The Effects of a Drug-Induced Stress on the Contrafreeloading Phenomenon in Rats

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Bennett,
Jeanne M.
1976
THE EFFECTS OF A DRUG-INDUCED STRESS ON THE
CONTRAFOELOADING PHENOMENON IN RATS

A Thesis
Presented to
the Faculty of the Department of Psychology
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
Jeanne M. Bennett
January, 1976
THE EFFECTS OF A DRUG-INDUCED STRESS ON THE CONTRAFORELOADING PHENOMENON IN RATS

Recommended 2/3/76

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Approved 5/22/76

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ACKNOWLEDGEMENTS

I was fortunate enough to have several friends help me in the unique experience of working on a master's thesis, and they cannot escape being given due credit for contributing to my learning experience.

Heading my list is Peter "Captain Strange" Mirabelle, who aided me during the four crucial testing days by a) ripping toenails off of several rats during the no-stress condition b) pulling a rat's tail off during the no-stress condition and c) ripping the wires out of the panel by sitting on them, which put me in a stress condition. How could I have finished without your help, Pete?

Leroy Metze helped me alot by not giving me much help. By leaving me on my own to finish and wire the operant cages, I finally learned what a bit drill is (I only drilled my thumb twice while putting holes in the corks) and I was able to apply Fundamentals of Physics 231 (I know you would be very surprised if you knew, Dr. Wu). I do remember the thought crossing my mind that I hoped I wouldn't kill iv
myself by electrocution in the lab and put you in an embar-rassing position, Leroy.

Jim Craig contributed to my learning experience by being absent on my first testing day. When everything went wrong (from ODing a rat to losing large amounts of data) I not only had a quick lesson in frustration tolerance and fast thinking, but was also given the opportunity to apply *Principles of Growth Group 101*. You have helped me through some painful growing, Jim.

And I must mention Herb Chapman, who helped me pass the many three hour daily training sessions. Resulting from our long conversations I a) encountered a growth group b) went skydiving for the first time and c) lost a lot of sleep on Saturday and Sunday nights. It's all been fun, Herb.

But to be serious momentarily, I did appreciate the support and love given by each of you and hope that someday I may be able to support and help each of you in some way comparable to the help you gave to me (watch out, Pete!).
PREFACE

While it is interesting to speculate on how one's research using animal subjects may be applied to the human population, I believe it must be done cautiously and with reservation. There has been a proliferation of PEE studies in the past ten years but most have centered on animals (usually rats, sometimes pigeons or cats). My study also uses animal subjects (rats) but poses for interesting application to people. I would like to see my study replicated measuring a stress factor in people on welfare and correlating that with their working (employment) versus freelancing (unemployment) behavior. If this were done, perhaps it would help to ease Elsie Dotson's mind a bit more in knowing that those twelve animals used in my study served a greater purpose than to be a pragmatic solution to my search for a thesis topic.
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The effects of a drug-induced stress on the contrafreeloading phenomenon in rats

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January, 1976

50 pages

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The purpose of this experiment was to determine if stress, induced by intraperitoneal (IP) injections of epinephrine, influenced rats' preference to freeload (drink sucrose solution from a drinking tube) or to work for a liquid reinforcer (obtain sucrose solution by barpressing). Furthermore, the order in which stress was introduced was investigated.

Following two weeks of water deprivation, 6 female and 6 male Hooded rats approximately 90 days old were divided into two experimental groups. The first group (S-N) was stressed the first and second experimental testing days in which a choice was presented between barpressing and freeloading for a 10% sucrose solution. The choice was presented the third and fourth testing days in the absence of stress. The second group (N-S) was given the choice of barpressing or freeloading the first and second experimental testing days in the absence of stress, and was presented with the same choice the third and fourth days in the presence of stress. Two dependent variables were measured: the ratio of the amount of solution earned by barpressing to the total amount of solution consumed and the amount of solution earned by barpressing.
The results of the study indicated that rats in the stress condition preferred to freeload. Furthermore, the order in which the stress was introduced affected work versus freeloading preference. When permitted to make the initial choice between barpressing or freeloading in the absence of stress, all rats chose to barpress. When the stress was subsequently introduced on the third experimental testing day, all rats preferred to freeload. Results of the (S-N) group were not as significantly conclusive because of the large variance of choice in both the stress and non-stress conditions.
Chapter 1

