5	1.33	0.0	6	1.66	0.01	5	1.36	0.02
	SE		0.22	0.0		0.70	0.01		0.35	0.02
(1.98)	$\bar{X}$	6	2.32	0.08	5	1.54	0.01	5	1.56	0.0
	SE		0.36	0.04		0.33	0.01		0.65	0.0

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	0.42	0.91
STIMULUS SEGMENT	(S)	1	81.29	177.06***
RAT	(R)	2	0.60	1.31
C X S		3	0.59	1.28
C X R		6	0.33	0.71
S X R		2	0.52	1.12
C X S X R		6	0.34	0.75
ERROR		118	0.46	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 58 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.00	0.99	0.50	1.98	0.99	1.98	0.50	0.00
MEANS	1.32	1.46	1.70	1.84	0.01	0.03	0.06	0.11

Any two means not underscored by the same line are significantly different at $P < 0.05$.

APPENDIX B

Predrug sessions for amphetamine self-ingestion in chronically treated rats.

TABLE 59

CONSEQUENTIAL LICKING RATES DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-29			Z-30			Z-33	
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	7	272.57	226.43	6	248.33	247.50	5	274.40	263.40
	SE		21.83	18.87		18.93	11.66		12.30	17.00
(0.125)	$\bar{X}$	7	270.14	247.86	7	278.29	279.43	7	286.00	254.43
	SE		7.29	10.30		14.43	7.26		10.10	9.78
(0.25)	$\bar{X}$	5	267.80	254.00	6	271.33	258.50	6	277.17	249.00
	SE		9.95	7.28		14.32	8.04		9.39	9.70
(0.50)	$\bar{X}$	7	260.57	241.00	6	278.17	259.83	6	268.83	234.00
	SE		8.64	12.94		9.67	13.92		11.11	11.84

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	1658.99	1.64
STIMULUS SEGMENT	(S)	1	15463.53	15.24***
RAT	(R)	2	1766.77	1.74
C X S		3	71.32	0.07
C X R		6	882.03	0.87
S X R		2	1573.95	1.55
C X S X R		6	583.68	0.58
ERROR		126	1014.67	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 59 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.00	0.50	0.25	0.125	0.00	0.50	0.25	0.125
MEANS	265	269	272	278	244	245	254	261

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 60

TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	7	10.23	14.05	6	11.27	13.80	5	11.13	13.02
	SE		0.65	0.49		0.18	0.38		0.44	0.26
(0.125)	$\bar{X}$	7	11.08	14.01	7	11.51	13.73	7	11.37	13.59
	SE		0.50	0.33		0.32	0.61		0.40	0.55
(0.25)	$\bar{X}$	5	11.64	14.68	6	11.86	15.06	6	11.49	13.75
	SE		0.24	0.25		0.04	0.16		0.28	0.60
(0.50)	$\bar{X}$	7	10.38	12.45	6	10.57	12.97	6	10.07	11.99
	SE		0.15	0.32		0.85	0.52		0.88	0.77

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	17.77	12.06***
STIMULUS SEGMENT	(S)	1	244.02	165.60***
RAT	(R)	2	3.56	2.42
C X S		3	1.10	0.74
C X R		6	0.37	0.25
S X R		2	2.38	1.61
C X S X R		6	0.68	0.46
ERROR		128	1.47	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 60 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.50	0.00	0.125	0.25	0.50	0.00	0.125	0.25
MEANS	10.34	10.82	11.32	11.67	12.47	13.68	13.78	14.48

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 61

DROPS OF FLUID DELIVERED DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-29			Z-30			Z-33	
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	7	2766.86	3162.00	6	2805.00	3409.33	5	3067.00	3436.00
	SE		228.41	266.20		233.81	165.91		230.75	250.52
(0.125)	$\bar{X}$	7	3002.14	3478.71	7	3219.14	3835.86	7	3261.29	3463.00
	SE		178.56	184.10		219.58	196.16		186.59	172.03
(0.25)	$\bar{X}$	5	3126.00	3731.80	6	3219.17	3847.83	6	3198.33	3449.67
	SE		171.63	138.32		168.13	105.66		171.70	266.67
(0.50)	$\bar{X}$	7	2704.14	3003.57	6	2943.17	3402.67	6	2715.67	2823.50
	SE		91.45	194.49		256.13	286.54		254.74	250.87

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
CONCENTRATION (C)	3	2028735.47	7.42***
STIMULUS SEGMENT (S)	1	6452214.00	23.60***
RAT (R)	2	784961.43	2.87
C X S	3	70499.45	0.26
C X R	6	181653.50	0.66
S X R	2	385245.84	1.41
C X S X R	6	15206.40	0.06
ERROR	126	273340.81	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 61 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.50	0.00	0.125	0.25	0.50	0.00	0.125	0.25
MEANS	2783	2863	3161	3184	3073	3321	3592	3673

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 62

INCONSEQUENTIAL LICKING RATE DURING SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-29		Z-30		Z-33	
CONC(mM)		N	SPS	N	SPS	N	SPS
(0.0)	$\bar{X}$	7	28.68	6	32.33	5	28.00
	SE		5.78		5.48		4.56
(0.125)	$\bar{X}$	7	33.57	7	29.29	7	34.00
	SE		5.97		5.87		5.45
(0.25)	$\bar{X}$	5	45.20	6	52.00	6	36.67
	SE		3.06		4.03		5.73
(0.50)	$\bar{X}$	7	21.71	6	21.33	6	24.33
	SE		1.44		4.57		6.61

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	1507.67	8.96**
RAT	(R)	2	48.77	0.29
C X R		6	135.32	0.81
ERROR		63	168.19	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 62 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	0.50	0.00	0.125	0.25
MEANS	22.40	29.70	32.30	44.60

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 63

CONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED STIMULUS(SPS) IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-29		Z-30		Z-33	
CONC(mM)		N	SPS	N	SPS	N	SPS
(0.0)	$\bar{X}$	7	29.10	6	32.44	5	29.74
	SE		5.57		4.07		3.80
(0.125)	$\bar{X}$	7	37.50	7	36.93	7	39.39
	SE		5.43		6.55		5.93
(0.25)	$\bar{X}$	5	47.53	6	47.41	6	39.83
	SE		6.17		2.03		5.32
(0.50)	$\bar{X}$	7	21.49	6	25.87	6	23.80
	SE		1.51		5.54		5.16

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	1516.93	9.42***
RAT	(R)	2	55.66	0.34
C X R		6	46.09	0.29
ERROR		63	161.10	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 63 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS			
CONC	0.50	0.00	0.125	0.25
MEANS	23.60	30.39	37.94	44.77

