

ACCURACY OF A TWO-LEVER
OPERANT DISCRIMINATION TASK.
THREE EXPERIMENTS

A Dissertation
Presented to
the Faculty of the Department of Psychology
University of Houston

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

By
William Joseph Broussard

May, 1975

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ABSTRACT

Little research is currently available concerning the most accurate method for assessing discriminative control during a two-lever choice operant task when extinction sessions are utilized. Past and present research has noted a decrease in correct bar presses during extinction when compared to correct bar presses during reinforced responding. Investigators have noted an apparent "cue-search" exhibited by animals during extinction testing and have proposed that the elimination of the food reinforcement cue is responsible for searching behavior and subsequent low discrimination scores. A growing body of evidence obtained from operant discrimination experiments, psychopharmacology research, and motivational investigations is reviewed here and methods for elimination of animal searching behavior are proposed. Since extinction sessions, by definition, require the elimination of the reinforcement cue, methods for altering cue valence or cue importance are discussed.

A series of investigations was performed to determine the effect of motivational states on performance of a two-lever operant discrimination task. In all experiments, animals were trained to discriminate between tactile cues and then tested during extinction periods. Experiment I investigated discrimination accuracy for groups trained under a food-motivated condition and tested either in a motivated or non-motivated state. Experiment II followed the general pattern of the first investigation but with an additional point on the motivation continuum. Experiment III investigated the effect of amount of preliminary training when in a motivated state and subsequently tested in a non-motivated condition. Results from these experiments indicated

that the non-motivated animals performed the discrimination task significantly better than did animals in a motivated condition. In addition, results suggested that a minimal amount of training was necessary to produce accurate non-motivated discrimination during extinction. There was no discernible relationship observed between number of responses occurring during extinction periods and deprivation level. Results are discussed in terms of the reinforcement cue, cue valence, and state-dependent learning theory.

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CHAPTER I

THE ROLE OF MOTIVATIONAL INVOLVEMENT AND THE REINFORCING STIMULUS IN TWO-LEVER OPERANT DISCRIMINATION DURING EXTINCTION: A REVIEW

ABSTRACT

Little research is currently available concerning the most accurate method for assessing discriminative control during a two-lever choice operant task when extinction sessions are utilized. Past and present research has noted a decrease in correct bar presses during extinction when compared to correct bar presses during reinforced responding. Investigators have noted an apparent "cue-search" exhibited by animals during extinction testing and have proposed that the elimination of the food reinforcement cue is responsible for searching behavior and subsequent low discrimination scores. A growing body of evidence obtained from operant discrimination experiments, psychopharmacology research, and motivational investigations is reviewed here and methods for elimination of animal searching behavior are proposed. Since extinction sessions, by definition, require the elimination of the reinforcement cue, methods for altering cue valence or cue importance are discussed.

THE ROLE OF MOTIVATIONAL INVOLVEMENT AND THE
REINFORCING STIMULUS IN TWO-LEVER OPERANT
DISCRIMINATION DURING EXTINCTION: A REVIEW

At present, little is known concerning motivational effects on two-lever discrimination performance during extinction in an operant conditioning paradigm. Reviews of existing research and additional knowledge concerning motivational and stimulus functions may contribute to a better understanding of motivational effects and may clarify problems in motivational research, stimulus investigations, discrimination performance, and even behavioral pharmacology.

Although somewhat over-simplified, research in all of these areas seems to either ignore motivational parameters or direct attention to single-bar tasks in an effort to simplify problems while risking the loss of potentially useful data. Perhaps a careful review and examination of motivational, stimulus, task, and drug research would point to optimal conditions for investigation of discriminative control in all of these areas.

Role of Reinforcement as a
Stimulus Cue in Discrimination

A number of investigators concerned with accuracy of discrimination performance during an operant task have advanced the hypothesis that poor discrimination may result from the elimination of an essential cue during extinction testing. The experiments to be discussed generally propose that omission of food reinforcement results in a stimulus generalization decrement adversely affecting discrimination performance.

Farmer and Schoenfeld (1964) trained two rats for thirty days on a bar press response with a FI-30 sec schedule with a DRL component added. The resultant effect was that a minimal inter-response time (IRT) for the reinforced response, in addition to the FI variable, was necessary for reinforcement. When post-reinforcement break length (time between responses) was compared with length between responses not resulting in reinforcement, it was observed that a greater precision of timing behavior (measured by IRTs) significantly increased if a response followed a previous response that was reinforced. These authors conclude that the reinforcement event, rather than the organism's response, initiated IRTs more appropriate to the schedule in effect. In addition, the relative frequency of a sequence of two reinforced responses appeared greater than that of a sequence of a non-reinforced response followed by a reinforced one. A second experiment utilizing only a DRL 24-sec schedule was conducted and confirmed the findings observed in the initial investigation. These authors conclude that a "greater intensity of exteroceptive cueing" is the main function of the reinforcing stimulus. They propose that omission of such cue conditions eliminates a necessary stimulus event essential for animal discrimination performance. Such a view is more parsimonious than earlier explanations proposed by investigators relying on internal factors to explain mediation of timing behavior. Farmer and Schoenfeld propose that when an animal encounters the reinforcing stimulus, a relatively less ambiguous condition is prevalent than if the animal does not encounter a reinforcing stimulus. An opposing view is discussed by Anger (1963) concerning the development

of internal "clocks" or timing mechanisms. Anger proposed that discriminative control evolves through both internal timing mechanisms and individual organismic variability. He felt that the development of high or low response probability has little to do with environmental change. For Anger, discrimination implies the presence of discriminable events. According to this author, however, temporal discrimination must be a function of organismic differences since he does not accept the omission of reinforcement as constituting a change in environmental stimulus events.

Other investigators, however (Carter and Bruno, 1968a, 1968b; Ferraro, Schoenfeld, and Snapper, 1965; Holz and Azrin, 1963; Reynolds, 1964a, 1964b) seem to think that exteroceptive cue conditions are more likely responsible for accurate temporal discriminations than are any hypothetical internal mechanisms. Carter and Bruno (1968a) trained three groups of rats given 300, 900, or 1500 water reinforcements for responses on a DRL-6 sec schedule of reinforcement. While resistance to extinction was subsequently low for all animals, rapid and accurate reconditioning to the initial schedule was observed when reinforcement was again programmed. In addition, these authors observed that a response met the DRL criterion more often if it followed a reinforced rather than an unreinforced response. They suggest that the stimuli produced by criterion responses serve not only to reinforce those responses but also to set the occasion for further reinforced responding. Such data support the hypothesis suggested by Farmer and Schoenfeld concerning the role of reinforcement as a discriminative stimulus.

In a subsequent investigation, Carter and Bruno (1968b) examined steady-state DRL behavior by training seven naive rats on a DRL-15 sec water-reinforced task. An examination of the conditional probabilities following 20 hours of conditioning indicated that an animal was more likely to make a reinforced response if the previous response were reinforced than if the previous response were unreinforced. Their data clearly demonstrated that behavior following a reinforced response is quite different than behavior following an unreinforced response when all behavior is graphically presented with the abscissa being relative frequency of responses and the ordinate axis inter-response time in seconds. In all animals, responses following reinforced responses met or closely matched the IRT requirement of the schedule. Responses that were not reinforced were not statistically likely to be followed by reinforced responses. In addition, re-acquisition following extinction was rapidly acquired following the first reinforced response. Again, the authors interpret these data to indicate a discriminative control function of the reinforcer.

All the investigations cited suggest that the omission of reinforcement (particularly where the ratio of number of responses to the number of reinforcements during training is high) serves as a discriminative cue for accurate responding or for not responding during extinction. Thus, it appears that the omission of reinforcement eliminates the discriminative stimulus for further responding.

While these experiments are obviously germane to discussions concerning discrimination assessment during extinction, other investigators (Waters, Richards, and Harris, 1972) have observed "cue

search" behaviors emitted by animals during extinction of a two-bar discrimination task. Such cue searching behavior cannot be explained in any way other than external stimulus control. It seems unlikely that organisms would search the external environment for salient cue conditions if such conditions were internally present as suggested by Anger. Such searching behavior was first observed when pharmacological agents were used as discriminative stimuli for a two-lever choice task. When such internal cue conditions are used, discrimination performance seems related to the availability of reinforcing stimuli but not schedule requirements (DRL timing) or previous variations in reinforcement densities (Richards, 1974a). For this reason, a discussion concerning the evolution of behavioral measures used in psychopharmacology may be helpful in an understanding of discriminative control during extinction.

Evolution of Drug-Behavior Evaluations

Activity Measures

Investigators interested in the pre-clinical assessment of behavioral changes associated with drug administration have searched for accurate and reliable evaluation devices for almost a century. As early as 1898, Stewart reported that a general decrease in the activity level of laboratory rats resulted from chronic feeding of alcohol solutions to these animals. While his measurement operations were primitive by contemporary standards, his observations encouraged over fifty years of work concerning drug effects on the general activity of experimental animals. During those years, behavioral measures were rarely evaluated or refined. Instead, investigators chose to study a

variety of pharmacological compounds and their effects on "general" activity or activity defined in terms of running speed or latencies.

Emotionality Measures

Activity was only one area of pre-clinical drug evaluation researched during the early years of behavioral pharmacology. As early as 1927, reports from Pavlov's laboratory indicated a concern with drug influences on experimentally produced neurosis. Federov, Furman, and Zimkin (Pavlov, 1927) produced experimental neurosis in dogs and observed that the animals were "cured" by the administration of bromides. Gantt and Wolff (1935) confirmed the calnative action of bromides and similar compounds on behavior elicited from animals subjected to experimentally produced neurosis. Wikler and Masserman (1943) later demonstrated that morphine seemed to "markedly diminish" behavioral disturbances in cats when these animals were first trained on a positively reinforced instrumental response and then punished with an air blast and shock for performance of the response. As in the history of research concerning emotionality, researchers concerned with the effects of pharmacological agents on experimental neurosis have almost always held the behavioral measurements constant across experiments while varying the drug conditions (Masserman and Yum, 1946; Bailey and Miller, 1952; Jacobson and Skaareys, 1955).

In general, work on activity measures continued to utilize gross behavioral assay techniques until Brady and Hunt (1955) adopted the use of a free operant for the evaluation of drug-produced emotionality. Previous lack of concern for specification and definition of behavioral

variables had caused researchers (Brady, 1959a; 1959b) to comment on the availability of more accurate assessment devices. Brady (1959a) reviewed the pharmacology literature up to that time and noted that terms like "conflict," "stress," and "neurosis" were, at best, ambiguous. He felt that the use of operational definitions were essential for the analysis of drug-behavior problems.

Although such operational methods were previously available, Skinner (1953) and Ferster (1953) are usually given credit for their introduction into psychopharmacology. The application of operant conditioning was rapidly accepted and incorporated into pharmacological research shortly after (Brady, 1955; 1959a; 1959b; Sidman, 1959; Boren, 1966).

For almost fifteen years, operant conditioning seemed to be a favored technique for researchers involved with the evaluation of drug action on behavior. During this period, conceptualizations of drug-behavior interactions remained rigidly fixed and most experiments utilized designs in which pharmacological action was defined as a change in response patterning or response rate following administration of a drug. Brady (1959b) proposed that a procedure producing conditioned suppression of a bar-press response provided a stable baseline for the accurate evaluation of drugs reported to reduce or enhance "emotionality." In his procedure, a monkey was trained to bar-press for a liquid (orange juice) reward. Following stable baseline performance, the animal received repeated pairings of a clicking noise followed by a short and "painful" electric shock to the feet. Using alternating five-minute periods of "clicker" and "no clicker," Brady reported that the animal developed almost complete disruption of responding during presentation

of the clicking noise but generated a response pattern indicating no disruption during the periods of "no clicker." The author suggested that the behavioral baselines produced in such experiments provide a useful tool for evaluating specific drug effects upon "affective" response systems while concurrently controlling for more generalized motor disturbances or malaise.