Review of the Literature

The study of working behavior in organisms has been a topic of research in progress with a flourishment of studies in the past ten years. The vanguard in studying the phenomenon now called contrafreeloading was Havelka, who, in 1956, investigated the problem solving behavior in rats. Giving subjects a choice as to which route to take to obtain food was an experimental method Havelka used in studying problem solving behavior. He distinguished problem solving behavior from exploratory behavior by saying that exploratory behavior diminishes as the organism becomes adapted to the novel stimulus, while problem solving behavior is continually aroused by the relationship between the food goal and the barriers presented in getting there. In his study Havelka offered two routes to food. The first route was short, direct, and led to a fixed goal while the other route was longer, less direct, and had food locations varied after each choice trial. His results showed that 18 of the rats preferred the longer route, 16 preferred the shorter route, and 16 showed no preference. While offering no explanation for the results, he did suggest that "the intrinsic reward value of the secondary reinforcing stimulus" (which he considered to be delay in attainment of food) may play a part in the reward value of the problem goal.
Jensen (1963) suggested that common operants, such as maze running or barpressing, may hold some amount of intrinsic appeal for rats. He defined intrinsic appeal as "a pleasant emotional state experienced while performing the operant". Jensen trained 200 rats to barpress for 40, 80, 160, 320, 620, or 1280 pellets, and then introduced a tin cup containing food into the Skinner box. The rats had the choice of eating free food (FF) from the cup or barpressing for food. The mean percentage of pellets obtained by barpressing positively correlated with the number of rewarded presses made prior to the choice situation. This puts to question the Hullian theory (1943) of least effort which states that if habit strengths are equal, subjects, in a choice situation, will take the alternative requiring the least amount of work. The preference for barpressing can be considered a habit strength. However, the normal experience of eating would have a higher reinforcement rate than barpressing and, therefore, would be a stronger habit strength. If the contrafreeloading phenomenon, coined the Protestant Ethic Effect (PEE), as described by this experiment followed Hull's theory, the rats would have preferred to freeload because it is a stronger habit strength and requires the least amount of work.

Singh (1970) attempted to control for habit strength by allowing rats to barpress for food on one side of the chamber during the work experimental session and to freeload from the other side of the chamber during the no-work
experimental session. In discussing his results he concluded that when giving equal amounts of training on the work and no-work side, there was no greater habit strength associated with either of the sides. The results after ten days training were consistent with Jensen's (1963) findings and showed that the rats preferred working over freeloading.

In another early study dealing with the PEE, Stolz and Lott (1964) trained 37 rats to run an 8 ft. alley for a .15-g pellet of food located in the goal box at the end of the alley. On test days a pile of pellets 1/2 in. deep and 6 in. long, and extending over the width of the alley, was placed halfway down the alley. The rats were not limited to the amount of food eaten from the food pile, but were not removed from the alley until the pellet in the goal box was eaten. The rats persisted in running over the pile of food, identical to the pellet in the goal box, to eat the pellet in the goal box, then frequently retraced the alley to eat from the pile of food. This behavior persisted for over 22 trials.

Studies such as those of Havelka (1956), Jensen (1963), and Stolz and Lott (1964) are harbingers in the investigation of the Protestant Ethic Effect. In essence the PEE describes a phenomenon whereby, in some animal species (e.g. Koffer and Coulson, 1971; Singh and Query, 1971; Crossman and Cheney, 1973; and Powell, 1974) a preference exists for obtaining food by working instead of obtaining food by less effortful means.
Since these initial studies were conducted, variables such as reinforcement schedules, types of reinforcers, and training conditions have been investigated in an effort to explain PEE. The studies conducted examining the relationship between these variables and PEE will be discussed in the remaining literature review.

**Reinforcement Schedules**

Continuous reinforcement schedules (CRF), where each response emitted is reinforced, are used in many of the PEE studies. However, some investigators manipulated reinforcement schedules to ascertain if the PEE existed when reinforcement was varied.

Carder and Berkowitz (1970) trained six rats to eat free food from a dish and then trained them to barpress for food using several different reinforcement schedules. Six daily, 1 1/4 hour training session with each response reinforced (CRF) was followed by two 1 hour testing sessions in which free food was introduced after 25 presses. The rats were then given two training sessions with every second barpress reinforced (FR10). In the two testing sessions which followed free food was introduced after 50 presses. A strong preference for pressing for food was found in the CRF and FR2 schedules. However, on the FR10 schedule a strong preference for freelloading developed and barpressing was reduced drastically. Carder and Berkowitz concluded that barpressing was not due to an intrinsic reinforcement for pressing but was
due to a preference for eating earned food over free food when work demands were not too high.

MacDonald (1970) criticized the conclusions drawn by Carder and Berkowitz (1970) by saying that the work demands were confounded by food deprivation. He stated that it was likely rats were hungrier on the FR10 schedule because they could not eat as much in the short training session so instead they resorted to eating free food. Carder (1970) replied to MacDonald's criticism by pointing out that the average consumption of earned food differed by only eight pellets between the FR2 and the FR10 schedules. Such a difference, he argued, was not enough to account for the reduced preference for earned food in the FR10 schedule.