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 64

INCONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-29			Z-30			Z-33		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.0)	$\bar{X}$	7	3.12	0.33	6	4.66	1.05	5	1.41	0.00
	SE		0.55	0.26		0.51	0.86		0.32	0.00
(0.125)	$\bar{X}$	7	2.27	0.10	7	4.53	0.20	7	1.69	0.00
	SE		0.34	0.05		0.20	0.08		0.25	0.00
(0.25)	$\bar{X}$	5	2.90	0.07	6	3.94	0.29	6	2.02	0.08
	SE		1.01	0.04		0.37	0.08		0.30	0.08
(0.50)	$\bar{X}$	7	1.93	0.08	6	3.88	0.14	6	2.39	0.00
	SE		0.23	0.04		0.44	0.10		0.49	0.00

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	3	1.15	1.46
STIMULUS SEGMENT	(S)	1	274.78	347.50***
RAT	(R)	2	25.24	31.92***
C X S		3	0.05	0.06
C X R		6	1.25	1.58
S X R		2	13.11	16.58***
C X S X R		6	0.78	0.99
ERROR		126	0.79	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 64 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				PROGRAMMED STIMULUS			
CONC	0.50	0.125	0.25	0.00	0.00	0.50	0.125	0.25
MEANS	2.69	2.83	2.96	3.16	2.74	3.64	4.11	4.81

Any two means not underscored by the same line are significantly different at P <0.05.

APPENDIX C

Predrug session for amphetamine self-ingestion in normal rats. Food pellets were concurrently available on FI-60 second lever pressing.

TABLE 65

CONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INCIATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.00)	$\bar{X}$	6	266.17	206.83	8	290.38	193.75	6	362.67	276.33
	SE		31.97	28.99		31.31	21.42		19.29	14.71
(0.0625)	$\bar{X}$	5	265.40	200.00	5	222.20	146.60	6	227.67	205.50
	SE		44.26	14.98		10.22	19.29		15.05	24.66
(0.125)	$\bar{X}$	9	297.11	218.89	9	281.11	198.78	8	327.75	255.00
	SE		20.12	15.43		9.47	10.33		25.40	19.45
(0.25)	$\bar{X}$	7	286.71	236.57	5	312.00	231.20	6	363.50	297.50
	SE		21.20	17.63		16.14	48.49		17.38	18.44
(0.50)	$\bar{X}$	12	214.50	184.25	15	257.93	186.00	13	249.46	218.00
	SE		16.42	6.66		13.47	4.48		19.46	16.61

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	47259.89	15.52***
STIMULUS SEGMENT	(S)	1	235250.82	77.28***
RAT	(R)	2	39162.38	12.86***
C X S		4	3256.97	1.07
C X R		8	6742.02	2.22*
S X R		2	5096.73	1.67
C X S X R		8	797.67	0.26
ERROR		210	3044.10	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 65 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.0625	0.50	0.125	0.00	0.25	0.0625	0.50	0.00	0.125	0.25
MEANS	238	242	301	305	319	185	196	222	223	255

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 66

TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.00)	$\bar{X}$	6	7.81	8.33	8	8.39	9.48	6	7.12	8.38
	SE		0.72	0.95		0.93	0.88		0.75	0.96
(0.0625)	$\bar{X}$	5	11.66	12.71	5	9.94	12.00	6	8.48	8.79
	SE		0.35	0.66		0.95	1.09		0.66	0.71
(0.125)	$\bar{X}$	9	9.57	10.87	9	10.64	11.73	8	8.31	9.15
	SE		0.77	0.73		0.44	0.54		0.71	0.96
(0.25)	$\bar{X}$	7	9.73	10.25	5	9.72	9.51	6	7.24	7.68
	SE		0.70	0.81		0.78	1.25		1.01	0.95
(0.50)	$\bar{X}$	12	10.66	11.84	15	9.81	11.02	13	8.76	9.69
	SE		0.65	0.85		0.43	0.55		0.46	0.57

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	38.21	8.50***
STIMULUS SEGMENT	(S)	1	54.52	12.12***
RAT	(R)	2	86.33	19.20***
C X S		4	1.16	0.26
C X R		8	6.48	1.44
S X R		2	0.46	0.10
C X S X R		8	0.74	0.16
ERROR		210	4.50	-

*Significant at P < 0.05
**Significant at P < 0.01
***Significant at P < 0.001

TABLE 66 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.00	0.25	0.125	0.50	0.0625	0.00	0.25	0.125	0.50	0.0625
MEANS	7.84	8.90	9.56	9.73	9.93	8.81	9.19	10.64	10.83	11.02

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 67

DROPS OF WATER DELIVERED DURING CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34			Z-35			Z-37	
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.00)	$\bar{X}$	6	2097.83	1763.17	8	2322.75	1783.00	6	2555.83	2356.50
	SE		341.04	341.08		236.79	182.56		269.17	322.42
(0.0625)	$\bar{X}$	5	3115.40	2576.40	5	2241.60	1780.20	6	1937.83	1879.83
	SE		552.08	289.36		300.11	304.47		200.28	301.16
(0.125)	$\bar{X}$	9	2737.11	2366.67	9	3000.67	2343.56	8	2669.75	2271.50
	SE		143.55	207.57		122.98	192.20		232.90	224.72
(0.25)	$\bar{X}$	7	2731.43	2391.14	5	2989.60	2050.60	6	2619.67	2335.17
	SE		260.75	210.12		151.80	291.90		350.06	390.83
(0.50)	$\bar{X}$	12	2187.33	2190.33	15	2554.93	2049.53	13	2137.23	2047.15
	SE		96.21	180.97		189.45	120.03		158.66	145.01

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	1823134.04	4.49**
STIMULUS SEGMENT	(S)	1	7654081.67	18.85***
RAT	(R)	2	319133.31	0.79
C X S		4	211144.52	0.52
C X R		8	986830.05	2.43*
S X R		2	905732.05	2.23
C X S X R		8	74791.80	0.18
ERROR		210	406022.02	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 67 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.50	0.00	0.0625	0.25	0.125	0.00	0.0625	0.50	0.25	0.125
MEANS	2309	2325	2401	2766	2808	1949	2063	2091	2278	2329

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 68

INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34		Z-35		Z-37	
CONC(mM)		N	SPS	N	SPS	N	SPS
(0.00)	$\bar{X}$	6	24.00	8	35.75	6	11.83
	SE		7.64		15.85		2.46
(0.0625)	$\bar{X}$	5	29.20	5	17.60	6	9.33
	SE		6.58		6.80		2.08
(0.125)	$\bar{X}$	9	16.11	9	28.89	8	15.12
	SE		3.15		9.97		3.24
(0.25)	$\bar{X}$	7	18.29	5	12.20	6	6.87
	SE		6.62		2.89		1.13
(0.50	$\bar{X}$	12	21.17	15	17.07	13	14.38
	SE		2.99		3.28		3.75

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	361.08	1.11
RAT	(R)	2	1246.35	3.84*
C X R		8	303.55	0.94
ERROR		105	324.40	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 68 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	0.25	0.50	0.0625	0.125	0.00
MEANS	12.79	17.42	18.12	20.23	25.05

Any two means not underscored by the same line are significantly different at P <0.05.