An alternative approach was to supply an organism with a behavioral repertoire: any component of which could be elicited at any time. The assumption was that any given drug could be tested over a spectrum of behavior in the same animal at different times. Dews (1956) demonstrated such a technique using pigeons and a multiple schedule design. In his experiment, food-deprived birds were rewarded with access to grain for pecking a lighted key. When the key was red, 60 pecks were required for reinforcement, but when the key was blue, birds were rewarded for the first peck occurring 15 min following the previous reinforcement. Thus a fixed ratio schedule of 60 responses per reinforcement (FR-60) and a fixed interval schedule of 15 min (FI-15 min) were brought under the discriminative control of colored cue lights. Following baseline stabilization on both schedules, phenobarbital sodium was administered intraperitoneally to each bird, and the time course of drug action observed. Three hours following drug injection, there was almost no pecking behavior on the FI schedule. Although FR behavior was severely disturbed, there was still substantial response output after three hours. The author interpreted these data as demonstrating that drugs do not exercise generalized depressive effects upon all behavior but are relatively specific to reinforcement contingencies and schedule effects.

Herrnstein and Morse (1956) confirmed these findings and Boren (1966) demonstrated similar results using the tranquilizer benactyzine.

Blough (1955) conducted an experiment designed to show drug effects upon an organism's "discriminative" capacity. In this study, pigeons were presented with two response keys separated by a vertical bar. The keys and the bar could be independently illuminated. Food-deprived birds were required to peck the correct key and then were reinforced on a variable interval (VI) schedule. If the vertical key was lighted, the bird was reinforced for pecking the darker of the two keys, and if the bar was dark, pecks occurring on the brighter key were reinforced. Reinforcement, then, was not only contingent upon bright and dark discrimination but was also conditional upon illumination of the center bar.

Blough's design permitted two measures for evaluating drug effect; they were (1) rate of response or total number of responses emitted per session and (2) accuracy of choice expressed in per cent correct responding. Performance was plotted as both rate and accuracy scores over time following either administration of LSD-25 or equivalent volumes of saline. It was observed that there was no drug effect on rate of behavior but, shortly after administration, discrimination scores increased for birds receiving the drug. Birds receiving LSD-25 continued to demonstrate increased accuracy as long as five hours following administration. In a subsequent experiment, Blough (1956) demonstrated that alcohol and pentobarbital have opposite effects. In this case, drug administration resulted in an increase in absolute rate of responding but a decrease in the accuracy of discriminative control.

While findings such as those mentioned seemed interesting and promising at the time, research in other areas of pharmacology hinted that operant technology was not a panacea for evaluation of drug effect. During the 1950's researchers noticed that while drugs may modify ongoing behavior (rate, for instance), they do not necessarily create behavior. Dews (1955) was the first to demonstrate that the behavioral effects of drugs depend on the organism's reinforcement history. In his study intramuscular injections of pentobarbital (ranging from 0.25 to 5.6 mg per bird) were administered to four food-deprived pigeons maintained on a concomitant FR-50-FI-15 min schedule. The most significant observation of this study was that the behavioral effect of a particular dose varied from a decrease in responding on a FR component to an increase in response rate while on the FI component. Only the schedule component in effect at the time of drug administration seemed relevant to changes in behavior. Subsequent investigators (Morse and Herrnstein, 1956) demonstrated the same effect using concurrent schedules and pentobarbital administration with pigeons. Only the contingency of food presentation reliably covaried with alterations in response patterning; not drug dose.

Kelleher and Morse (1964) designed an elaborate experiment to demonstrate schedule-controlled effects on response patterning following drug administration. In their study, response patterns between monkeys were compared when the animals were trained on a multiple FR FI schedule of reinforcement maintained by different reinforcement events. One group was food-deprived and trained to respond under a multiple FR FI schedule for food reinforcement. A rectangular window located in front of each animal could be illuminated to produce (1) a pattern of horizontal

lines, (2) a red light or (3) a white light. When the horizontal line pattern was presented, responding to any schedule never resulted in reinforcement. In the presence of the red light, a FR-30 schedule was in effect and in the presence of the white light, a FI-10 min schedule was in effect. A second group of monkeys was trained to a multiple FR FI schedule in which reinforcement was termination of stimuli correlated with occasional electric shocks. As in the first group, the horizontal line pattern had no consequences for behavior. When the red cue was presented shocks were delivered every 30 seconds. Shocks could be avoided, however, if the animal emitted 30 responses. The 30th response terminated the red light and produced the horizontal-line pattern. In the presence of the white light, shocks were delivered at 1-sec intervals starting after 10 minutes. The first response after 10 minutes terminated the white light and produced the pattern of horizontal lines. The authors observed that while performances were maintained by different events, the two multiple schedules generated similar patterns of responding. Behavior under the FR component of each multiple schedule was described as a sustained high rate of approximately 2.3 responses per second. Performance under the FI components was characterized by a typical pause followed by response patterning of about 0.6 responses per second. Following response stabilization, intramuscular injections of d-amphetamine (0.01; 0.03; 0.1 and 1.0 mg/kg) were given these animals and response patterning recorded. A consistent finding across all animals was that -- except at the highest dose (1 mg/kg) -- d-amphetamine administration increased rates of responding under both FI schedules but decreased rates under both FR schedules. The authors

point out that although decreases in responding after amphetamine administration occurred under a variety of conditions, it seems tenuous to assume that such a decrease in the rate of food-reinforced operant may result from the drug's anorexic properties. Since the data demonstrate similar changes in response patterning following drug administration, regardless of how the behavior is maintained, interpretations based on anorexia are potentially specious (Morse and Kelleher, 1970). Such results strongly suggest that drug effects on operant behavior are readily modifiable by schedule effects. Such findings, in turn, suggested that a re-evaluation of the drug-behavior problem was necessary for an accurate conceptualization of drug action in pre-clinical assessment.

A complete reassessment has been called for by some researchers concerned with the drug-evaluation problem (Kelleher and Morse, 1968; Thompson and Pickens, 1971; Schuster and Balster, 1974). For the most part, these researchers have noted instances of environmentally-controlled regulation of drug action and propose that the introduction of a drug into an organism be considered a stimulus event. If drugs are viewed as stimuli, then operational models for drug-behavior-environment interactions can be formed. Schuster and Balster (1974) suggest that when drugs are conceptualized as stimuli, drug action can then be described in the operational terms used to define more traditional types of stimuli. According to these authors, drugs can serve the following stimulus functions:

1. Unconditional Stimuli

If a drug presentation reliably elicits an unconditional reflex from an organism, then drug presentation can be conceptualized as

presentation of an unconditioned stimulus. As early as 1937, Girden and Culler observed what appeared to be unconditional drug effects using curare and a classically conditioned leg flexion response in dogs. Brady (1959) suggested that methodological problems result from unconditional drug reactions when paired with environmental change and that such contiguous relationships may permanently affect behavior. At that time, Brady did not propose that drugs could serve as a stimulus function, although procedural problems resulting from drug administration suggested that some form of re-evaluation was necessary. In discussing methodological problems, Brady (1959a) noted that there was an obvious interaction effect between the biological effects of a drug and the environmental contingencies maintaining an organism's behavior at the time of administration. He observed animals producing a stable output of lever pressing on a variable interval schedule (VI) and noted a decrease in rate following administration of a depressant drug. What Brady was most concerned with was the observation that lever pressing never regained its original rate for periods of time long after the drug effect had subsided.

What Brady observed was an unconditional drug response subsequently reinforced and maintained by environmental contingencies. Interestingly enough, it seems that only one drug presentation is required in order for a lasting conditioned response to be acquired. In experiments utilizing pharmacological agents as stimuli, the intensity and duration of stimulus presentation may be a sufficient condition for overcoming the multiple-pairing requirement. Unlike external cues which can be ignored or missed by organisms, interoceptive drug-produced cues may be

pervasive and inescapable. As a result, conditioning may proceed with fewer pairings.

2. Conditioned Stimuli

Drugs may serve as a conditioned stimulus (CS) if drug presentation acquires the ability to reliably elicit a conditioned response (CR) following repeated pairings with some unconditional stimulus (US). To date there are only two experiments that directly bear on drugs serving as conditional stimuli. Cook, Davidson, Davis, and Kelleher (1960) demonstrated classical conditioning effects using 30 second intravenous infusions of central nervous system stimulants (epinephrine, norepinephrine, and acetylcholine) as conditioned stimuli for a leg flexion avoidance response in dogs. These investigators report the establishment of a strong CR following 60 to 140 shock pairings. Turner, Brownson, and Braud (1974) offer more recent demonstrations of drug states serving as conditional stimuli. These investigations concern d-amphetamine produced interoceptive cues serving as (1) a CS for shock-elicited aggression (Ulrich and Azrin, 1962), (2) a CS for T-maze avoidance learning, and (3) a CS for suppression of an operant response. In the first of three experiments, 10 male albino rats were assigned to 5 pairs according to body weight. Three pairs each received shock in conjunction with a different dosage of drug (0.5; 1.0; and 3.0 mg/kg). One control group received 3 mg/kg of drug with no shock presentations and the fifth group received saline injections and shock. All animals were given injections 15 minutes previous to the start of shock trials. In addition, all animals were given a three minute test session for spontaneous aggressions previous to any shock presentations. Shock presentations

consisted of 180 out of 200 trials per day (2 na scrambled shock of 1 sec duration) with the other 20 trials used as "probes" for observation of non-shock elicited aggressions. All shock presentations were controlled by equipment located outside the experimental room and aggressive behavior was recorded by two observers stationed within the experimental room. While all pairs given shock exposure increased in fighting behavior over trials, only those animals in the drug-shock paired groups demonstrated frequent spontaneous (non-shock elicited aggression) during the 3 minute test sessions preceding the start of shock presentations. The drug-non-shock group never displayed aggression during the 3 min probe period. In the drug-shock pairs there were no dose-response relationships. Following experiment 1, one animal from each group was placed in a standard 1-maze following 24 hour water deprivation according to the following sequence.

1. 10 random forced-choice trials per day (5 trials to each side) to dishes containing 0.5 ml of sucrose-saturated water for a period of six days. Right or left turn preference was recorded following 3 additional days of preference testing.
2. 2 forced-choice trials per day for a period of 5 days in which the preferred side contained sucrose-amphetamine-water (3 mg/kg). Each trial required a 15 min stay in the goalbox following ingestion of the liquid. The drug choice was always run as the last of both trials.
3. 10 preference non-reinforced trials per day were run for 3 days to determine if preference-reversal had occurred.

All animals with amphetamine-shock experience showed a marked preference reversal following drug ingestion in the previously preferred goalbox.

The saline-shock animal showed no preference for the drug goalbox, while the drug-non-shock animal demonstrated an increased preference for the drugged goalbox.

Following experiment I, the other 5 animals not used in experiment II were placed on food-cycling and reduced to 80% free-feed weight. During training, all animals were given saline injections 15 min previous to being placed in operant chambers. Animals were shaped and subsequently maintained on a VI-1 min schedule of reinforcement and given a 30 min session each day until response rate varied no more than $\pm 5\%$. During three days of testing, all animals were given 1.5 mg/kg injections of d-amphetamine 15 min previous to the experimental session. All animals with previous drug-shock experience demonstrated a marked decrease in response rate and total number of responses during the three drug test sessions. The saline-shock and amphetamine non-shock animals showed an increase in rate during test sessions. These experiments suggest at least three workable designs for the investigation of drug states serving as conditional stimuli in addition to demonstrating a classical conditioning effect.

3. Reinforcing Stimuli

Drugs can be conceptualized as reinforcers if their effects (either presentation or removal) are under the organism's control and they subsequently increase the probability of occurrence for the response which they follow. While the mechanics of drug self-administration may vary from experiment to experiment, the basic routes of administration and reference experiments for such investigations are (1) oral (Harris, Claghorn, and Schoolar, 1967), (2) inhalation (Jarvik, 1967),

(3) intraperitoneal (Cappock and Nichols, 1955), (4) intracerebral (Olds and Olds, 1958; Myers, 1963), and (5) intravenous (Thompson and Schuster, 1964). Recent reviews of the literature relevant to drug self-administration have been provided by Thompson (1968) and Schuster and Thompson (1969), and will not be covered here.