Neuringer (1970) used pigeons on different reinforcement schedules and his findings were similar to those of Carder and Berkowitz (1970). With free grain present, if the fixed ratio schedule was less than five responses to one reinforcement, the pigeons preferred earned food. However, responses in excess of a 10:1 ratio caused a significant decrease in working for grain. Using a procedure different from that of Carder and Berkowitz, Neuringer was able to get the pigeons to peck more than 40 times for each reinforcement while identical free food was available. The procedural differences were that the birds were at 80 percent of normal body weight, a variable-interval schedule of reinforcement was used, free food sessions were alternated with control sessions, and the subjects had received previous experimental training.
Singh (1970) used three schedules of reinforcement, FR1, FR3, and FR11, in investigating two variables: (1) the effect of increasing the amount of work required to obtain food, and (2) the effect of making free food more readily available than earned food. Besides being randomly assigned to the reinforcement group, the rats were randomly assigned to work and non-work chambers in the apparatus. If one side of the chamber was a work side for the rat, the other side was a free food side. Reinforcement on the non-work side was based on the response rate of the rat on the work side. After 10 days of training, five days of work, and five days of non-work, preference testing was conducted fifteen min. a day for four consecutive days. The partition which had divided the chamber into work and non-work sections was removed and the rat was placed in the center of the apparatus. The number of reinforcements received in each chamber and the number of times the rat switched chambers was recorded. Singh found that 25 of the 30 rats earned 51% or more of reinforcement by working, regardless of the reinforcement schedule, but the FR1 group obtained significantly more reinforcement by working than did either the FR3 group or the FR11 group.

Attempting to investigate more thoroughly the control conditioning exerts on behavior, Davidson (1971) trained rats to barpress on an FR10 schedule for 56 sessions before free food was introduced to the conditioning chamber. The barpress response averaged 160/min. before the introduction of free food. With free food available in the chamber, the
response rate was lower but the rats continued to press ten times for each reinforcement. After eight testing sessions where free food was available, the rats still barpressed for food, ate all the pellets obtained by pressing, and consumed little or no free food. Davidson concluded that this behavior was under strong conditioned stimulus control established during the training period and not related to satisfying a nutritional need or to a stronger desire to work for food instead of freeload.

Reinforcers

Several different reinforcers have been used in studies on the PEE. Typically a .045-g food pellet has been used (e.g. Jensen, 1963) when rats were used as subjects. With pigeons, grain has been used (e.g. Neuringer, 1969) and with children marbles or tokens have been used (e.g. Singh, 1970; Anderson, Metze, Craig & Brunick, Note 1). Carder (1972) investigated reinforcers used as a specific variable influencing the PEE. Using water, a 10% sucrose solution, and a sucrose solution with quinine, Carder found that rats reinforced with the 10% sucrose solution earned an average of 83% of the solution instead of freeloding. However, only an average of 26% of the solution was earned by rats having water as a reinforcer. Rats also freeloded significantly when reinforced with the quinine adulturated solution. Carder concluded that the difference may lie in the food value of the solution and that the reinforcer used should be a variable given consideration in PEE studies.
Also using water as a reinforcer, Taylor (1972) found an overwhelming percentage (over 95%) of freeloading instead of earning water by rats. The training session consisted of allowing the rats to press on CRF for water until 1,000 responses had been completed. His experimental sessions spanned fifteen days in which a high preference for free water was prevalent from the first day. Taylor concluded this to be evidence against a general preference for working and does not consider that his choice for a reinforcer may have contributed to the results.

Attempting to replicate Jensen's (1963) findings in support of the PEE, Knutson and Carlson (1973) used water as a reinforcer. The rats were on an FR2 schedule with .01-cc of water used as a reinforcer. In three test sessions, consumption of the response contingent reinforcers was recorded as was the time used in free reinforcer consumption. It was found that, unlike those described in Carder (1972), the rats preferred to work for water at least 50% of the time. Knutson and Carlson used a dipper instead of a licking tube to administer the reward and suggested that this may be a factor in the discrepant findings between their study and that done by Carder.