TABLE 69

INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34			Z-35			Z-37	
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.00)	$\bar{X}$	6	1.81	0.42	8	5.69	2.23	6	3.07	0.02
	SE		0.66	0.32		2.25	1.67		0.42	0.02
(0.0625)	$\bar{X}$	5	1.72	0.18	5	1.85	0.15	6	2.22	0.00
	SE		0.34	0.12		0.23	0.08		0.20	0.00
(0.125)	$\bar{X}$	9	1.99	0.12	9	4.79	0.71	8	4.13	0.14
	SE		0.28	0.05		0.54	0.58		0.88	0.14
(0.25)	$\bar{X}$	7	2.62	0.33	5	3.52	1.26	6	2.44	0.24
	SE		0.69	0.22		0.72	0.67		0.67	0.16
(0.50)	$\bar{X}$	12	0.99	0.33	15	2.05	0.09	13	2.96	0.06
	SE		0.12	0.18		0.34	0.03		0.27	0.04

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	15.84	5.03***
STIMULUS SEGMENT	(S)	1	338.89	107.68***
RAT	(R)	2	25.49	8.10***
C X S		4	5.10	1.62
C X R		8	7.35	2.34*
S X R		2	12.27	3.90*
C X S X R		8	1.50	0.48
ERROR		210	3.15	-

*Significant at P< 0.05
**Significant at P< 0.01
***Significant at P< 0.001

TABLE 69 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.0625	0.50	0.25	0.125	0.00	0.0625	0.50	0.125	0.25	0.00
MEANS	1.96	2.03	2.81	3.61	3.74	0.10	0.15	0.33	0.56	1.02

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 70

RIGHT LEVER PRESSING FOR FOOD PELLETS UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34			Z-35			Z-37	
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.00)	$\bar{X}$	6	4.22	3.10	8	2.67	4.11	6	2.78	1.30
	SE		1.37	0.72		0.22	0.40		0.90	0.35
(0.0625)	$\bar{X}$	5	2.50	0.96	5	2.94	1.57	6	2.58	0.98
	SE		0.76	0.46		0.99	0.75		0.68	0.40
(0.125)	$\bar{X}$	9	5.18	3.32	9	2.93	3.62	8	2.56	1.38
	SE		0.97	1.38		0.60	0.66		0.60	0.37
(0.25)	$\bar{X}$	7	7.50	5.05	5	2.61	4.54	6	3.67	2.07
	SE		1.41	1.20		0.36	1.38		0.73	0.63
(0.50)	$\bar{X}$	12	4.35	2.38	15	3.62	2.20	13	3.30	1.31
	SE		1.43	0.85		0.61	0.35		0.50	0.48

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	25.32	4.33***
STIMULUS SEGMENT	(S)	1	77.16	13.21***
RAT	(R)	2	58.08	9.94***
C X S		4	4.98	0.85
C X R		8	6.98	1.20
S X R		2	20.40	3.49*
C X S X R		8	3.04	0.52
ERROR		210	5.84	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 70 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0.0625	0.00	0.125	0.50	0.25	0.0625	0.50	0.125	0.00	0.25
MEANS	2.67	3.17	3.59	3.73	4.86	1.16	1.96	2.82	2.96	3.92

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 71

CONSEQUENTIAL RIGHT LEVER PRESSING FOR FOOD PELLETS UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULS IN PRE DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34			Z-35			Z-37		
CONC(mM)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0.00)	$\bar{X}$	6	0.70	0.62	8	0.52	0.68	6	0.62	0.57
	SE		0.08	0.12		0.07	0.05		0.13	0.13
(0.0625)	$\bar{X}$	5	0.64	0.50	5	0.54	0.45	6	0.59	0.47
	SE		0.04	0.12		0.13	0.11		0.10	0.15
(0.125)	$\bar{X}$	9	0.75	0.75	9	0.63	0.82	8	0.68	0.46
	SE		0.07	0.09		0.07	0.05		0.08	0.11
(0.25)	$\bar{X}$	7	0.78	0.79	5	0.48	0.90	6	0.60	0.57
	SE		0.08	0.07		0.09	0.19		0.13	0.13
(0.50)	$\bar{X}$	12	0.60	0.65	15	0.46	0.55	13	0.73	0.51
	SE		0.09	0.06		0.06	0.04		0.06	0.09

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	0.19	2.99*
STIMULUS SEGMENT	(S)	1	0.01	0.02
RAT	(R)	2	0.21	3.42*
C X S		4	0.06	0.95
C X R		8	0.06	1.03
S X R		2	0.43	6.88***
C X S X R		8	0.04	0.69
ERROR		210	0.06	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 72

CONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-34		Z-35		Z-37	
CONC(mM)		N	SPS	N	SPS	N	SPS
(0.00)	$\bar{X}$	6	9.54	8	12.04	6	7.18
	SE		2.23		3.16		1.24
(0.0625)	$\bar{X}$	5	30.95	5	20.45	6	9.15
	SE		5.23		5.92		1.62
(0.125)	$\bar{X}$	9	17.98	9	24.74	8	10.23
	SE		3.69		5.67		2.02
(0.25)	$\bar{X}$	7	17.00	5	14.51	6	8.24
	SE		3.46		3.18		2.92
(0.50)	$\bar{X}$	12	28.59	15	18.02	13	13.58
	SE		4.41		2.72		3.73

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	443.90	3.63**
RAT	(R)	2	1255.79	10.26***
C X R		8	174.98	1.43
ERROR		105	122.43	-

*Significant at P <0.05
**Significant at P <0.01
***Significant at P <0.001

TABLE 67 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	0.00	0.25	0.125	0.0625	0.50
MEANS	9.83	13.39	17.92	19.50	19.75

Any two means not underscored by the same line are significantly different at $P < 0.05$.

APPENDIX D

Predrug sessions for amphetamine injection in normal rats.

TABLE 73

CONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY DOSAGE IN PARENTHESES.