An example of behavior reinforced by self-administered drug presentation is given by Thompson and Schuster (1964). Three adult male rhesus monkeys were surgically implanted with a jugular catheter and infused 4 times daily with 7 mg of morphine sulphate for a period of 30 days. Following the period used to build physical dependence, all monkeys were conditioned to emit a specific behavioral sequence in order to obtain infusions of morphine. The final series of behaviors were a FI-FR chain. The interval component was signalled by a tone onset, and the first response occurring after 2 min of tone turned on a white light signalling a change to the FR component. Twenty-five responses in the presence of the white light produced a subsequent infusion of 7 mg of morphine over a 60 sec period. Thus, in order to obtain the drug, animals were required to complete the 2 min fixed interval giving it the opportunity to emit 25 additional responses followed by morphine infusion. Following stabilization of the FI-FR sequence, the infusion and stimulus presentation apparatus was turned off for 24 hours. The following day, the FI-FR schedule was reinstated and changes in behavior were recorded. The number of responses in the fixed interval were dramatically increased, as compared to baseline conditions. In addition, latency to completion of the 25 responses in the FR component was reduced. Dose-response information obtained indicated a decrease in the tendency to work for

the drug as dose (amount of reinforcer) increased.

Experiments such as this suggest that drug administration can serve as reinforcers for behavior in that organisms will (1) show an increased probability of responses followed by drug administration, (2) generate a stable baseline of behavior if the behavior is drug reinforced, (3) chain behavior and (4) increase or decrease response rate as a function of increased or decreased levels of deprivation or amount of reinforcement. While drug self-administration has been shown to demonstrate all of the above behavior, most investigators seem to agree that a drug can be considered reinforcing if an increased rate of responding over operant baseline rate results when the response is followed by a drug injection.

4. Discriminative Stimuli

If behavior is reliably emitted and reinforced in the presence of a drug state, then it may be possible to bring an operant under stimulus control in such a way that behavior can be shown to predictably covary with experimental variations in the drug condition. When approached in this manner, drug states do demonstrate properties similar to more traditional external stimulus control conditions (Catania, 1971).

Overton (1968) has written a comprehensive review of the discriminative control literature published before 1967. Therefore, only a couple of relevant experiments will be reviewed in this section. Since discriminative control of behavior by drug states research employs experimental techniques relevant to this investigation, methodological and procedural problems concerning reference experiments will be discussed in some detail.

Harris and Balster (1971) demonstrated discriminative control by a drug state using a one-bar operant task employing a multiple FR-50 and a differential reinforcement of a low response rate schedule with a 20 second inter-reinforcement contingency (DRL-20 sec). Saline (1.0 ml/kg) and dl-amphetamine (1.0 mg/kg) were administered intraperitoneally and served as the discriminative stimulus for the multiple schedule components. During training, the amphetamine state was always paired with reinforcement contingent upon DRL response patterning while saline administrations signaled that an FR-50 pattern was appropriate. Following stabilization of response patterning, animals were extinguished for a 30 min period under one or the other of the two stimulus conditions. Responding throughout the amphetamine extinction session showed a pattern typical of DRL performance while the cumulative recordings obtained during extinction under saline conditions showed only a few instances of spaced responding. Similar experiments were conducted using a multiple schedule comprised of a fixed ratio schedule and an extinction component (FR-EXT). When saline (1.0 ml/kg) served as the cue for extinction and pentobarbital (5.0 mg/kg) for FR responding, extinction under either cue condition reflected the animal's previous reinforcement history. The cumulative recordings obtained under saline showed FR bursts during the first five minutes followed by a complete lack of responding.

While the presentation of cumulative recordings obtained during operant conditioning experiments may represent an accurate account of behavioral control, such records preclude statistical analysis and interpretation of data. Although some investigators (Sidman, 1960) have argued that pictorial accounts of behavior are sufficient evidence

for demonstrating the effect of some manipulated variable, recent trends in operant conditioning suggest that both cumulative recordings and statistical examination provide a more complete description.

An alternative design that permits statistical analysis employs a two bar operant task in which a stimulus condition (S_1) is consistently paired with reinforcement on one bar and a different stimulus condition (S_2) with reinforced responding on the other bar. Stimulus control can then be evaluated during extinction sessions if only one stimulus condition is presented. The degree to which a stimulus controls behavior may be quantified in terms of a Discrimination Ratio (DR) defined as the number of correct bar responses divided by the total number of responses. If the DR is then multiplied by 100, per cent correct scores are obtained and may be used for illustration purposes. Waters, Richards, and Harris (1972) employed such a design for evaluation of discriminative control and generalization using dl-amphetamine as S_1 and saline (equivalent volumes of a 9% NaCl solution) as S_2 . Three groups of rats ($n = 5$ per group) were trained to perform a multiple DRL-15" - DRL-15" schedule in a two lever operant chamber. Drug-stimulus conditions were introduced by intraperitoneal injections of either amphetamine or saline 15 minutes previous to each of 28 one-hour training sessions. Correct lever choice conditions were designated for each of the three groups as either: (a) 0.3 mg/kg vs. 2.5 mg/kg; (b) saline vs. 2.5 mg/kg; or (c) saline vs. 0.3 mg/kg. Evaluation of strength of discriminative control was obtained by presentation of a stimulus condition during a 12 min extinction probe every fifth day of training. Generalization testing was conducted by administering intermediate doses of drug previous to extinction probes.

These investigators expressed their data in terms of DRs and per cent correct responding. Results from these experiments show a strong statistical effect (using chi square and comparing obtained DRs to a theoretical expected DR of 0.50 or 50% correct random responding) indicating a high degree of stimulus control in all three experimental conditions. The use of such a design allows both graphic and statistical representations of behavior and permits more precise evaluation of discriminative control.

Even this method, however, is not without problems. Waters, et al. observed that responses shifted from one bar to another over time during the 12 min probes. Although they acknowledge that such shifts decrease the final obtained DR and may result from the drug effect becoming more salient later in the extinction test period, they suggest that other factors may play a part in response shifts. Such factors as the removal of the food-stimulus during extinction may contribute to response shifts. Following close examination of their data, they proposed that animals go through a "cue search" process with drug cues becoming less important relational to other stimuli such as reinforcement. Later in the test session, animals may increasingly depend on available cues such as drug produced internal stimuli. They further suggest that discrimination scores could be modified if either less of a cue change was introduced or some procedure developed allowing organisms to attend to relevant cues early in testing. These authors fail to mention that the frequent use of the first 5 min period of an experimental probe is typical of other investigations using similar designs but different pharmacological agents. Kubena and Barry (1969) recommend short

measurement periods since longer probes also result in "cue search" behaviors which correspondingly decrease DRs. A procedure that eliminates all "cue search" behavior would possibly increase DR scores and be a more accurate assessment tool for the evaluation of discriminative control. Possible reasons for cue searching and methods for elimination of such behavior are suggested in the literature concerning the stimulus function of reinforcement and of drive level in discrimination performance. The role of reinforcement as a cue for behavior has already been discussed and the complexity of the problem is obvious. Perhaps the most convincing argument for not pursuing reinforcement as a cue is that discrimination is almost always measured by rate of acquisition or extinction performance. By definition, the use of extinction performance eliminates reinforcement cues. Motivation, however, seems to be highly correlated with performance of discrimination tasks other than those using a two-lever choice procedure. A solution to cue searching behavior may be found in the motivational literature.

Motivational States and Discrimination Learning

Although it may seem reasonable to assume that as an animal becomes increasingly motivated, it will try harder to solve complex tasks, if such a view was ever tenable, it had to be rejected following a study by Yerkes and Dodson (1908) which showed that performance in a maze learning situation increased with increased motivation up to a point -- after which performance deteriorated. These investigators also showed that the level of optimum motivation was higher for easy tasks and lower for

more difficult problems. This relationship between performance and motivational level has generally been termed the Yerkes-Todson Law. In a more general sense, discriminative performance can be considered a complex task with task difficulty relational to the complexity of the discrimination.

In the area of discrimination learning, motivational effects on performance have not been fully studied. In fact, only partial attention has been given operant discrimination with no attention given a two-lever choice design. Previous research concerning motivation and discrimination should be reviewed in order to illustrate the degree to which conclusions about drive effects on discrimination performance are, at best, tenuous.

Spence, Goodie and Ross (1959) observed that when animals are given the opportunity for an equal number of correct or incorrect responses during acquisition of a discrimination task, drive level has little or no effect on subsequent discriminations. Other investigators (Birch, 1955; Meyer, 1951; Tolman and Gleitman, 1949) report conflicting data suggesting either a facilitatory or inhibitory effect of increased drive level on discrimination acquisition.

More relevant to the investigations presented here, Dinsmoor (1952) trained rats on a one-bar operant light-dark discrimination task and observed that discriminability remained invariant when changes in normal body weight were manipulated following training. From these results, he suggested that the slope of the generalization gradient between stimuli is unaffected by drive level.

Lachman (1961) trained rats in a three arm Y maze under high (4 hr water presentation on alternating days) and low (10 min water presentation 4 hr prior to training) conditions. Using correct choice as a criterion of discrimination learning, he found that while thirst level produced no influence upon measures of discrimination learning, it did significantly influence locomotion rate.

In an operant conditioning paradigm, investigators utilizing a one-bar task have noted some interesting patterns. Both Dinsmoor (1952) and Choate (1964) used a one-bar task and noted that as drive level increased, rate of responding increased. But since the rate of responding under the two stimulus conditions (S_1 and S_2) always increased in a constant ratio, the apparent accuracy of discrimination (DRs) were not influenced.

Additional space and detail could be devoted to this subject, but since all the literature to date concerns itself with either maze learning or one-bar operant tasks, it is probably more parsimonious to point out the major findings in this area of research:

1. Drive level seems to have its greatest effect upon acquisition of a discrimination task; not upon post-acquisition performance.
2. If variations in drive level have any effect at all, it is to increase the animal's activity level (Lachman, 1961; Choate, 1964). Such data are consistent with relationships observed between general activity measures and increased deprivation levels. Hall (1956), Skinner (1933), and Miles (1962) have demonstrated that increased

levels of light, confinement, or food deprivation subsequently increase activity and manipulatory behavior in experimental animals.

3. A final observation that is both interesting and relevant to the problem of two-lever choice designs concerns the effects of motivational levels on resistance to extinction. Following manipulation of drive level, deprivation level during training had no effect upon subsequent extinction if drive level was then held constant (Heathers and Arakelian, 1941; Strassburger, 1950; Brown, 1956). Extinction effects did occur, however, in an unpredictable manner when motivational levels were altered during extinction sessions. Both Kendler (1945) training rats on a one-bar operant task under food deprivation and Reynolds (1949) using a panel pushing procedure, observed that resistance to extinction was much greater for those animals that were low motivated than for animals under a high drive condition. In both experiments, the results were not predicted initially but were highly reliable.

To summarize, it appears that low motivation during extinction sessions may increase resistance to extinction while high drive conditions may facilitate a suppression of responding. In addition, general activity and manipulatory behavior seems to increase when the organism's motivational level is increased.

The situation is even further complicated by relationships observed between discrimination acquisition and motivational states. Not only is a decrease in an animal's ability to perform complex tasks noted throughout the literature, but similar relationships seem to apply to human performance as well. As early as 1959, Easterbrook reviewed the human performance literature and proposed a general formulation stating, "the number of cues utilized in any situation tends to become smaller with increase in emotion" (p. 197). Subsequent experiments (Willett and Eysenck, 1962; Eysenck and Willett, 1962) manipulating task difficulty and motivational states in humans demonstrated the reliability and generality of Easterbrook's previous formulations.

The Problem and Possible Solutions

All of the findings reviewed here suggest a possible solution to the problem of increased accuracy during a two-lever choice operant task. Since high levels of deprivation seem to result in an increase of manipulatory activity and a decrease in the effective use of available stimuli, such high drive conditions could account for cue searching behavior held responsible for decreases in DRs during extinction testing.