In an attempt to replicate the findings of Carder (1972), Tarte, Townsend, Vernon, and Rovner (1974) examined several deprivation-reward combinations. Further, they examined sucrose as a sweet reinforcer with nutritional food value against saccharin as a sweet reinforcer with no nutritional food value.
In the groups using sucrose and saccharin as reinforcers, a 10% solution of sucrose and an equally sweet solution of saccharin were used and were delivered via a .1-cc dipper feeder. Twenty-eight rats were randomly assigned to one of seven deprivation-reward groups: food-food, food-water, food-sucrose, food-saccharin, water-water, water-sucrose, and water-saccharin. The rats were trained to barpress on a CRF schedule for six days or the training was extended several more days until 800 barpresses were reached. The food-water and food-saccharin groups never attained the level of 800 barpresses. The rats then went through two days of test sessions in which a choice could be made between free food or earned food. Except for the water-saccharin group, which preferred free food, all other groups showed a preference for earned food. Almost 67% of the food consumed in the water-sucrose group was earned via barpressing. Since saccharin proved to be nonreinforcing, Tarte et al. concluded that sucrose was reinforcing, not for its sweetness, but for its nutritive value.

**Secondary reinforcers**

Secondary reinforcers have recently been studied to determine any possible function they have in maintaining operant behavior in PEE. Neuringer (1969) investigated the possibility that secondary reinforcers might maintain pecking behavior in pigeons. Specifically, studying auditory and visual cues (e.g. the sound of the feeder and the sight of
the grain), one pigeon was trained to keypeck for food, which activated an empty feeder and produced an auditory cue. For the second pigeon keypecking resulted in grain appearing in the feeder cup. However, the cup was covered with a plexiglass shield so the pigeon could see but not reach the grain. Free food (FF) was available at all times to both subjects during the testing sessions. When the earned food was inaccessible to the pigeons, response rate decreased to low levels and the pigeons ate from the FF dish. When the earned grain became accessible, the response rate rose again. Neuringer therefore concluded that the auditory and visual cues were not sufficient in maintaining working behavior.

Alferink, Crossman, and Cheney (1973) used the presence or absence of a hopper light to test for any interaction of secondary reinforcers. To acquire a strong work history, pigeons were put on a gradually increasing fixed ratio schedule until an FR300 was attained. During training a hopper light was on during the 3 sec. feeding at the end of the 300 keypecks. In the testing session the hopper was permanently raised so FF became available at all times and the hopper light was no longer presented. They found that when the hopper light was off, keypecking decreased but the pigeons continued to eat the FF from the hopper. When the FR300 schedule and presence of the hopper light were again resumed, keypecking increased. Alferink, Crossmar, and Cheney concluded that the presence or absence of the hopper light could control keypecking in the presence of free food.
Training conditions

Several recent studies have indicated that experimental procedures used in training sessions may account for the work preference observed in PEE studies. Tarte and Snyder (1973) conducted a series of five tests studying various aspects of training conditions. The first three experiments were designed to replicate the Carder and Berkowitz (1970) findings which did indeed render similar results. The fourth and fifth experiments were designed to equalize the time spent in the training sessions in barpressing and eating free food and to equalize the amounts of pellets eaten in both conditions.

In the fourth experiment three rats received free food in an operant chamber for one hr. and three rats pressed for food for one hr. on the first day of the testing session. For eight days of testing these conditions were alternated between the two groups of rats so that each group had four days of pressing and four days of freeloding. Three days of testing in which a choice was given to barpress or consume freely ensued in which none of the rats preferred to barpress for food. In experiment five, the number of pellets obtained through barpressing and free food was equalized in the 18 days of training. Results of the subsequent four days of choice sessions showed that again the rats preferred to eat the free food to barpressing for it. Tarte and Snyder concluded that training conditions affect choice behavior in rats and should be considered in conducting further PEE studies.
Another study examining training conditions was conducted by Leung, Jensen, and Tapley (1965) in which rats, having either 75 or 285 previous trial runs in the testing session, were trained to run in a runway for a .045-g pellet. In the choice session the rats could either eat from a free food cup containing 300 pellets at the beginning of the runway or run for a single pellet. The results showed that rats with the 285 runs in the testing session preferred to freeload more than rats who ran the 75 test runs.

An extension of the Leung, Jensen, and Tapley (1965) study was done by Jensen, Leung, and Hess (1970) in which rats were randomly assigned to either a runway or a Skinner box. On a CRF schedule, the rats were assigned to either 0, 40, or 285 trial groups in the testing sessions. Results of this study showed that freeloding increased with an increased number of trials in training for those rats in the Skinner box groups.

Further studies show environmental conditions might affect barpressing and freeloding behavior in rats. Tarts, Townsend, and Vernon (1973) housed 18 rats for 66 days in four environmental conditions--stimulus-enriched, motor-enriched, stimulus-deprived, and a control. The stimulus-enriched group was handled frequently throughout the experiment whereas the rats in the other conditions were seldom handled. After nine days of training, two days of choice testing ensued in which results showed that two of the four groups preferred the earned reinforcer. The control group barpressed for an average of
76.2% of the food and the motor-enriched groups barpressed for an average of 61.2% of the food. The stimulus-enriched and stimulus-deprived groups preferred to freeload. The findings are explained as differences in novelty between the testing situation and the environmental conditions in which the animals were housed. Tarte et al. (1973) explained the high percentage of barpressing in the control group as being a function of having a large exploratory behavior (in this case, barpressing in the presence of free food), due to the large novelty difference.