DOSE(MG/KG)		Z-19 N	Z-19 SPS	Z-19 PS	Z-20 N	Z-20 SPS	Z-20 PS	Z-22 N	Z-22 SPS	Z-22 PS
(SALINE)	$\bar{X}$	5	230.40	152.60	6	253.33	200.83	4	236.25	204.25
	SE		6.45	20.94		15.43	34.58		31.95	21.31
(0.25)	$\bar{X}$	5	230.66	158.40	4	256.50	203.75	4	167.00	159.75
	SE		23.26	5.99		15.38	31.40		18.43	4.85
(0.50)	$\bar{X}$	6	217.00	176.50	4	219.50	186.00	2	156.50	185.00
	SE		15.82	10.85		26.16	39.60		29.50	41.01
(1.00)	$\bar{X}$	3	269.00	223.33	4	286.75	254.25	5	218.80	214.80
	SE		13.65	6.84		13.42	13.89		34.17	21.49
(2.00)	$\bar{X}$	3	261.67	211.33	3	302.67	284.00	3	221.00	178.67
	SE		9.26	20.30		21.17	10.50		5.51	27.14

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	13920.43	6.95***
STIMULUS SEGMENT	(S)	1	46195.70	23.06***
RAT	(R)	2	20573.17	10.27***
D X S		4	1224.80	0.61
D X R		8	2801.13	1.40
S X R		2	4917.21	2.46
D X S X R		8	436.38	0.22
ERROR		92	2002.84	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 73 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
DOSE	0.50	0.25	SALINE	1.00	2.00	0.25	0.50	SALINE	2.00	1.00
MEANS	208	219	241	254	262	173	181	186	225	230

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 74

DROPS OF FLUID DELIVERED UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY DOSAGE IN PARENTHESES.

		Z-19			Z-20			Z-22	
DOSE(MG/KG)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(SALINE)	$\bar{X}$	5	2131.80	1815.60	6	2094.33	2280.17	4	2125.50	2300.25
	SE		281.83	449.69		445.56	684.45		191.97	360.24
(0.25)	$\bar{X}$	5	2029.00	1725.80	4	2592.75	2558.25	4	1125.75	1489.00
	SE		215.53	192.78		223.93	452.50		35.54	181.37
(0.50)	$\bar{X}$	6	1996.50	2068.33	4	2157.00	2304.50	2	1591.50	2254.00
	SE		179.71	138.04		428.75	674.65		450.57	691.10
(1.00)	$\bar{X}$	3	2907.67	3033.00	4	2941.25	3296.25	5	1914.60	2377.20
	SE		233.12	213.52		320.76	352.26		291.55	256.59
(2.00)	$\bar{X}$	3	2639.67	2772.67	3	3291.33	3698.33	3	1770.00	1879.67
	SE		340.41	510.72		240.82	136.73		279.04	513.07

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	3340790.14	5.64***
STIMULUS SEGMENT	(S)	1	583328.66	0.99
RAT	(R)	2	5385910.20	9.10***
D X S		4	126953.78	0.22
D X R		8	988252.73	1.67
S X R		2	479801.46	0.81
D X S X R		8	57693.68	0.10
ERROR		92	591858.26	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 74 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
DOSE	0.25	0.50	SALINE	1.00	2.00	0.25	SALINE	0.50	2.00	1.00
MEANS	1924	1982	2115	2505	2567	1909	2131	2178	2784	2848

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 75

INCONSEQUENTIAL LICKING RATE UNDER SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY DOSAGE IN PARENTHESES.

DOSE(MG/KG)		Z-19 N	Z-19 SPS	Z-20 N	Z-20 SPS	Z-22 N	Z-22 SPS
(SALINE)	$\bar{X}$	5	26.80	6	14.00	4	16.00
	SE		15.41		5.89		5.12
(0.25)	$\bar{X}$	5	16.60	4	11.50	4	10.25
	SE		7.25		2.21		4.66
(0.50)	$\bar{X}$	6	13.50	4	20.75	2	23.00
	SE		2.47		5.59		0.00
(1.00)	$\bar{X}$	3	22.00	4	28.50	5	11.20
	SE		6.00		13.11		0.66
(2.00)	$\bar{X}$	3	21.67	3	18.33	3	10.67
	SE		6.12		2.33		3.18

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	95.44	0.41
RAT	(R)	2	206.94	0.90
D X R		8	151.10	0.65
ERROR		46	231.22	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 75 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
DOSE	0.25	2.00	0.50	SALINE	1.00
MEANS	13.08	16.89	17.50	18.80	19.67

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 76

TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE AMPHETAMINE SESSIONS INDICATED BY DOSAGE IN PARENTHESES.

DOSE(MG/KG)		Z-19			Z-20			Z-22	
	N	SPS	PS	N	SPS	PS	N	SPS	PS
(SALINE)	$\bar{X}$ 5	9.20	11.28	6	7.89	9.87	4	9.08	11.08
	SE	1.05	1.44		1.38	1.85		0.57	0.92
(0.25)	$\bar{X}$ 5	8.93	10.85	4	10.08	12.40	4	7.08	9.38
	SE	0.85	0.97		0.34	0.52		1.05	1.27
(0.50)	$\bar{X}$ 6	9.28	11.83	4	9.58	11.86	2	10.00	11.94
	SE	0.61	0.72		0.80	0.82		1.00	1.08
(1.00)	$\bar{X}$ 3	10.78	13.54	4	10.17	12.87	5	8.80	11.04
	SE	0.48	0.52		0.70	0.77		0.20	0.19
(2.00)	$\bar{X}$ 3	10.00	12.92	3	10.89	13.02	3	8.00	10.13
	SE	0.96	1.17		0.48	0.00		1.26	1.91

ANALYSIS OF VARIANCE

SOURCE	df	MSS	F
DOSE (D)	4	11.11	2.44
STIMULUS SEGMENT (S)	1	157.23	34.55***
RAT (R)	2	15.26	3.35*
D X S	4	0.28	0.06
D X R	8	8.04	1.77
S X R	2	0.14	0.03
D X S X R	8	0.15	0.03
ERROR	92	4.55	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 76 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
DOSE	SALINE	0.25	0.50	2.00	1.00	SALINE	0.25	0.50	2.00	1.00
MEANS	8.64	8.72	9.50	9.63	9.75	10.66	10.88	11.86	12.02	12.27

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 77

INCONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO AMPHETAMINE SESSIONS INDICATED BY DOSAGE IN PARENTHESES.

DOSE(MG/KG)		Z-19			Z-20			Z-22		
		N	SPS	PS	N	SPS	PS	N	SPS	PS
(SALINE)	$\bar{X}$	5	0.50	1.00	6	1.49	0.74	4	1.38	0.02
	SE		0.34	0.50		0.43	0.41		0.27	0.02
(0.25)	$\bar{X}$	5	1.69	0.57	4	2.14	0.71	4	1.55	0.02
	SE		0.61	0.16		0.83	0.30		0.39	0.02
(0.50)	$\bar{X}$	6	0.75	0.60	4	1.01	0.76	2	1.72	0.00
	SE		0.14	0.28		0.12	0.44		0.72	0.00
(1.00)	$\bar{X}$	3	0.67	0.06	4	1.20	0.22	5	2.33	0.09
	SE		0.27	0.03		0.27	0.10		0.33	0.09
(2.00)	$\bar{X}$	3	0.72	0.08	3	1.84	0.20	3	2.27	0.00
	SE		0.22	0.04		0.79	0.20		0.08	0.00

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	0.45	0.78
STIMULUS SEGMENT	(S)	1	30.26	52.83***
RAT	(R)	2	1.19	2.08
D X S		4	1.19	2.08
D X R		8	0.66	1.15
S X R		2	5.45	9.51***
D X S X R		8	0.31	0.54
ERROR		92	0.57	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 77 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
DOSE	0.50	SALINE	1.00	2.00	0.25	2.00	1.00	0.25	0.50	SALINE
MEANS	1.00	1.13	1.54	1.61	1.79	0.09	0.13	0.44	0.55	0.64

Any two means not underscored by the same line are significantly different at $P \leq 0.05$.