If a decrease in motivational conditions eliminates manipulatory activity and general behavioral arousal and also results in an increased resistance to extinction and effective use of relevant cue situations, then a more accurate and reliable assessment of discriminative control could result during extinction testing. The motivational literature concerning both man and animal suggests that such a hypothesis is at least worth testing and research in pharmacology using discrimination

designs suggest that present methods of evaluation are in need of refinement.

Previous sections have reviewed past and present techniques for the assessment of reinforcement as stimuli, drug research using operant conditioning techniques, and motivational parameters governing discrimination performance and the unanswered questions or problems inherent in each case. Even the most common of operant techniques produce unsatisfactory discrimination scores that have either been observed, discussed and subsequently ignored (Waters, et al., 1972) or partially remedied by eliminating data through limiting testing time (Kubena and Barry, 1969).

In using a two-bar lever choice design at the Texas Research Institute of Mental Sciences (TRIMS), it has been observed that a high degree of discriminative control (95% or greater) can be obtained during reinforced practice sessions. When extinction testing is prolonged, however, a discrimination score may drop to 60% correct lever choices. Such scores are only 10% greater than would be expected had no discrimination been learned and animals were randomly responding.

The motivational literature previously reviewed suggested that drive level may play an important role in producing activity and manipulatory behaviors in addition to creating a lack of attention to relevant cue situations. If an organism were first trained under a drive condition and then tested when not in a drive state, two possible results might occur.

First, a non-motivated animal could cease responding completely or, at best, respond for only a brief period of time. Such a result seems

unlikely since previous researchers have demonstrated that trained animals seem to prefer the opportunity to perform a well-learned operant rather than cease responding.

Jensen (1963) gave 200 rats a choice between eating pellets from a dish attached to the floor of an operant chamber or pressing a bar on a continuous reinforcement schedule following 40, 80, 160, 320, 640, or 1280 rewarded responses. The mean percentage of all pellets earned during choice periods was an increasing function of the number of rewarded presses made prior to a choice between bar pressing or free food in the "freeloading" dish. Jensen suggested that the opportunity to perform an operant for a well-trained animal has an "intrinsic appeal" greater than the opportunity to eat free food.

Even more interestingly, Neuringer (1969) demonstrated that both pigeons and rats will (a) perform an operant when trained in a food-motivated state but tested in a non-deprived condition and (b) prefer the opportunity to perform the operant when free food is available in the experimental chamber. Neuringer suggests that performance of the operant itself is reinforcing and can maintain behavior for prolonged periods of time.

It seems reasonable to assume then that animals trained while deprived and then tested in a non-motivated condition should continue to respond. These findings combined with the results concerning animal motivation suggest that non-deprived animals may (a) continue to perform a task if previously trained to the task, (b) show a greater resistance to extinction and (c) attend to cues relevant to the appropriate bar choice. If these assumptions were experimentally demonstrated, such

findings might improve accuracy scores obtained from a two-bar discrimination task and allow a more precise assessment of discriminative control. The only other possibility negating such an approach can be found in the area of state-dependent or dissociated learning.

When experimental subjects are trained under one set of internal cue conditions and then tested under a changed set of cue conditions, a performance decrement may be observed and is sometimes related by degree to the amount of change imposed. This phenomenon has been termed state-dependent or dissociated learning by some authors (Overton, 1968). When applied to drug experimentation, animals trained under either a drug or non-drug condition would be expected to show a decrement in performance if tested under the alternative condition. Although some minimal performance is usually observed during testing, extreme examples demonstrating total retention failure have been reported (Bindra and Reichert, 1967) and are usually referred to as dissociation.

Girden and Culler (1937) reported one of the first experiments demonstrating a state-dependent effect. When dogs were trained to reliably give a classically conditioned leg flexion response under curare, the same animals failed to demonstrate the response under a non-drugged condition. The response could only be reinstated when the drug was again administered. Similarly, animals trained without drugs failed to show the conditioned response when curare was administered.

Grossman and Miller (1961) pointed out methodological problems often confusing results and interpretations obtained from earlier state-dependent research. These authors suggest that caution must be exercised when initiating such research so that changes in drug states between

training and testing can be distinguished from contributions made by novel stimulus conditions. They suggested the use of a 2 x 2 balanced design in which half of all subjects are trained in a drug condition and half in a non-drug condition. Half of each training group is then tested in the training condition and half in the opposite condition. Resulting from the frequent use of such a design, state-dependent or dissociated learning has been demonstrated for a variety of tasks (Overton, 1972) and for such drugs and pentobarbital (Kayser-Pandi, 1970), ethanol (Crow, 1966), scopolamine (Gruber, Stone and Reed, 1967), and amphetamine (Belleville, 1964).

Although concepts such as state-dependent learning have evolved from the drug research literature, similar properties could be applicable to other internal cue conditions such as those produced by manipulation of fear or motivational variables. If the general state-dependent conceptualizations apply to other internal conditions, then a change in performance should accompany a change in conditions. When drive states are considered and the relevant literature reviewed, a change in drive conditions seems only to effect performance variables. Since the literature has already been reviewed in detail, it seems only necessary to mention that researchers concerned with motivational changes report no true state-dependent effects (Lachman, 1961; Brown, 1956; Reynolds, 1949; Kendler, 1945). Either internal cue conditions produced by drive states are considerably different in nature than are drug-produced conditions, or the most appropriate experimental conditions for demonstrating state-dependency in motivational research have not yet been developed. For

the purpose of this review, it is sufficient to point out that a state-dependent conceptualization would predict a decrement in performance when drive states were altered and little or no performance change if drive conditions are held constant. Previous research has not consistently demonstrated such an effect.

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CHAPTER II

THE EFFECT OF DRIVE
LEVEL AND AMOUNT
OF TRAINING ON
DISCRIMINATION PERFORMANCE
OF A TWO LEVER
OPERANT IN RATS

ABSTRACT

A series of investigations were performed to determine the effect of motivational states on performance of a two-lever operant discrimination task. In all experiments, animals were trained to discriminate between tactile cues and tested during extinction periods. Experiment I investigated discrimination accuracy for groups trained under a food-motivated condition and tested either in a motivated or non-motivated state. Experiment II followed the general pattern of the first investigation but with an additional point on the motivational continuum. Experiment III investigated the effect of amount of preliminary training when in a motivated state and subsequently tested in a non-motivated condition. Results from these experiments indicated that the non-motivated animals performed the discrimination task significantly better than did animals in a motivated condition. In addition, results suggested that a minimal amount of training was necessary to produce accurate non-motivated discrimination during extinction. There was no discernible relationship observed between number of responses occurring during extinction periods and deprivation level. Results are discussed in terms of the reinforcement cue, cue valence, and state-dependent learning theory.

THE EFFECT OF DRIVE LEVEL AND AMOUNT
OF TRAINING ON DISCRIMINATION PERFORMANCE
OF A TWO-LEVER OPERANT IN RATS

Operant conditioning research investigating the role of discriminative stimuli has frequently employed designs using one-bar, multiple schedules of reinforcement with one cue serving as the discriminative stimulus for one schedule and another cue (or the absence of the first cue) serving as the stimulus controlling behavior under a different schedule (Harris and Balster, 1971). In terms of quantifying data, multiple schedules have some limitations when used in the evaluation of discriminative control. Problems arise in such a design since data are usually presented as a cumulative recording and are not amenable to statistical testing unless rates are divided by time periods and converted to ratio measures.

An alternative design uses a two-bar discrimination task with behavior on either bar under the control of a single schedule of reinforcement, but with responding on either bar consistently under stimulus control by a given cue (Waters, Richards, and Harris, 1972). Such a design typically uses a differential reinforcement of low response rate schedule (DRL) since such a schedule (a) has a low reinforcement density, (b) produces responding between organisms of approximately equal rates, and (c) usually results in prolonged responding during extinction. In addition, such a design generates data that are statistically testable since the strength of stimulus control can be expressed as per cent correct response scores by dividing the number of correct bar-press

responses by the total number of responses emitted on both bars during the testing session. Such testing periods may be either complete extinction sessions or shorter non-reinforcement periods ("probes") preceding a period of reinforced practice. Almost all testing sessions, however, are periods of non-reinforcement since it is assumed that removal of the reinforcement cue allows more accurate assessment of behavioral control by the discriminative stimulus.

In using such designs for research purposes at the Texas Research Institute of Mental Sciences (TRIMS), pilot studies have shown that although discriminative control as high as 95% accuracy was not uncommon when reinforcement was in effect, such discrimination scores may drop to approximately 60% accuracy during an extinction session. A possible reason for such a decrease is suggested by the concept of a stimulus generalization decrement. The observed decrease could result from the omission of the food-stimulus during extinction. Such a possibility is consistent with explanations advanced for poor temporal discriminations observed during extinction of a DRL task. Farmer and Schoenfeld (1964) suggest that a greater intensity of exteroceptive cueing can account for the more accurate timing behavior exhibited on a DRL schedule when the organism is under reinforcement conditions. These authors propose that such "exteroceptive cueing" accompanies reinforcement in most situations. The result of such cue conditions is a relatively unambiguous contingency following reinforcement compared to the contingency that exists after a non-reinforced response.

Other authors (Reynolds, 1964a; Carter and Bruno, 1968a) have suggested that stimuli accompanying reinforcement serve not only to

reinforce those responses which they follow but also to set the occasion for further reinforced responding. These investigators theoretically agree that reinforcement may become a discriminative stimulus for further responding during performance of an operant task.

Results from investigations concerning extinction and reconditioning of DRL responding further support a stimulus view of reinforcement in that reinforcement appears to set the occasion for further responding and facilitate rapid re-conditioning (Carter and Bruno, 1968b).

It is odd, however, that research concerning extinction of a DRL task has shown no predictable relationship between reinforced practice and resistance to extinction. Some experimenters have shown less than seventy responses emitted during extinction (Carter and Bruno, 1968b; Ferraro, Schoenfeld, and Snapper, 1965), while other investigators report continued responding for many hours (Holz and Azrin, 1963; Reynolds, 1964a, 1964b; Willson and Keller, 1953). The reasons for such discrepancies are not clear since amount of training and inter-reinforcement times varied greatly between these experiments. Neither of these two variables, however, seems systematically related to number of responses emitted during extinction. In reviewing these studies, Kramer and Rilling (1970) note that only the ratio of responses to reinforcements in pre-extinction sessions appears to be directly related to resistance to extinction.

An alternative hypothesis which may account for the observed decrease in discrimination scores during extinction is that poor discrimination scores may be an artifact of the organism's motivational or drive state.

Such a hypothesis suggests that low discrimination scores may result from stimulus search behaviors emitted by an animal in an effort to obtain food reinforcement while the animal is under a high drive condition. If such search behaviors do occur when a well-trained animal is extinguished under high drive conditions, then elimination of the drive state should result in either an absence of behavior or behavior that is less distracted from cue conditions and is thus a more accurate index of discriminative control. Previous research (Jensen, 1963; Neuringer, 1969) has demonstrated that animals continue to perform an operant even if food is readily available and not made contingent upon behavior. These investigations suggest that the opportunity to perform an operant serves as its own reward and that performance of an operant can alone maintain behavior.

Examination of the drive state hypothesis was undertaken in a series of three experiments. The first experiment was designed to determine if animals trained at 80% free-feed weight would perform a discrimination task with greater accuracy if tested during extinction at 100% free-feed weight. Performance scores obtained from this group were compared to scores obtained from animals tested at 80% free-feed weight and to a 100% free-feed "Freeloading" group (Jensen, 1963).

The second experiment was designed to investigate whether performance scores covaried predictably at low, intermediate, and high drive levels. The final experiment was performed to determine what effect amount of training at 80% free-feed weight had upon subsequent performance when animals were subsequently tested at 100% free-feed weight.