Mitchell, Scott, and Williams (1973) found that container neophobia affected a rat's preference for earned versus free food. In the first of three experiments, training procedures were directly manipulated by exposing rats, in varying combinations, to both free and earned food before being put in a choice situation. They found that rats put in the free food condition before being put in a choice situation were most likely going to freeload. In the second experiment the rats were exposed to equal time of free food and earned food, resulting in almost all of the rats choosing the free food. The third experiment directly manipulated the variable of container novelty by alternating the function of a novel glass dish between holding free food and holding the earned food. It was found that food preference followed container familiarity. The rats preferred free food when the FF container was familiar and earned food container was novel, and preferred earned food when the conditions were switched.
Mitchell, Scott, and Williams concluded that container neophobia does exist in laboratory rats and this should be controlled in future PEE studies.

Metze, Craig, and Nau (Note 3) manipulated pre-choice training conditions where 12 rats barpressed for water for either 0, 5, 15, or 25 days. When presented with the choice of barpressing for water or drinking water from a freely available source, the rats barpressed for most of the water with the choice percentage directly related to the number of prechoice days. They concluded that inconsistencies in PEE may be a function of methodological differences.

**Physiological conditions**

An almost unexplored area of study in the PEE is the effect of the physiological state of stress on work versus freeloading behavior in the organism. Using Selye's (1959, p. 442) definition of stress as "the state of the organism following the failure of the normal homeostatic mechanisms of adaptation" it may be considered that a subject introduced to stress will react with observable differences in behavior.

One way of inducing stress is to produce a state of physiological arousal by injection of the sympathicomimetic amine ephinephrine. Several studies (e.g. Schachter, 1959; Singer, 1961; Schachter & Singer, 1962, Schachter & Wheeler, 1962) have used epinephrine as a stressor in studying emotional behavior. Latane and Schachter (1962) explored the range of dosages of epinephrine, suggesting that too much epinephrine may cause physiological debilitation or deterioration in the
in the subject's ability to perform an operant. They found that a weak dosage of 1/2 cc. of .001 solution of epinephrine (a dosage of about .0125 mg of epinephrine per 100-g of body weight in a rat weighing around 400 mg) was an adequate amount to enhance physiological arousal without deterioration in performance.

Kosman and Gerard (1955) reported that massive doses of epinephrine depressed activity and motor capabilities. Using a dosage of .6 mg/100g epinephrine in oil (1:500 solution), they investigated the effects of such a strong dosage on the performance of a learned response. Finding depressed performance of the learned response, they suggested that epinephrine suppresses movements produced by stimulation of the motor cortex. In the testing situation they noted the animals appeared weak, lethargic, moved slowly, and experienced great difficulty in performing the task.

Singer (1959) noted further side effects of epinephrine when studying the amount of emotional behavior displayed as a direct function of the degree of sympathetic activity. Used as signs of drug effect, Singer cited defecation, urination, and face-washing as increased activities exhibited by rats when injected with epinephrine. Singer observed and measured these activities in a nondrug and a drug condition and used these measurements to scale the degree of sympathetic arousal.

Another way of inducing stress is by administering electrical shock. Schnur (Note 4) studied the effects of stress
on the PEE by using an electrical shock of an intensity level of .6 ma. Using twelve rats for subjects, Schnur trained the rats to barpress for .045g food pellets for ten days after individual asymptotic levels of performance were reached. The next fifteen days the rats were given 15 min. choice sessions in which they could barpress for food or eat from pellets available in the free food cup. A ratio index was computed for each subject by dividing the total number of pellets consumed into the number of earned pellets consumed. The next fifteen days the rats were again given daily 15 min. choice sessions. However, before being introduced to the experimental chamber, they were given ten shocks for a duration of .9 sec. per shock with a 2 sec. interval between each. The result of this study showed that the effect of introducing stress was to depress the preference for earned food and to increase freeloading.
Chapter 2

Statement of the Problem

As stated previously regarding the PEE, it is evident that a variable which has had little investigation in the study of the PEE is the effect of stress on working behavior. Recent investigation of the variable stress by Schnur (Note 4) found that subjects with a previous history of work preference showed a preference for freeloading when under stress. Schnur introduced stress over a period of fifteen choice sessions by administering electrical shock before introducing the animal to the experimental chamber. Based on the results of Schnur's (Note 4) study, it is hypothesized that the presence of stress will have a significant effect on the choice to work or freeload for a reinforcer.