TABLE 78

CONSEQUENTIAL LEFT LEVER PRESSING FOR SECONDARY REINFORCEMENT UNDER SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO AMPHETAMINE SESSIONS INDICATED BY DOSAGE IN PARENTHESES.

DOSE(MG/KG)		Z-19 N	Z-19 SPS	Z-20 N	Z-20 SPS	Z-22 N	Z-22 SPS
(SALINE)	$\bar{X}$	5	25.71	6	18.31	4	14.84
	SE		12.53		8.09		3.06
(0.25)	$\bar{X}$	5	16.48	4	20.66	4	9.84
	SE		4.56		2.67		3.93
(0.50)	$\bar{X}$	6	17.75	4	20.95	2	32.59
	SE		2.87		7.52		6.83
(1.00)	$\bar{X}$	3	28.63	4	26.27	5	12.71
	SE		9.09		7.40		0.35
(2.00)	$\bar{X}$	3	28.02	3	26.76	3	12.51
	SE		11.85		3.04		4.93

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
DOSE	(D)	4	88.02	0.44
RAT	(R)	2	342.64	1.73
D X R		8	152.58	0.77
ERROR		46	197.71	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 78 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
DOSE	0.25	SALINE	1.00	0.50	2.00
MEANS	15.72	19.85	21.21	21.29	22.43

Any two means not undersoored by the same line are significantly different at $P < 0.05$.

APPENDIX E

Predrug sessions for ethanol self-ingestion in normal rats.

TABLE 79

CONSEQUENTIAL LICKING RATES DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-25			Z-26		
CONC(%V/V)		N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	5	314.00	284.10	7	292.14	275.90
	SE		8.59	7.09		17.77	15.20
(10)	$\bar{X}$	6	295.50	251.00	6	312.67	282.67
	SE		2.80	5.56		3.61	8.45
(20)	$\bar{X}$	10	284.70	232.00	10	309.80	283.70
	SE		13.14	11.09		5.48	6.90
(40)	$\bar{X}$	7	303.71	245.71	6	309.50	287.00
	SE		4.02	6.03		3.71	3.85
(80)	$\bar{X}$	6	303.17	255.83	6	305.83	286.33
	SE		5.14	8.12		3.63	3.56

TABLE 79 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
(0)	$\bar{X}$	5	284.00	246.04	4	309.25	274.12
	SE		39.81	31.67		5.57	14.34
(10)	$\bar{X}$	6	314.33	319.00	6	301.67	290.17
	SE		16.84	10.98		4.62	7.73
(20)	$\bar{X}$	10	288.40	302.30	10	299.00	286.60
	SE		17.41	13.70		3.51	6.81
(40)	$\bar{X}$	6	252.50	244.50	6	303.67	267.50
	SE		27.79	19.99		3.28	5.76
(80)	$\bar{X}$	6	282.17	301.67	6	288.17	281.33
	SE		24.15	21.15		6.38	4.42

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	2268.72	2.01
STIMULUS SEGMENT	(S)	1	33612.82	29.72***
RAT	(R)	3	5362.74	4.74**
C X S		4	636.66	0.56
C X R		12	3260.64	2.88***
S X R		3	7195.71	6.36***
C X S X R		12	602.91	0.53
ERROR		227	1130.97	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 79 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0	40	80	20	10	0	40	20	80	10
MEANS	283	293	295	296	306	257	261	276	281	286

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 80

DROPS OF WATER INGESTED DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-25			Z-26		
CONC(%V/V)		N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	5	2424.60	2428.75	7	3468.57	3468.14
	SE		450.68	557.86		375.87	402.73
(10)	$\bar{X}$	6	2459.67	2542.00	6	3439.50	3867.83
	SE		98.06	130.10		110.94	176.24
(20)	$\bar{X}$	10	2530.20	2593.40	10	3496.90	3935.50
	SE		146.94	174.42		68.42	106.67
(40)	$\bar{X}$		2776.86	2729.00	6	3295.17	3674.50
	SE		107.28	81.20		122.27	143.04
(80)	$\bar{X}$	6	3032.00	2968.50	6	3417.50	3807.33
	SE		146.63	196.94		103.46	108.04

TABLE 80 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
(0)	$\bar{X}$	5	2966.60	3276.80	4	2428.00	2921.00
	SE		431.11	553.05		260.34	306.12
(10)	$\bar{X}$	6	3270.33	3936.33	6	2577.00	2829.17
	SE		161.33	254.92		136.44	223.17
(20)	$\bar{X}$	10	3233.20	4335.20	10	2796.10	3324.40
	SE		161.33	254.92		136.44	223.17
(40)	$\bar{X}$	6	2793.33	3214.50	6	2576.50	2858.50
	SE		352.82	328.00		179.41	188.75
(80)	$\bar{X}$	6	3110.67	3849.00	6	2377.00	2846.17
	SE		291.72	265.79		149.16	125.16

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	1223230.57	3.72**
STIMULUS SEGMENT	(S)	1	9469049.58	28.79***
RAT	(R)	3	14324004.80	43.54***
C X S		4	223885.26	0.68
C X R		12	568722.92	1.73
S X R		3	1363959.45	4.15**
C X S X R		12	74075.66	0.22
ERROR		227	328913.84	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significnat at $P < 0.001$

TABLE 80 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0	40	10	80	20	0	40	10	80	20
MEANS	2684	2857	2937	2984	3014	2955	3104	3294	3368	3547

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 81

INCONSEQUENTIAL LICKING RATE DURING SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

CONC(%V/V)		Z-25 N	Z-25 SPS	Z-26 N	Z-26 SPS	Z-27 N	Z-27 SPS	Z-28 N	Z-28 SPS
(0)	$\bar{X}$	4	11.98	7	26.08	5	24.98	4	43.92
	SE		4.63		5.96		3.86		8.72
(10)	$\bar{X}$	6	9.17	6	28.83	6	22.67	6	27.83
	SE		0.91		3.76		4.16		3.74
(20)	$\bar{X}$	10	14.90	10	34.40	10	37.00	10	43.60
	SE		3.32		3.90		5.77		5.57
(40)	$\bar{X}$	7	13.00	6	23.00	6	28.41	6	31.17
	SE		1.63		4.02		7.93		6.00
(80)	$\bar{X}$	6	18.72	6	30.67	6	28.00	6	25.83
	SE		4.12		6.69		3.97		3.96

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	511.41	3.06*
RAT	(R)	3	2721.03	16.31
C X R		12	147.05	0.88
ERROR		113	166.85	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 81 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	10	40	0	80	20
MEANS	22.10	23.50	25.30	25.80	32.50

Any two means not underscored by the same line are significantly different at P <0.05.