Drug research using two lever choice designs at TRIMS prompted the investigations presented here. For the purposes of these investi-

gations, however, drug states were not used since such conditions may produce confounding and undesirable effects. As a result, these preliminary experiments utilized tactile cues as discriminative stimuli (S_1 and S_2) since such cues (1) eliminate possible confounding effects resulting from the unconditional activity or anorexic properties of some drugs (Harris and Balster, 1971) and (2) have demonstrated an ability to acquire discriminative control over behavior as rapidly, and with as much strength, as drug states (Kilbey, Harris and Aigner, 1972), thereby allowing comparisons with drug discrimination experiments.

METHOD

Subjects

Subjects were adult (250 to 350 gram) male Simmons (F-3-44) albino rats, obtained from the Texas Research Institute of Mental Sciences Colony. For a period of ten days, all animals were housed in individual cages equipped with built-in "lick-valve" drinking fixtures from which water was available at all times throughout the experiment. During the ten day period, all animals were allowed free access to food (Purina Rat Chow), and weighed and handled daily. Previous to training, the mean weight over the ten day period was calculated and used as the animals' "free-feed" weight. Before training, all animals were put on a food-cycling schedule in which animals were fed small rations of food daily (about the same time of day the experiment was to be conducted) until their weight dropped to 80% of the calculated free-feed weight. During pre-training and training, all animals were maintained at 80% by daily weighing and food adjustment. Between training and testing, weight adjustments were accomplished by putting appropriate animals on an "ad lib" schedule until the original free-feed weight was achieved. These animals had food available to them at all times during the pre-testing and testing periods. Animals trained and tested at 80% of free-feed weight were maintained at that weight throughout the experiment by daily weighing and food adjustment procedures. All animals were weighed, fed, trained, and tested at the same time each day for the duration of the experiment.

Apparatus

All training and testing was conducted in five plexiglass operant chambers (Scientific Prototype, Model A-100) enclosed in protective, sound-attenuating chambers (Scientific Prototype, Model SPC-300). Each enclosure was equipped with a fan used to circulate air and a two-inch speaker used to provide masking noise from a Grason Stadler (Model 455C) noise generator. Two response levers (Scientific Prototype, Model PLS-100) were mounted on the front wall of each chamber one inch above the grid floor and three inches either side of midline. On the same wall, a small brass receptacle dish was mounted centrally and connected to a Foringer (Model PDC) pellet dispenser located behind the front panel. A small 7-watt house light illuminated each enclosed chamber, and solid-state electronic programming equipment (Grason Stadler, 1200 Series), located in the same room controlled each chamber's contingencies. The same equipment controlled cumulative recorders (Gerbrands, Model C3) and response totals which served as the data for the experiments. Rough plexiglass squares (64 pyramids per square inch) cut to fit over the chamber's grid floor served as one discriminative stimulus (S_1) for lever choice and the grid floor itself served as the other stimulus (S_2).

Preliminary Training

Previous to discrimination training, all animals were given several days of preliminary training sessions. These training sessions lasted for approximately 30 min periods. During preliminary training, contingencies were individualized for each animal since some animals were

easily shaped to bar-press while four animals required extended hand-shaping procedures.

In general, the preliminary training procedure proceeded by use of auto-shaping in which animals were shaped to magazine feed through food presentation automatically occurring an average of once every 100 seconds. During magazine training, one of the levers was arbitrarily assigned to be correct for CRF responding and the other incorrect. The correct lever alternated every day during initial training. Magazine training was terminated for each animal after it demonstrated consistent performance on CRF.

Following magazine training and CRF sessions, animals were shaped to a DRL-15 sec schedule of reinforcement. During these and all subsequent sessions, presses which were separated by a specified time interval (15 sec) were reinforced. Chaining of responses between two levers was prevented by a contingency programmed to reset the interval following an incorrect lever choice. Shaping was accomplished by gradually raising the inter-response time requirements after each animal stabilized at lower interval levels. This procedure was in effect until a DRL-15 sec interval was obtained. When all animals exhibited stable DRL-15 performance, training was initiated.

At the start of training, animals were divided into nine groups of five animals each. Weight for all animals at the start of training was approximately 80% free-feed weight. For half of the experimental animals, the plexiglass floor (S_1) served as a cue for lever pressing on one bar and the absence of the plexiglass floor (S_2) as the cue condition for lever pressing on the other bar. For the other half of the animals, cue conditions relational to correct lever choice was reversed.

EXPERIMENT I

Subjects

Fifteen of the initial forty-five animals described previously were randomly chosen and used for this experiment.

Procedure

Training consisted of preliminary training described previously followed by six "blocks" of training sessions. A block of training consisted of six reinforced training days (with the presentation of S_1 and S_2 counter-balanced for cue-lever association and order of presentation for animals) and an extinction probe (30 minute non-reinforced session) with either S_1 or S_2 present but responses on either bar not reinforced. During both training and extinction days, number of correct and incorrect lever choices were recorded as were number of reinforcements. Following each session, all animals were either given food or not allowed food in order to maintain an 80% free-feed weight.

Following six blocks of training, all animals were weighed and reassigned to three new groups based on an average of their previous response rates. The results of this procedure were that each group was matched according to high and low responders.

Following assignment to groups, one group was designated as a free-feed group; another as a free-load group; and the third as an 80% free-feed group. The 80% group was maintained at that weight while the other groups were allowed free access to food until their original free-feed weight was obtained. During the remainder of the experiment, both the free-feed and free-load groups were allowed food in the home cages at all times.

Following weight adjustment, all animals were given six additional reinforced days of discrimination practice. Except for discrimination day 1, the free-load group was allowed access while in the operant chamber to a small "freeloading" dish containing 100 45 mg food pellets (Jensen, 1963).

Following six days of reinforced discrimination practice, all groups were given three days of 30 minute extinction tests. The measurements taken during both training days and extinction sessions were (a) the total number of reinforcements per session, (b) the number of responses on each bar per session, and (c) the number of food pellets eaten from the free-loading dish during a session.

Results

Data from extinction and training days are presented as grouped data and were subjected to analysis of variance procedures. For the analysis of variance, data were converted and expressed as a ratio (per cent correct stimulus appropriate responses) for each animal during the last block of training and testing. In order to facilitate analysis of the data, the six reinforced training days were paired and a mean score determined by groups for days one and two; three and four; five and six. The three means calculated by this procedure were then subjected to analysis of variance for comparison with the three extinction-test days. The means obtained for each group by blocks (training versus extinction) are presented in Table 1. This procedure was repeated for number of responses occurring within each session and means obtained from these data are presented in Table 2.

Treatment sums of squares for both sets of data were tested by means of Hartley's test for homogeneity of variance (Weiner, 1962). The results

TABLE 1

Means of the Proportion of Cue-Appropriate Responses During Six Days of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT I

Group	Days	
	Reinforced	Extinction
Free-Feed	94.5	88.1
Free-Load	83.7	81.4
80% Free-Feed	94.9	65.9

TABLE 2

Means of Number of Responses Occurring per Session During Six Days
of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT I

Group	Days	
	Reinforced	Extinction
Free-Feed	123.13	55.53
Free-Load	124.93	35.40
80% Free-Feed	126-33	48.20

of these operations proved nonsignificant for response scores ($F_{\max} (6,4) = 5.36, p < .05$) and for discrimination ratio scores ($F_{\max} (6,4) = 7.42, p < .05$). The results of the analysis of variance for response scores are shown in Table 3 and for discrimination scores in Table 4. In both Table 3 and Table 4, "Blocks" refers to scores grouped by reinforced practice or extinction, while "Test" refers to scores grouped by session.

Figure 1 shows the mean number of responses per group over six days of reinforced practice and three days of extinction-testing. The significant within subject effects from Table 3 can be accounted for by an expected decrease in responding over three days of non-reinforced practice. Individual comparisons of group response scores were obtained by calculating group means for the extinction period only and testing means using the Neuman-Keuls method. Significant differences between the means of all three groups were obtained and are reported in Table 5. Inspection of Figure 1 shows the Free-Load group demonstrating the lowest response rate over the three day period followed by the Free-Feed animals. Animals maintained at 80% free-feed weight demonstrated the highest response rate throughout extinction days.

Discriminative control scores appeared to be subject to group treatment (and more resistant to extinction effects). Figure 2 shows cue-correct responding for each group during reinforced practice and extinction. Table 4 suggests that not only were significant overall group effects obtained, but that a significant effect was observed when shifting from reinforced practice to extinction testing. A Neuman-Keuls test was used on group DR means obtained during extinction testing and the results are

TABLE 3

Analysis of Variance Tests for Number of Responses Occurring During the Last Six Days of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT I			
<u>Source</u>	<u>ss</u>	<u>df</u>	<u>F</u>
Between Subjects	20,807.52	14	
Groups	4,738.27	2	1.789
Error _B	16,069.24	12	
Within Subjects	160,266.99	75	
Blocks	138,375.63	1	457.10*
Tests	1,387.67	2	7.387*
Blocks x Tests	1,804.95	2	4.727*
Group x Blocks	7,271.61	2	12.010*
Group x Tests	414.11	4	1.103
Group x Tests x Blocks	545.71	4	0.715
Error ₁	3,632.70	12	
Error ₂	2,253.39	24	
Error ₃	4,581.91	24	
Error _w	10,467.91	60	
Total	181,074.50	89	

*p < .01

TABLE 4

Analysis of Variance Tests for Discriminative Control During the Last Six Days of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT I			
<u>Source</u>	<u>ss</u>	<u>df</u>	<u>F</u>
Between Subjects	2,541.75	14	
Groups	2,004.30	2	22.376**
Error _B	537.45	12	
Within Subjects	11,667.77	75	
Blocks	3,558.83	1	39.173**
Tests	63.371	2	0.448
Blocks x Tests	750.67	2	8.231*
Groups x Blocks	3,068.58	2	16.89**
Groups x Tests	163.59	4	0.579
Groups x Tests x Blocks	181.98	4	0.998
Error ₁	1,090.17	12	
Error ₂	1,696.18	24	
Error ₃	1,094.42	24	
Error _w	3,880.77	60	
Total	14,209.516	89	

*p < .01

**p < .001

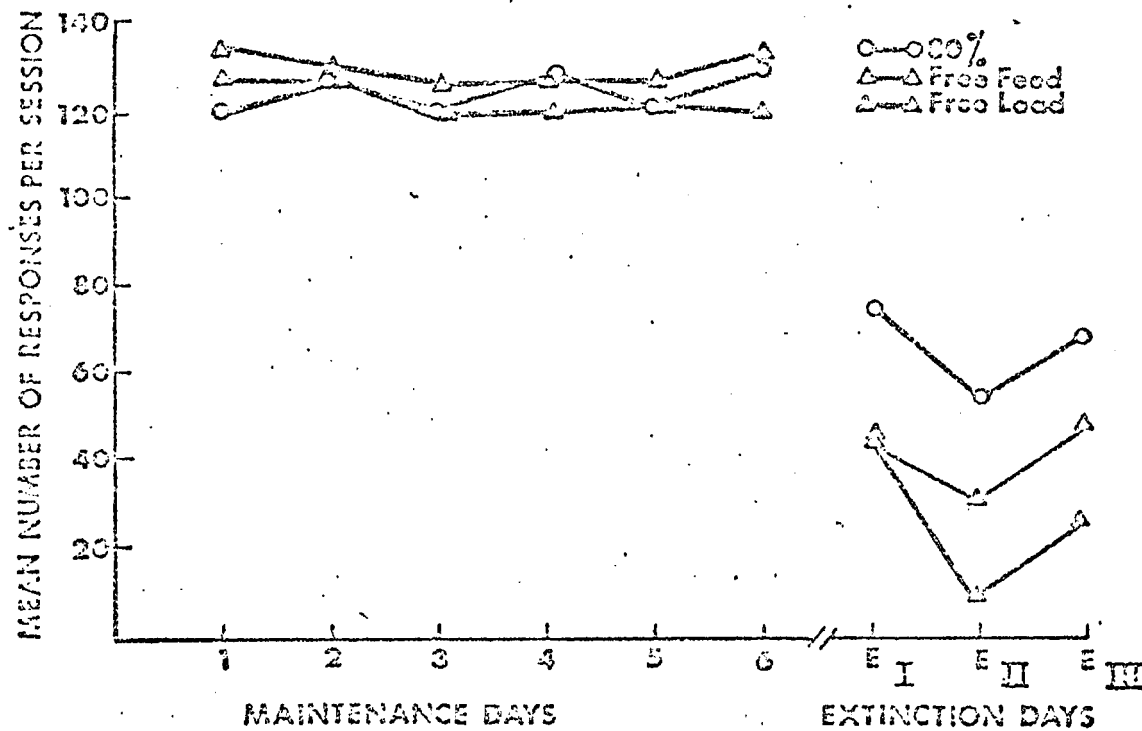


Figure 1. Mean number of responses per session for each group (80% ad lib.; Free-Feed; and Free-Load) over six days of reinforced practice and three days of 30 min. extinction testing.