The dependent variable to be measured will be the amount of sucrose solution earned by each animal by barpressing. Two measures of this variable will be used: the ratio of the amount of solution earned by barpressing to the total amount of solution consumed and the amount of solution earned by barpressing.
Chapter 3
Method

Subjects

Six male and six female experimentally naive Hooded rats from the animal colony at Western Kentucky University were used as subjects. The animals, approximately 90 days old at the beginning of the experimentation, were housed individually with food available ad lib. The rats were placed on a 23 1/2 hr. water deprivation schedule two weeks prior to shaping and were maintained on the same schedule throughout training and testing sessions. Two female subjects were discarded from the experiment during the first of the choice sessions due to procedural errors. Therefore, the data represented herein is based upon six male and four female animals.

Apparatus

Three double housing cages (42 cm x 24 cm x 18 cm) were used in the study. On two of the cages a steel bar was mounted in the left wall 14.5 cm from the top and 2.0 cm from the front of the cage. A bottle, delivering approximately .1 cc of a 10% sucrose solution via a drinking tube, was attached on the front left of the cage next to the bar. A bottle delivering the free sucrose solution was placed on the front right side of the cage. This bottle was empty throughout
the 35 training days. On the third cage a steel bar was mounted in the right wall with a bottle dispensing the sucrose solution mounted next to it. On the left side of the cage was the bottle used to deliver the free solution. The bottles and bar were mounted equidistant from the sides as measured on the other two cages.

Procedure

Pilot. Using three subjects on water deprivation, a pilot study was conducted to determine the dosage level of epinephrine to be used and the parameters of the drug at that level. The dosage level decided upon was .01 cc/36g body weight of a .001 solution of epinephrine chloride diluted 1:3 in Ringer's (normal saline) solution.

Training procedure. The rats were shaped on a CRF schedule, receiving a .1 cc sucrose solution as a reinforcer, then subsequently began barpress training on the same reinforcement schedule. Barpress training consisted of 30 min. daily session conducted over 35 consecutive days in which the subjects barpressed for the sucrose solution. During this training period, the only source of water was the water received as part of the sucrose solution earned in the experimental chamber.

Testing. Following the training period each rat each day for four days had 30 min. choice testing sessions. The rats were assigned to one of two testing groups. In the first group (S-N), the first and second days of choice testing were in the presence of stress; the third and fourth
days of choice testing were in the absence of stress. Conditions were reversed for the second group (N-S). Stress was absent the first and second days of choice testing and introduced in the third and fourth choice days. During choice testing the free solution bottles were filled with the 10% sucrose solution.

Each rat in the stress condition was given an injection intraperitoneally (IP) of the epinephrine solution. After injection, the rat was returned to the home cage for twenty minutes and then introduced to the experimental chamber by placing the rat in the center of the cage. The rat was allowed to choose between barpressing for the solution or drinking from the free sucrose solution bottle.

Design

A repeated measures design was utilized with two independent variables and one dependent variable. The first independent variable, stress, was operationally defined as the state of physiological arousal twenty minutes after an injection of .01cc/36g body weight of .001 solution of epinephrine chloride diluted 1:3 in Ringer's solution. The second independent variable, order, was operationally defined by the order of stress induction. In the nonstress-stress (N-S) order, the rats received no stress the first 2 days of choice testing but were stressed the second 2 choice days. In the stress-nonstress (S-N) order the rats were stressed the first 2 days of choice testing but were not stressed the second 2 days. The dependent variable was the consumption of sucrose solution and was measured in ml.
Chapter 4

Results

Two measures of the dependent variable (the amount of earned and free sucrose solution consumed and the ratio of the sucrose solution earned by barpressing to the total amount of solution consumed) are graphically depicted in Figures 1 and 2. Group data of the amount of earned and free reinforcers consumed for each of the four choice days is represented in Figure 1. Figure 2 gives group data representing the percentages of solution earned by barpressing for each choice day.

On the first choice day the S-N group preferred the free solution while working for 45.56% of the total solution consumed (see Figure 1). The average (10.88 ml, see Figure 2) earned was only 25.89% of the average amount of solution worked for by this group on the last day of training (average terminal acquisition=42.02 ml). The N-S group exhibited a high working preference earning an average of 80.04% of all the solution consumed. The average 27.28 ml earned on this first choice day was 82.86% of the terminal acquisition of this group (32.92 ml).

The S-N group switched preferences from freeloading to working on the second choice day earning 58.98% of the solution consumed. The N-S group earned 77.27% of all solution consumed, maintaining the high working preference shown on the previous choice day.
After a day of rest the stress conditions were reversed within each group for the third choice day. The S-N group continued to exhibit a preference for earned solution by working for 58.89% of the total solution. However, the N-S group, under the stress condition, earned only 18.58% of the total solution consumed, showing a dramatic change in preference.