TABLE 82

TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-25			Z-26		
CONC(%V/V)		N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	4	7.00	8.53	7	10.48	12.17
	SE		1.43	1.93		0.94	1.40
(10)	$\bar{X}$	6	8.33	10.13	6	11.00	13.65
	SE		0.35	0.46		0.31	0.29
(20)	$\bar{X}$	10	9.01	11.20	10	11.30	13.82
	SE		0.53	0.58		0.23	0.23
(40)	$\bar{X}$	7	9.14	11.20	6	10.67	12.82
	SE		0.32	0.32		0.47	0.53
(80)	$\bar{X}$	6	10.00	11.58	6	11.17	13.28
	SE		0.43	0.61		0.27	0.28

TABLE 82 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
(0)	$\bar{X}$	5	10.47	13.08	4	8.50	10.70
	SE		0.52	0.69		0.55	0.77
(10)	$\bar{X}$	6	10.45	12.40	6	8.56	9.76
	SE		0.58	0.82		0.46	0.74
(20)	$\bar{X}$	10	11.24	14.35	10	9.34	11.60
	SE		0.27	0.32		0.31	0.34
(40)	$\bar{X}$	6	10.84	13.13	6	8.50	10.70
	SE		0.38	0.60		0.61	0.72
(80)	$\bar{X}$	6	11.00	12.82	6	8.28	10.13
	SE		0.31	0.42		0.58	0.46

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	12.69	5.46***
STIMULUS SEGMENT	(S)	1	242.09	104.29***
RAT	(R)	2	116.39	50.14***
C X S		4	1.10	0.48
C X R		8	4.14	1.78
S X R		2	1.33	0.57
C X S X R		8	0.37	0.16
ERROR		172	2.32	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 82 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	0	10	40	80	20	0	10	40	80	20
MEANS	8.94	9.58	9.76	10.11	10.22	10.83	11.49	11.91	11.95	12.74

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 83

INCONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-25			Z-26		
CONC(%V/V)		N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	5	1.18	0.00	7	2.20	0.02
	SE		0.37	0.00		0.76	0.02
(10)	$\bar{X}$	6	1.72	0.04	6	1.16	0.00
	SE		0.26	0.04		0.40	0.00
(20)	$\bar{X}$	10	2.29	0.08	10	0.57	0.04
	SE		0.26	0.04		0.10	0.02
(40)	$\bar{X}$	7	2.06	0.00	6	0.68	0.00
	SE		0.28	0.00		0.14	0.00
(80)	$\bar{X}$	6	1.93	0.04	6	0.92	0.00
	SE		0.36	0.03		0.32	0.00

TABLE 83 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
(0)	$\bar{X}$	5	3.43	0.00	4	2.45	0.64
	SE		0.22	0.00		0.49	0.31
(10)	$\bar{X}$	6	3.98	0.00	6	1.19	0.07
	SE		0.50	0.00		0.18	0.05
(20)	$\bar{X}$	10	4.49	0.00	10	1.84	0.06
	SE		0.33	0.00		0.21	0.03
(40)	$\bar{X}$	6	3.86	0.01	6	1.80	0.12
	SE		0.38	0.01		0.30	0.04
(80)	$\bar{X}$	6	4.44	0.00	6	1.75	0.18
	SE		8.37	0.00		0.24	0.10

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	0.41	0.99
STIMULUS SEGMENT	(S)	1	308.38	748.43***
RAT	(R)	3	27.88	67.77***
C X S		4	0.19	0.46
C X R		12	1.14	2.77***
S X R		3	30.14	73.14***
C X S X R		12	0.91	2.20*
ERROR		227	0.41	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 83 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	10	40	0	80	20	10	40	20	80	0
MEANS	2.02	2.10	2.24	2.26	2.30	0.03	0.03	0.05	0.06	0.13

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 84

CONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-25		Z-26		Z-27		Z-28	
CONC(%V/V)		N	SPS	N	SPS	N	SPS	N	SPS
(0)	$\bar{X}$	4	9.77	7	40.02	5	26.04	4	14.92
	SE		4.02		5.20		6.37		2.97
(10)	$\bar{X}$	6	10.91	6	31.94	6	23.23	6	10.41
	SE		1.07		4.26		3.98		1.36
(20)	$\bar{X}$	10	14.86	10	35.41	10	32.79	10	15.01
	SE		2.09		3.12		3.95		1.54
(40)	$\bar{X}$	7	15.22	6	26.28	6	28.84	6	11.94
	SE		1.62		4.33		4.82		2.26
(80)	$\bar{X}$	6	18.65	6	31.49	6	23.74	6	10.18
	SE		3.14		3.56		3.10		1.44

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	140.81	1.81
RAT	(R)	3	3478.06	44.68***
C X R		12	86.38	1.10
ERROR		113	77.84	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 84 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	10	40	80	0	20
MEANS	19.12	20.36	21.02	24.25	24.52

Any two means not underscored by the same line are significantly different at $P \leq 0.05$.

TABLE 85

RIGHT LEVER PRESSING DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSION INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-25			Z-26		
CONC(%V/V)		N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	5	0.24	0.00	7	0.00	0.00
	SE		0.14	0.00		0.00	0.00
(10)	$\bar{X}$	6	0.13	0.00	6	0.00	0.00
	SE		0.13	0.00		0.00	0.00
(20)	$\bar{X}$	10	0.06	0.02	10	0.05	0.00
	SE		0.04	0.02		0.05	0.00
(40)	$\bar{X}$	7	0.00	0.00	6	0.00	0.00
	SE		0.00	0.00		0.00	0.00
(80)	$\bar{X}$	6	0.01	0.00	6	0.00	0.00
	SE		0.01	0.00		0.00	0.00

TABLE 85 - CONTINUED

CONC(%V/V)		Z-27 N	Z-27 SPS	Z-27 PS	Z-28 N	Z-28 SPS	Z-28 PS
(0)	$\bar{X}$	5	0.00	0.00	4	0.00	0.00
	SE		0.00	0.00		0.00	0.00
(10)	$\bar{X}$	6	0.00	0.00	6	0.06	0.00
	SE		0.00	0.00		0.03	0.00
(20)	$\bar{X}$	10	0.01	0.00	10	0.07	0.00
	SE		0.01	0.00		0.03	0.00
(40)	$\bar{X}$	6	0.00	0.00	6	0.03	0.00
	SE		0.00	0.00		0.03	0.00
(80)	$\bar{X}$	6	0.00	0.00	6	0.04	0.00
	SE		0.00	0.00		0.03	0.00