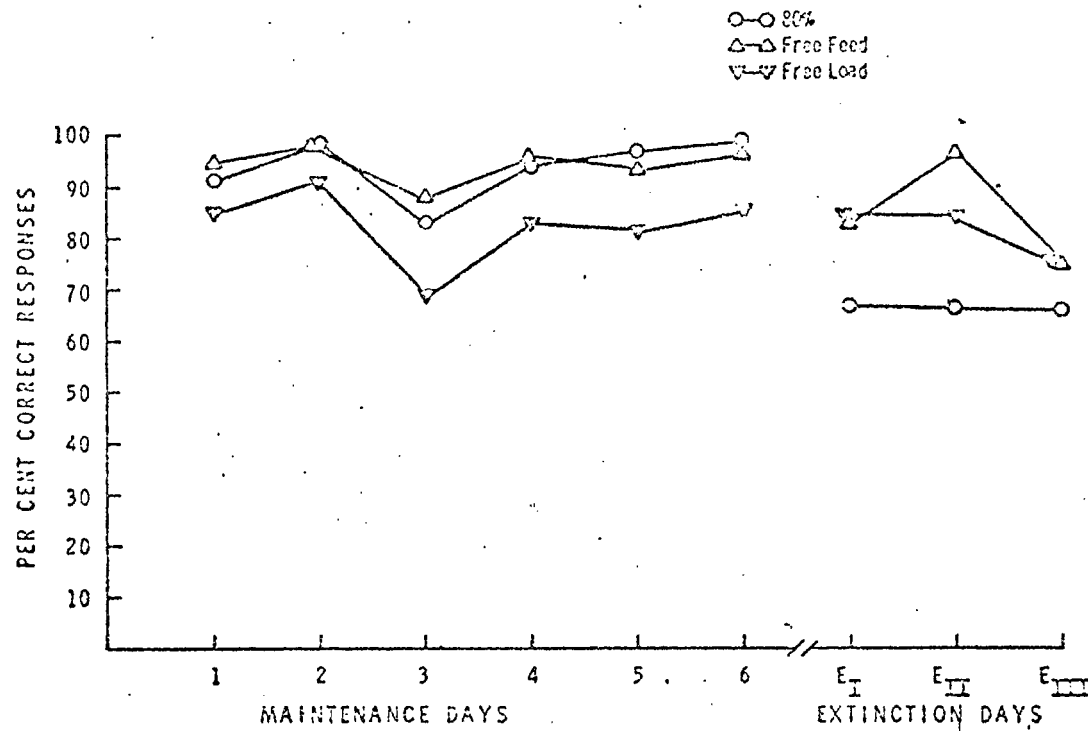


Figure 2. Mean per cent correct response per session for each group (80% ad lib.; Free-Feed; and Free-load) over six days of reinforced practice and three days of 30 min. extinction testing.

TABLE 5

Neuman-Keuls Test of Between Group Comparison
Tests of Response Score Means During Extinction

EXPERIMENT I

	I	II	III
I (Free-Load)		*	*
II (Free-Feed)			*
III (80% Free-Feed)			

*p < .05

reported in Table 6. As can be seen from Table 6, there was no significant difference between the Free-Feed and Free-Load animals relational to cue-correct responding. The 80% Free-Feed animals, however, performed the discrimination task significantly poorer during extinction than did either of the other two groups. The poor discrimination scores obtained from the 80% group probably accounts for the within subject effects and group effect reported in Table 4.

Figure 3 shows the mean number of pellets eaten by the Free-Loading group during reinforced and extinction sessions. The mean number of pellets eaten during any session never approached the amount available. While such low free-loading scores may re-affirm previous observations concerning the reinforcing nature of performing an operant, the scores did not appear altered when animals were changed from reinforced practice to extinction.

TABLE 6

Neuman-Keuls Test of Between Group Comparison Tests of
Discriminative Control of Lever Choice During Extinction

EXPERIMENT I

	I	II	III
I (80% Free-Feed)		*	*
II (Free-Load)			
III (Free-Feed)			

* $p < .05$

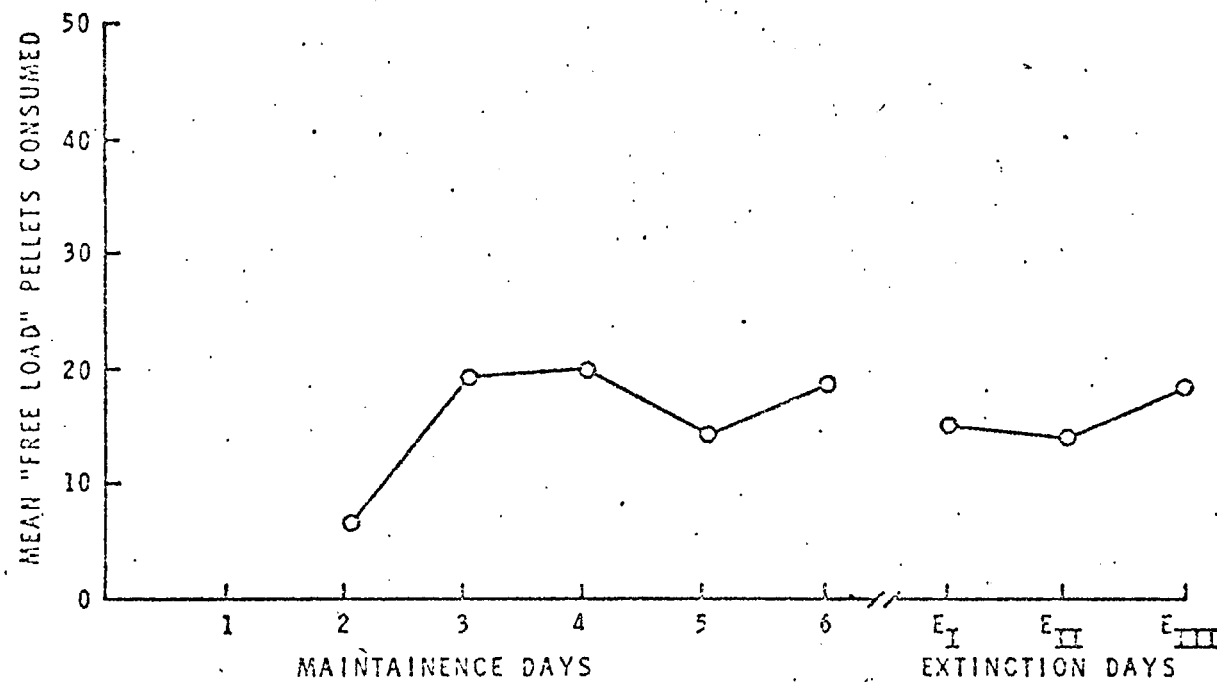


Figure 3. Mean number of food pellets consumed (100 being the highest possible score) by the Free-Loading group during five days of reinforced practice and three days of 30 min. extinction testing.

EXPERIMENT II

The initial investigation considered only two points on the drive continuum, i.e., 80% and 100% of free-feed weight. While the first experiment demonstrated that animals maintained at free-feed weight performed the discrimination task significantly better than those subjects maintained at deprivation levels, it was not possible to determine if any relationship existed between intermediate motivational levels and discrimination performance. This experiment was conducted in order to determine what relationships exist between levels of deprivations and discriminative performance during non-reinforcement sessions.

Subjects

Fifteen of the initial forty-five animals previously described were randomly assigned to three groups.

Procedure

Training consisted of the preliminary training previously described followed by six blocks of reinforced training-testing sessions. Following the six blocks of reinforced-extinction sessions, animals were re-assigned to one of three groups on the basis of average response rate per session. This procedure allowed all groups to have both low and high responding animals for the remainder of the experiment.

Following re-assignment, one group (80%) was maintained at 80% free-feed weight; another group (90%) was allowed access to food until weights reached 90% of free-feed weight and the final group (100%) was allowed to reach ad lib. weight and given access to food in the home cages for the

duration of the experiment. Weight adjustment was accomplished by the procedures previously described.

Following weight adjustment, all animals were given six additional days of reinforced practice followed by three days of extinction testing during which S_1 or S_2 were the only cues present signalling correct bar choice. Number of reinforcements, number of bar presses on each lever, and total number of responses per session were the measurements taken during reinforced and extinction testing sessions.

Results

The group means of the proportion of cue appropriate lever-choice responses and responses per session from the six reinforced training sessions and three extinction sessions are listed in Table 7. These data were organized according to a 3 (groups) x 2 (extinction and reinforced practice) x 6 (3 means derived from reinforced practice and 3 extinction tests) repeated measures design for analysis using analysis of variance procedures. Preliminary tests for homogeneity of variance were conducted on response and discrimination scores using a Hartley's test (Weiner, 1962). Both measures yielded nonsignificant results ($F_{\max}(6,4) = 5.27, p < .05$; $F_{\max}(6,4) = 5.61, p < .05$) thus supporting the assumptions of homogeneity of variance. The analysis was conducted and results for response scores are presented in Table 8. Discrimination score analysis was also conducted and is presented in Table 9. In both Table 8 and Table 9, "Blocks" refers to scores grouped by either reinforcement sessions or extinction sessions; "Tests" refers to scores grouped by sessions. Graphical representation of each of the groups means across days is shown in Figure 4 for response

TABLE 7

Group Means for Responses per Session and Discrimination
Scores for Reinforced Practice Days and Extinction Test Days

EXPERIMENT II

		Reinforced Days					Extinction Test Days			
<u>Group</u>		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>1</u>	<u>2</u>	<u>3</u>
80%	lever choice	87.3	87.7	88.8	87.3	88.3	89.2	67.0	64.6	64.6
	response	119.8	129.6	124.6	119.8	120.8	113.6	70.8	58.4	58.4
90%	lever choice	90.2	90.6	89.8	90.4	90.2	89.0	71.4	93.2	70.0
	response	127.4	133.0	123.4	128.0	131.0	133.4	111.6	119.8	63.0
100%	lever choice	90.7	90.0	92.8	93.0	92.4	92.6	89.0	91.4	83.6
	response	122.4	128.8	121.8	121.2	122.5	126.6	59.0	62.2	32.0

TABLE 8

Analysis of Variance Tests for Number of Responses Occurring During the Last Six Days of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT II

<u>Source</u>	<u>ss</u>	<u>df</u>	<u>F</u>
Between Subjects	42,699.38	14	
Groups	11,237.46	2	2.143
Error _B	31,461.91	12	
Within Subjects	124,885.31	75	
Blocks	64,775.45	1	21.690*
Tests	4,672.88	2	6.999*
Blocks x Tests	4,555.84	2	7.209*
Groups x Blocks	6,202.01	2	1.517
Groups x Tests	1,388.14	4	1.04
Groups x Tests x Blocks	3,167.40	4	2.505
Error ₁	24,528.19	12	
Error ₂	8,011.97	24	
Error ₃	7,583.65	24	
Error _w	40,123.81	60	
Total	167,584.69	89	

*p<.01

TABLE 9

Analysis of Variance Tests for Discriminative Control During the Last Six Days of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT II