An even higher preference for consuming the free solution was shown by the N-S group on the fourth choice day, as only 14.77% of all the solution consumed was earned. The S-N group again preferred to work for the solution on the fourth choice day, earning 63.08% of the total amount of liquid consumed.

In assessing the data for working preference, it is evident that 5 of the 10 animals showed an overall average preference for working by barpressing for more than 50% of the total amount of solution consumed during the 30 minutes session across the four choice testing days (see Appendix A). While there was no particular trend between groups in the overall preferences, the overall group mean percentages for both the S-N group and the N-S group indicate a preference for consuming earned food (see Appendix B for the amount of earned solution consumed, expressed in ml).

It is of interest to note the trend of working preference in both groups on each of the choice days. With the exception of one rat on Day 1, working preference in the S-N group was expressed consistently by two of the rats, in both the stress
FIGURE I

Group Data: Number of Bar Presses
FIGURE 2

Group Data: Percentages
and nonstress conditions. All other rats in this group showed consistent preference for freeloading. In the other order condition (N-S) the rats were permitted to choose, initially in the absence of stress, between working for a reinforcer or partaking of it freely. In the first two choice days, the nonstress condition, all of the rats preferred to earn the sucrose solution. However, when the drug-induced stress was present on Days 3 and 4, all of the rats consumed the liquid from the free bottle in preference to working for the reinforcer. As shown in Appendix A, it is evident that the trend was as expected, i.e., the order in which stress was presented strongly affected the initial and subsequent working preferences expressed by the rats.
Chapter 5
Discussion

The general trend of working preference in PEE studies has indicated a salient preference for earned reinforcers obtained by performing an operant. Such a trend questions Hull's (1943) theory that, if habit strengths are equal, subjects in a choice situation will take the alternative requiring the least amount of work that is necessary to reduce the motivating drive. Since the normal experience of drinking has a higher reinforcement rate than performing an operant to drink (in this case, barpressing), it would be expected that a preference for freeloading would be evident. Attempting to explain the preference for working, Jensen (1963) suggested that the performance of common operants may be intrinsically appealing in that the subject experiences a pleasant emotional state while performing that operant. Indirectly incorporating Jensen's concept of intrinsic appeal and directly opposing the drive-reduction theory of Hull, White's (1959) concept of competence can be considered as a possible explanation for work preference. Defining competence as "an organism's capacity to interact effectively with its environment", White asserts that organisms are motivated to attain feats of learning with the environment. During the 35 days of training in this study, incidental observation
of the animals' trend towards increasing time lengths of syn-
chronized barpressing without consuming the earned reinforcers
led to the conclusion that a more cogent explanation of the
PEE may lie in White's concept of competence.

The preference for earned reinforcers is especially
evident in the choice days immediately following training.
The stability of preference has been explored in recent
research (e.g. Tarte & Snyder, 1973; Taylor, 1972) with re-
results indicating an increased preference for free food over
a range of choice days. The results of the present study
indicate similar findings with all but two rats increasing
freeloading behavior over choice days (see Figures 1 and 2).
While the data show that stress is a significant variable which
needs to be taken into consideration in studying PEE, it is
difficult to ascertain how much of this effect, observed over
a period of choice days, is due to a diminishing preference
for work over time. It is suggested that this effect be
considered in interpreting the degree to which stress affects
contrafreeloading behavior.

Several differences were observed in the order in which
stress was introduced. In the S-N group a preference for
either working or freeloading was established on the first
choice day and, with a high degree of consistency, was main-
tained throughout the three remaining choice testing days.
This indicated that the initial preference made by the rat
in the physiological state of arousal will persist even when
the stress is alleviated. Even though the level of work was
reduced over the choice days, the preference was still maintained. However, when a choice situation was first presented in the absence of stress (N-S group), a high preference for working existed only in the nonstress condition. The work preference shown by all rats in the N-S group lends agreement to published studies (e.g. Jensen, 1963; Tarte & Snyder, 1973; Neuringer, 1969, 1970; Stolz & Lott, 1964; Carder & Berkowitz, 1970) which support the presence of PEE. When on the third choice day stress was introduced, a universal change was made towards a preference for freeloading. This finding indicated more clearly how stress affects the contrafreeloading phenomenon.