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	0.01	1.21
STIMULUS SEGMENT	(S)	1	0.08	11.37***
RAT	(R)	3	0.02	3.19*
C X S		4	0.01	0.93
C X R		12	0.01	1.23
S X R		3	0.02	2.36
C X S X R		12	0.01	1.21
ERROR		227	0.01	-

*Significant at P < 0.05
**Significant at P < 0.01
***Significant at P < 0.001

TABLE 85 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	40	80	0	10	20	80	40	10	0	20
MEANS	0.01	0.01	0.03	0.05	0.05	0.00	0.00	0.00	0.00	0.00

Any two means not underscored by the same line are significantly different at P <0.05.

APPENDIX F

Predrug sessions for ethanol self-ingestion in normal rats. Food pellets were concurrently available on FI-60 second lever pressing

TABLE 86

CONSEQUENTIAL LICKING RATES DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSION CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATION IN PARENTHESIS.

		Z-41			Z-42			Z-43	
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	9	306.22	265.67	8	316.38	231.62	8	274.38	215.12
	SE		24.09	22.35		12.99	15.97		40.11	23.88
(10)	$\bar{X}$	5	357.40	283.60	7	310.29	256.00	7	289.29	225.00
	SE		23.73	27.87		10.53	14.56		31.46	19.31
(20)	$\bar{X}$	5	294.40	234.00	7	291.71	214.43	7	177.43	187.29
	SE		26.00	26.84		24.52	24.83		27.64	16.59
(40)	$\bar{X}$	7	296.57	237.00	6	305.50	198.50	6	193.00	185.50
	SE		21.96	23.64		15.02	17.12		30.11	23.85
(80)	$\bar{X}$	7	234.00	182.43	7	252.29	200.43	5	112.20	143.00
	SE		9.75	17.94		11.53	32.06		5.10	9.76

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	53841.66	15.04***
STIMULUS SEGMENT	(S)	1	131912.10	36.84***
RAT	(R)	2	72100.18	20.14***
C X S		4	2368.37	0.66
C X R		8	3647.42	1.02
S X R		2	11568.20	3.23*
C X S X R		8	2790.14	0.78
ERROR		172	3580.85	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 86 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	20	40	0	10	80	40	20	0	10
MEANS	209	250	267	299	315	179	209	210	239	252

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 87

DROPS OF FLUID DELIVERED DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-41			Z-42			Z-43	
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	9	2665.33	2533.33	8	3233.00	2668.25	8	2643.75	2321.38
	SE		192.51	238.64		158.30	234.12		378.19	260.99
(10)	$\bar{X}$	5	2366.00	2042.40	7	2749.29	2328.00	7	2126.57	1801.29
	SE		347.84	311.00		242.60	229.03		312.98	233.47
(20)	$\bar{X}$	5	1845.60	1784.80	7	3127.43	2626.86	7	1524.14	1813.71
	SE		314.83	386.75		296.63	388.75		312.86	236.18
(40)	$\bar{X}$	7	2184.00	2083.71	6	3422.33	2586.33	6	1618.67	1719.83
	SE		107.58	83.21		255.97	291.90		251.17	206.16
(80)	$\bar{X}$	7	2045.57	1743.57	7	2849.43	1952.29	5	1199.00	1716.40
	SE		171.76	244.53		170.86	190.90		44.43	39.43

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	3383714.28	7.76***
STIMULUS SEGMENT	(S)	1	3833651.41	8.79***
RAT	(R)	2	13049806.06	29.93***
C X S		4	110813.46	0.25
C X R		8	617611.46	1.42
S X R		2	1891791.41	4.34*
C X S X R		8	263815.49	0.60
ERROR		172	435933.30	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 87 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	20	40	20	0	80	10	20	40	0
MEANS	2119	2199	2396	2419	2840	1813	2059	2106	2128	2509

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 88

INCONSEQUENTIAL LICKING RATE DURING SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

CONC(%V/V)		Z-41 N	Z-41 SPS	Z-42 N	Z-42 SPS	Z-43 N	Z-43 SPS
(0)	$\bar{X}$	9	25.89	8	20.12	8	16.38
	SE		4.47		2.16		2.52
(10)	$\bar{X}$	5	16.60	7	15.14	7	9.57
	SE		5.27		3.34		2.41
(20)	$\bar{X}$	5	16.60	7	16.57	7	9.97
	SE		7.83		4.44		1.80
(40)	$\bar{X}$	7	16.86	6	17.50	6	8.33
	SE		2.95		3.74		1.08
(80)	$\bar{X}$	7	13.14	7	17.43	5	12.40
	SE		2.48		3.03		2.69

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	217.30	2.62*
RAT	(R)	2	466.48	5.63**
C X R		8	34.33	0.42
ERROR		86	82.81	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 88 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	10	20	40	80	0
MEANS	13.47	14.15	14.37	14.53	21.00

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 89

TIME IN MINUTES SPENT IN CONSEQUENTIAL LICKING DURING SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

		Z-41			Z-42			Z-43		
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	9	8.82	9.51	8	10.20	11.75	8	9.76	10.83
	SE		0.34	0.28		0.44	0.66		0.48	0.56
(10)	$\bar{X}$	5	6.67	7.22	7	8.96	9.35	7	7.28	7.93
	SE		0.92	0.80		0.87	1.15		0.51	0.56
(20)	$\bar{X}$	5	6.47	7.68	7	10.76	12.16	7	8.66	9.66
	SE		0.33	1.49		0.68	1.04		0.90	0.76
(40)	$\bar{X}$	7	7.55	9.30	6	10.84	12.43	6	8.38	9.32
	SE		0.54	0.94		0.53	0.63		0.15	0.29
(80)	$\bar{X}$	7	8.68	9.31	7	11.23	12.45	5	10.77	12.24
	SE		0.55	0.77		0.29	0.19		0.67	0.92

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	44.58	13.68***
STIMULUS SEGMENT	(S)	1	47.55	17.66***
RAT	(R)	2	123.35	37.85***
C X S		4	1.09	0.34
C X R		8	5.96	1.83
S X R		2	0.36	0.11
C X S X R		8	0.43	0.13
ERROR		172	3.26	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 89 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	10	20	40	0	80	10	20	40	0	80
MEANS	7.74	8.85	8.86	9.56	10.17	8.27	10.06	10.30	10.65	11.24

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 90

INCONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DRUG SELF-PRODUCED(SPS) AND PROGRAMMED(PS) STIMULUS IN PRE-DRUG SESSION CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATION IN PARENTHESIS.