<u>Source</u>	<u>ss</u>	<u>df</u>	<u>F</u>
Between Subjects	4,608.43	14	
Groups	2,519.82	2	7.239**
Error _B	2,088.61	12	
Within Subjects	10,908.29	75	
Blocks	3,720.34	1	26.751**
Tests	451.459	2	4.929*
Blocks x Tests	406.85	2	3.88*
Groups x Blocks	1,264.46	2	4.546*
Groups x Tests	499.55	4	2.727
Groups x Tests x Blocks	540.43	4	2.579
Error ₁	1,668.86	12	
Error ₂	1,099.19	24	
Error ₃	1,257.16	24	
Error _w	4,025.21	60	
Total	15,516.72	89	

*p < .05

**p < .001

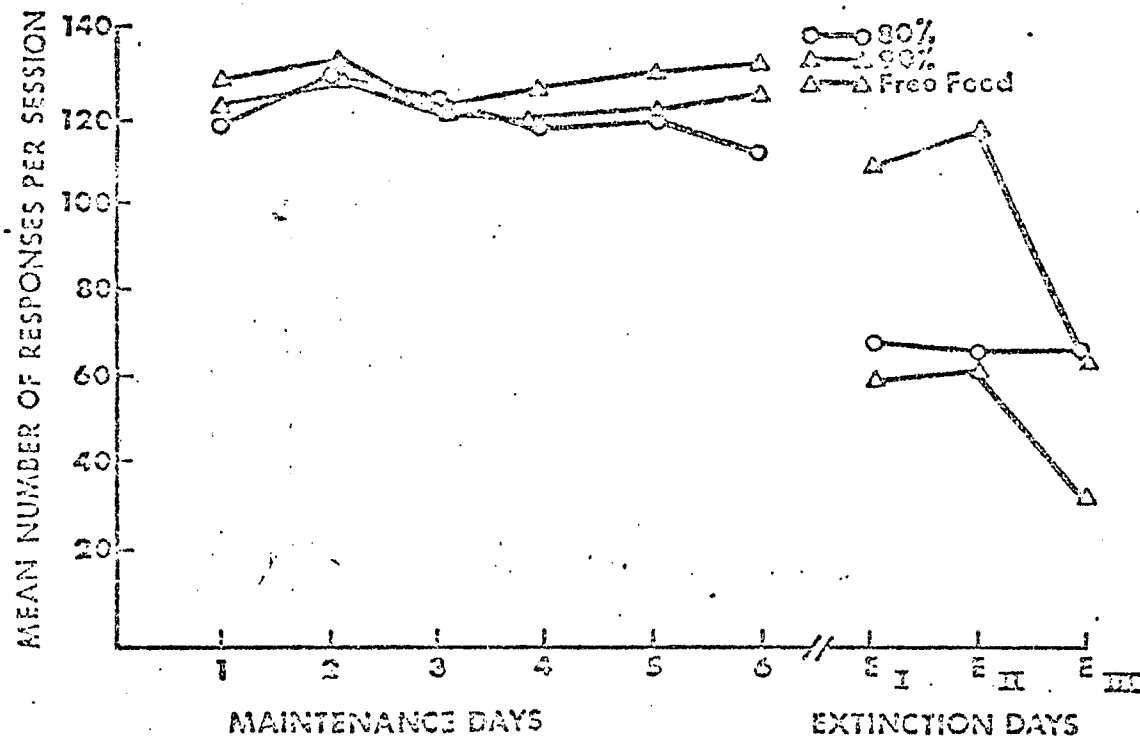


Figure 4. Mean number of responses per session for each group (80% ad lib.; 90% ad lib.; Free-Food) over six days of reinforced practice and three days of 30 min. extinction testing.

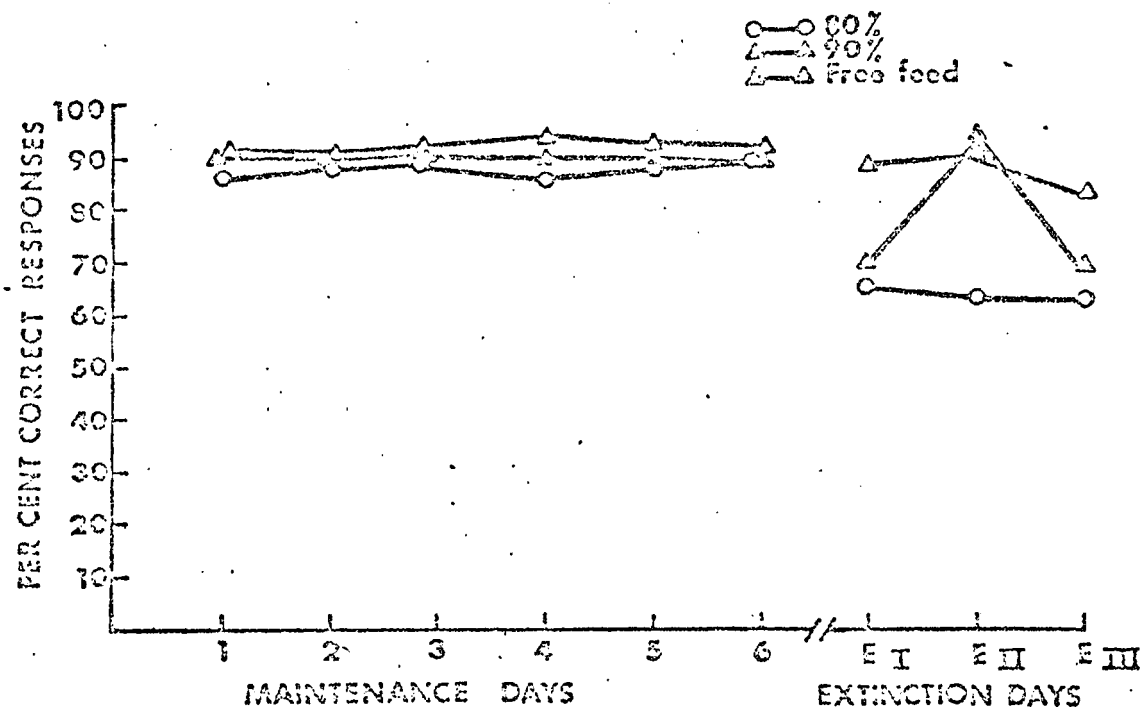


Figure 5. Mean per cent correct responses per session for each group (80% ad lib.; 90% ad lib.; Free-Feed) over six days of reinforced practice and three days of 20 min. extinction testing.

scores and Figure 5 for discrimination scores.

By referring to Table 8 and Figure 4, it would seem that the within subjects variance could be accounted for by the expected decrease in responding during three successive extinction periods. Comparisons of group response scores obtained during extinction was accomplished by calculating group means for the three test days and testing the means using the Neuman-Keuls method. Results from this test are presented in Table 10. Significant differences were obtained between all three groups with the Free-Feed group demonstrating the lowest mean number of responses; the mean of the 80% group higher and the 90% group highest.

Table 9 and Figure 5 seem to indicate that a strong between-group difference in discriminative control resulted from variations in drive state. This difference was further examined by computing means for each group across extinction-test days and testing the obtained means using the Neuman-Keuls method. Results from this test are presented in Table 11. Significant differences were observed among all groups with the Free-Feed group demonstrating the best performance followed by the group maintained at 90% free-feed weight. The 80% group demonstrated the poorest lever-choice control across all three days of extinction testing. Although not statistically tested, an examination of Figure 2 from the first experiment and Figure 5 from the present experiment shows a trend toward better discrimination performance for animals either at free-feed weight or at 90% during the second day of extinction testing. For these animals, performance scores on the first or third days of extinction were higher than 80% free-feed animals, but generally lower than scores obtained on the second test day. Such results were not anticipated.

TABLE 10

Neuman-Keuls Test of Between Group Comparison
Tests of Response Score Means During Extinction

EXPERIMENT II

	I	II	III
I (Free-Feed)		*	*
II (80%)			*
III (90%)			

* $p < .05$

TABLE 11

Neuman-Keuls Test of Between Group Comparison Tests of
Discriminative Control of Lever Choice During Extinction

EXPERIMENT II

	I	II	III
I (80%)		*	*
II (90%)			*
III (Free-Feed)			

* $p < .05$

EXPERIMENT III

The first experiment demonstrated that animals in a non-motivated condition performed the discrimination task better than animals in a motivated state. The first experiment utilized six blocks of training. It would be of interest to determine how much preliminary discrimination training is necessary to produce accurate discrimination under non-drive conditions. This experiment was conducted to determine the relationship between amount of training and subsequent discriminative performance under a non-drive condition.

Subjects

Fifteen of the initial forty-five animals described previously were randomly chosen and used for this experiment.

Procedure

Training consisted of the previously described preliminary training followed by either two, four, or six blocks of training sessions. Following the assigned number of training sessions, animals were placed on ad lib. food and allowed to reach base weight. After reaching base weight, animals were given six additional days of reinforced practice followed by three days of extinction testing. For this experiment, only the last six days of reinforced training and subsequent three days of extinction testing were compared between groups. The measurements taken for all groups were (a) number of reinforcements per session, (b) number of bar presses on each lever during both reinforced and extinction sessions, and (c) the total number of responses occurring per session. During extinction testing,

S₁ and S₂ were the only cues signalling correct bar choice. For the purpose of discussions to follow, the three groups will be referred to as either a two-blocks, four-blocks, or six-blocks group.

Results

Group means for the proportion of cue appropriate lever choices and responses per session over the six days of reinforced discrimination training and the three subsequent extinction sessions are given in Table 12. These data were then organized according to a 3 (groups) x 2 (extinction versus reinforced practice) x 6 (3 means derived from 6 reinforced practice sessions and 3 extinction sessions) repeated measures design for analysis using analysis of variance procedures. Preliminary tests for homogeneity of variance were conducted on response and discrimination scores using Hartley's test (Weiner, 1962). Both measures yielded nonsignificant results ($F_{\max}(6,4) = 4.97, p < .05$; $F_{\max}(6,4) = 5.39, p < .05$) thus supporting the assumption of homogeneity of variance. The analysis of variance was conducted and the results for response scores are presented in Table 13. Graphical representation of response score means across days is given in Figure 6. Comparisons of group response scores recorded during extinction were further examined by the Neuman-Keuls method for comparing means. Results from this procedure are presented in Table 14. The results shown in Table 13 and Table 14 indicate that the strong within group effect can be attributed to reduced responding during the three extinction sessions. Only the 2-Block group, however, was significantly different in total responses during extinction.

TABLE 12

Group Means for Responses per Session and Discrimination
Scores for Reinforced Practice Days and Extinction Test Days

EXPERIMENT III

		Reinforced Days						Extinction Test Days		
<u>Group</u>		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>1</u>	<u>2</u>	<u>3</u>
2 Blocks	lever choice	87.3	88.8	90.8	88.3	87.3	87.3	71.4	54.8	77.8
	responses	119.8	124.6	120.6	120.8	120.6	120.8	30.6	21.4	15.0
4 Blocks	lever choice	93.0	92.6	92.8	90.0	92.4	92.6	88.4	98.6	78.2
	responses	121.2	128.6	121.8	128.8	120.5	130.0	35.2	41.4	33.2
6 Blocks	lever choice	90.2	90.4	89.0	90.6	92.1	90.4	85.4	95.2	83.4
	responses	127.4	128.0	133.4	128.0	127.8	133.4	49.6	44.6	31.6

TABLE 13

Analysis of Variance Tests for Number of Responses Occurring During the Last Six Days of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT III

<u>Source</u>	<u>ss</u>	<u>df</u>	<u>F</u>
Between Subjects	7,855.06	14	
Groups	635.54	2	0.528
Error _B	7,219.52	12	
Within Subjects	199,659.48	75	
Blocks	170,215.19	1	191.250**
Tests	1,998.84	2	4.814*
Blocks x Tests	2,553.75	2	7.975*
Groups x Blocks	82.83	2	0.047
Groups x Tests	3,024.33	4	3.642*
Groups x Tests x Blocks	2,279.04	4	3.559*
Error ₁	10,680.40	12	
Error ₂	4,982.54	24	
Error ₃	3,842.60	24	
Error _w	19,505.54	60	
Total	207,514.50	89	

*p < .05

**p < .001

TABLE 14

Neuman-Keuls Test of Between Group Comparison Tests
of Response Score Means During Extinction Testing