It appeared that the presence of stress interfered with the choice made to either work or freeload. Perhaps stress interferes with the motivation necessary to attain the competence needed by the organism for effective environmental interaction. But it is also possible that the lowered rate of barpressing in the stress condition cannot be attributed to the effects of stress on working, but to the physiological effects of the drug. The tendency to freeload in the stress condition can possibly be attributed to a general depression of the animal's activity, which has been found to be a peripheral effect of the drug. If so, the results may be attributed more to the effects of epinephrine than to the effects of a physiological state of stress.

Another consideration to be made is the effect the deprivation may have on stress. The present findings seem
to indicate that the studies dealing with the preference of animals in a choice feeding situation need to control for a possible interaction effect between the type of deprivation and the drug used when investigating the effects of a drug-induced stress. The effects of the drug on the digestive system need to be considered when deciding on the type of deprivation. Epinephrine is known to stimulate glycogen output by the liver which serves to affect not only the hunger drive, but also possibly the thirst drive in that less liquid is directed towards the digestive system to aid in digestion as less food is consumed. Therefore, less liquid is required by the organism for homeostatic existence. It is suggested that another investigation be designed to determine the effects of both the food and water deprivation on a drug-induced stress. It is further suggested that an investigation be designed to determine if deprivation in itself is a stressor.

It is possible that the physiological side effects of epinephrine may mask the effects of the drug as a stressor and, consequently, epinephrine may be an inappropriate tool in studying stress as a variable. Therefore, future studies investigating the effect of stress on PEE using some stressor other than epinephrine may result in a more definitive conclusion regarding the effect of stress on PEE.
References


Powell, R. Comparative studies of the preference for free versus response-produced reinforcers. *Animal Learning and Behavior*. 1974, 2, 185-188.


Reference Notes


Appendix A
Mean Percentage of Sucrose
Earned by Barpressing
To Total Consumed

<table>
<thead>
<tr>
<th>Group</th>
<th>Animal</th>
<th>Day 1</th>
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<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>GROUP MEAN</th>
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<tbody>
<tr>
<td>S-N</td>
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<td>5.5</td>
<td>*64.19</td>
<td>*88.18</td>
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<td>*98.62</td>
<td>*62.35</td>
<td>*94.14</td>
<td>*85.63</td>
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<td></td>
<td>3</td>
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<td>5.66</td>
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<td>46.70</td>
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<td>N-S</td>
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<td>*92.52</td>
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<td>.99</td>
<td>6.59</td>
<td>*73.30</td>
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<tr>
<td></td>
<td>7</td>
<td>*90.14</td>
<td>*73.94</td>
<td>18.18</td>
<td>10.13</td>
<td>*53.76</td>
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<td></td>
<td>8</td>
<td>*56.69</td>
<td>*51.02</td>
<td>38.95</td>
<td>46.34</td>
<td>49.20</td>
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<td></td>
<td>9</td>
<td>*56.08</td>
<td>*54.26</td>
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<td>10</td>
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<td>*95.08</td>
<td>1.40</td>
<td>8.33</td>
<td>*70.53</td>
<td>59.77</td>
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*denotes those animals that preferred to work for more than half of the liquid they consumed.
Appendix B
Number of Milliliters
Earned by Barpressing
To Total Consumed

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<th>Group</th>
<th>Animal</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>OVERALL MEAN</th>
<th>OVERALL MEAN</th>
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<td>.4</td>
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<tr>
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<td>38.7</td>
<td>.2</td>
<td>.1</td>
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Footnotes

1 While this approach can be criticized, leaving the "free" bottle out during training can also be criticized since its sudden introduction during testing can create the conditions for neophobia. Metze, Craig, and Nau (Note 3) conducted several pilot studies testing the variable presence vs. absence of "free" food or water source in the PEE situation and have found out that it does not affect the choice behavior. One method of introducing the free source was investigated in a recent report (Cotton, Metze & Craig, Note 2) and was found not to have an effect.

2 Seven dosages were tried before a satisfactory level was obtained. The dosage level was begun at .01 cc/4.5 g body weight, the level cited by Latane and Schachter (1962) as being strong enough to induce stress but weak enough to avoid causing debilitating side effects. This dosage was seen to be much too strong, possibly because the effects of the drug are amplified in subjects on water deprivation. The dosage was gradually weakened until a level was obtained where motor impairment was minimized. Other dosages tried were: .01 cc/7.75 g body weight, .01 cc/9 g body weight, .01 cc/11.5 g body weight, .01 cc/18 g body weight, .01 cc/27 g body weight, and .01 cc/36 g body weight. In determining the time of onset of the drug and the duration of its effects, symptoms noted by Singer (1959) and Kosman and Gerard (1955) were observed. At the
dosage decided upon (.01 cc/36g body weight) motor impairment was still obvious but not debilitating.

3 Even the rats who showed a working preference in the stress condition barpressed at levels significantly lower than the pressing at terminal acquisition.