		Z-41			Z-42			Z-43	
CONC(%V/V)		N	SPS	PS	N	SPS	PS	N	SPS	PS
(0)	$\bar{X}$	9	3.45	0.26	8	3.39	0.26	8	4.90	0.31
	SE		0.82	0.16		0.57	0.11		1.38	0.25
(10)	$\bar{X}$	5	2.77	0.00	7	2.79	0.03	7	1.91	0.02
	SE		1.74	0.00		0.44	0.02		0.54	0.02
(20)	$\bar{X}$	5	1.66	0.00	7	3.20	0.15	7	2.00	0.00
	SE		0.40	0.00		0.35	0.11		0.71	0.00
(40)	$\bar{X}$	7	2.58	0.26	6	3.75	0.11	6	0.96	0.02
	SE		0.52	0.24		0.42	0.07		0.32	0.02
(80)	$\bar{X}$	7	2.43	0.24	7	2.71	0.06	5	0.96	0.00
	SE		0.32	0.02		0.20	0.05		0.23	0.00

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	7.67	4.14**
STIMULUS SEGMENT	(S)	1	346.55	186.80***
RAT	(R)	2	3.20	1.72
C X S		4	4.41	2.38
C X R		8	3.02	1.63
S X R		2	2.62	1.41
C X S X R		8	2.54	1.37
ERROR		172	1.86	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 90 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	80	20	40	10	0	10	80	20	40	0
MEANS	2.15	2.35	2.44	2.46	3.90	0.02	0.03	0.06	0.13	0.28

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 91

CONSEQUENTIAL LEFT LEVER RATE FOR SECONDARY REINFORCEMENT DURING SELF-PRODUCED(SPS) STIMULUS IN PRE-DRUG SESSIONS CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESES.

		Z-41		Z-42		Z-43	
CONC(%V/V)		N	SPS	N	SPS	N	SPS
(0)	$\bar{X}$	9	10.46	8	18.39	8	16.26
	SE		0.67		2.44		2.32
(10)	$\bar{X}$	5	6.83	7	16.53	7	7.80
	SE		2.07		3.79		1.20
(20)	$\bar{X}$	5	8.36	7	26.24	7	12.29
	SE		3.02		6.79		3.01
(40)	$\bar{X}$	7	8.87	6	23.76	6	10.01
	SE		1.57		5.99		0.44
(80)	$\bar{X}$	7	10.17	7	21.53	5	26.34
	SE		1.50		2.76		5.95

ANALYSIS OF VARIANCE

SOURCE		df	MSS	F
CONCENTRATION	(C)	4	175.25	2.42
RAT	(R)	2	1231.08	17.02***
C X R		8	121.51	1.68
ERROR		86	72.36	-

*Significant at $P < 0.05$
**Significant at $P < 0.01$
***Significant at $P < 0.001$

TABLE 91 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS				
CONC	10	40	0	20	80
MEANS	10.76	13.93	14.85	16.39	18.61

Any two means not underscored by the same line are significantly different at $P < 0.05$.

TABLE 92

RIGHT LEVER RATE FOR FOOD PELLETS DURING SELF-PRODUCED(SPS) AND PROGRAMMED STIMULUS(PS) IN PRE-DRUG SESSION CORRESPONDING TO RESPECTIVE ETHANOL SESSIONS INDICATED BY CONCENTRATIONS IN PARENTHESIS.

CONC(%V/V)		Z-41 N	Z-41 SPS	Z-41 PS	Z-42 N	Z-42 SPS	Z-42 PS	Z-43 N	Z-43 SPS	Z-43 PS
(0)	$\bar{X}$	9	1.24	0.49	8	5.95	6.03	8	2.24	1.56
	SE		0.25	0.24		0.56	1.41		0.31	0.41
(10)	$\bar{X}$	5	1.40	0.99	7	5.35	3.85	7	1.70	1.08
	SE		0.54	0.73		0.88	1.06		0.51	0.36
(20)	$\bar{X}$	5	1.19	0.37	7	7.86	8.22	7	1.19	0.69
	SE		0.26	0.18		2.17	2.49		0.22	0.23
(40)	$\bar{X}$	7	1.14	0.42	6	3.60	3.73	6	1.85	0.71
	SE		0.23	0.16		0.66	1.25		0.20	0.23
(80)	$\bar{X}$	7	1.78	1.37	7	4.47	8.04	5	1.46	0.06
	SE		0.38	0.31		0.52	4.34		0.17	0.04

ANALYSIS OF VARIANCE

SOURCE		df	MSS	P
CONCENTRATION	(C)	4	11.67	1.25
STIMULUS SEGMENT	(S)	1	4.31	0.46
RAT	(R)	2	486.76	52.10***
C X S		4	3.73	0.40
C X R		8	14.92	1.60
S X R		2	9.11	0.98
C X S X R		8	4.42	0.47
ERROR		172	9.34	-

*Significant at P < 0.05
**Significant at P < 0.01
***Significant at P < 0.001

TABLE 92 - CONTINUED

DUNCAN MULTIPLE RANGE TEST

	SELF-PRODUCED STIMULUS					PROGRAMMED STIMULUS				
CONC	40	80	10	0	20	40	10	0	20	80
MEANS	2.14	2.69	2.96	3.07	3.64	1.56	2.08	2.60	3.38	3.48

Any two means not underscored by the same line are significantly different at $P < 0.05$.

CURRICULUM VITAE

Joseph E. Zabik was born in Chicopee, Massachusetts on November 1, 1942. He attended St. Stanislaus Parochial School until 1956, and then Chicopee High School until 1960. He attended the Massachusetts College of Pharmacy in Boston, Massachusetts where he received the B.S. degree in Pharmacy in 1965. He then earned the M.S. degree in Pharmacology in 1967 from the Massachusetts College of Pharmacy. He then completed the course and research requirements for the degree of Doctor of Philosphy in Pharmacology in 1970 at the University of Rhode Island in Kingston, Rhode Island. After leaving the University of Rhode Island, he was given a joint appointment at Indiana University, Bloomington, Indiana as Lecturer in Pharmacology in the Medical Sciences Program in the Medical School and Associate Scientist in the Institute for Research in Public Safety. In 1971, he was appointed Instructor in Pharmacology in the Medical Sciences Program and in 1972 following the successful defense of his thesis, he was appointed Assistant Professor of Pharmacology in the Medical Sciences Program. Since 1972, he has also been serving as Director of the Bloomington Forensic Technical Center, a crime laboratory established to meet the needs of law enforcement agencies in Monroe County, Indiana.

He is married to the former Regina M. Kara, and they have two children, Laura aged 4 1/2 and Matthew aged 10 months.