EXPERIMENT III

	I	II	III
I (2 Blocks)		*	*
II (4 Blocks)			
III (6 Blocks)			

* $p < .05$

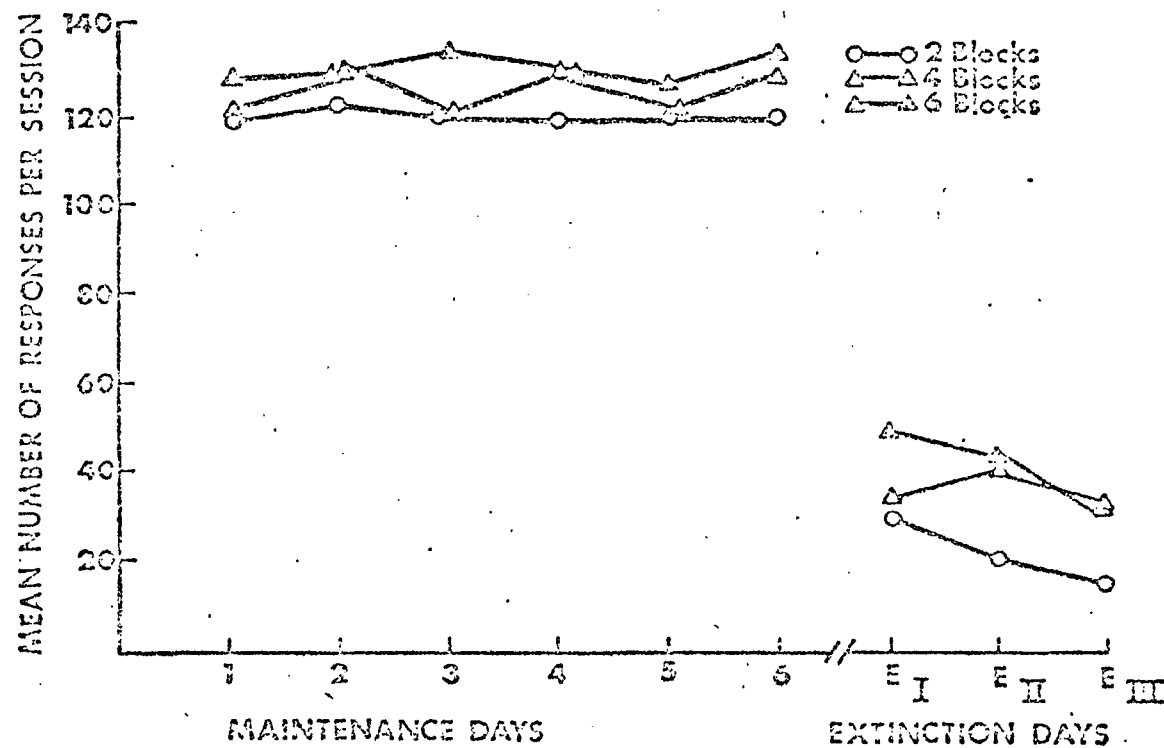


Figure 6. Mean number of responses per session for each group (2, 4, or 6 blocks of training) over six days of reinforced practice and three days of 30 min. extinction testing.

Accuracy of discrimination during extinction was tested using analysis of variance procedures and results are presented in Table 15. Graphical representation of group means for discriminative control across six days of reinforced practice and three days of extinction-testing is given in Figure 7. Following analysis of variance, comparisons of group discrimination scores were further examined using the Neuman-Keuls method. Results from these tests are presented in Table 16. As can be seen from Table 16, the 2-Block group differed significantly from both the 4-Block and 6-Block animals. No other group differences were observed using the Neuman-Keuls test. The difference between groups probably accounts for the strong group effect noted in Table 15. The divergent 2-Block discrimination scores also probably contributed to the strong within subjects effects. From these data it appears that there is a minimal amount of training required in order to produce higher discrimination scores during extinction testing. In addition, response strength also seems conditional upon amount of training previous to weight adjustment. There does not seem to be any effect upon either response or discrimination scores when weight adjustment is preceded by at least 4 blocks of training-extinction sessions.

TABLE 15

Analysis of Variance Tests for Discriminative Control During the Last Six Days of Reinforced Practice and Three Days of Extinction Testing

EXPERIMENT III

<u>Source</u>	<u>ss</u>	<u>df</u>	<u>F</u>
Between Subjects	3,972.94	14	
Groups	2,728.01	2	13.148**
Error _B	1,244.93	12	
Within Subjects	15,214.30	75	
Blocks	1,766.64	1	9.945**
Tests	31.02	2	0.115
Blocks x Tests	38.04	2	0.123
Groups x Blocks	1,482.99	2	4.174*
Groups x Tests	1,167.17	4	2.158
Groups x Tests x Blocks	1,628.24	4	2.624
Error ₁	2,131.62	12	
Error ₂	3,244.88	24	
Error ₃	3,723.77	24	
Error _w	9,100.27	60	
Total	19,187.24	89	

*p < .05

**p < .01

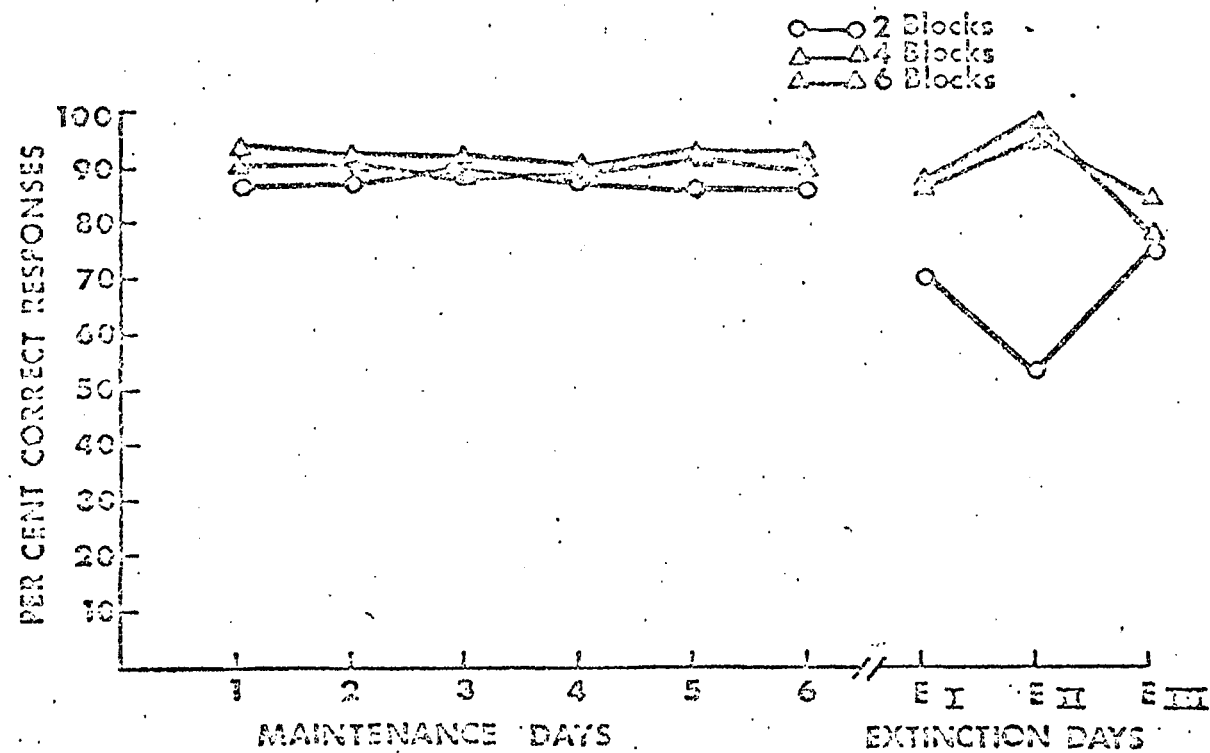


Figure 7. Mean per cent correct responses per session for each group (2, 4, or 6 blocks of training) over six days of reinforced practice and three days of 30 min. extinction testing.

TABLE 16

Neuman-Keuls Test of Between Group Means for
Discriminative Control of Lever Choice During Extinction

EXPERIMENT III

	I	II	III
I (2 Blocks)		*	*
II (6 Blocks)			
III (4 Blocks)			

* $p < .05$

DISCUSSION

The objectives of these experiments were to determine: (1) if animals would perform a two-lever operant discrimination under a non-motivated condition; (2) if accuracy of discrimination during extinction sessions would increase if subjects were non-motivated; (3) if accuracy was in any way relational to level of motivation and (4) if amount of previous discrimination training had any effect upon subsequent performance under a non-motivated condition. In order to demonstrate these effects, it was necessary to undertake a series of experiments.

In Experiment I, animals were first given six blocks of training-extinction before being changed to a non-motivated condition. Following initial discrimination training, animals were re-assigned to one of three groups: (1) Free-Feed; (2) Free-Load and (3) 80% ad lib. The Free-Load group was used to control for the possibility that, even though animal weights indicated a free-feed condition, the animals might still be hungry during the experiment and thus in a motivated state. Although animals in the Free-Load group did consume some of the food pellets available, "free-loading" scores never indicated that experimental animals were more than slightly food-motivated. The data from Experiment I support previous research (Jensen, 1963; Neuringer, 1969) indicating that animals prefer the opportunity to perform an operant rather than eat easily accessible food. These data extend such research findings by demonstrating that non-motivated animals will continue to perform a previously learned operant.

Experiment I was also concerned with accuracy of discrimination and rate of extinction. Although animals in both the Free-Feed and Free-Load

groups produced fewer responses during extinction sessions than did animals in the 80% group, all subjects continued to respond during three days of 30 min extinction periods. Since a DRL schedule was in effect, the lower response rates during extinction for both non-motivated groups may be considered an indication of superior temporal discrimination (Farmer and Schoenfeld, 1964; Carter and Bruno, 1968a, 1968b). Certainly cue-controlled lever-choice discrimination was superior for non-motivated animals during testing periods. The results of Experiment I support previous observations concerning motivational interactions with performance of difficult tasks (Yerkes and Dodson, 1908; Spence, Goodrich and Ross, 1959). The data from this experiment suggest that animals trained under a motivated condition may perform a two-lever operant discrimination task better if tested when in a non-drive state. These findings may be important for researchers concerned with problems requiring accurate discrimination performance or for investigators troubled with elimination of the food-reinforcement cue during extinction. Apparently, if the importance of a cue is eliminated (food cues for satiated animals), organisms attend to other available cues for information. It would then seem that cue elimination is not as important for behavioral control as is cue valence. Other investigators have suggested such a concept. Those researchers interested in drug-produced cues have suggested that the ability of pharmacological agents to produce rapid and long-term unconditioned, conditioned and discrimination effects (compared to external stimuli) results from the strong and pervasive nature of drug cues (Brady, 1959; Overton, 1964, 1968; Harris and Balster, 1971; Waters, Richards and Harris, 1972). These researchers

also seem to place an importance on cue valence. The data presented in Experiment I seem to extend notions of cue saliency to include (a) motivational interactions with external stimuli and (b) removal of cue importance by modification of motivational states.

Experiment II considered an additional motivational level and compared it to levels previously examined. Although there appears to be a relationship graphically between discriminative control and drive level, statistical examination did not support such a conclusion. Statistically, animals tested at 90% ad lib. weight discriminated as well as animals in a non-deprived condition. Both the 90% and Free-Feed animals, however, performed significantly better than animals tested at 80% body weight. If response scores are considered, animals maintained at 90% weight during testing responded significantly more times than did either of the other two groups. These data were not anticipated and are difficult to explain. If response scores are used as a measure of resistance to extinction, then it may be said that the 90% group was more resistant to extinction effects than either of the other groups. If the schedule is also considered, however, then high response scores are often used as indications of poor temporal discrimination for DRL schedule performance. Lever-choice discrimination, however, seems to discourage a poor discrimination interpretation since the 90% animals performed as accurately as the 100% group. A possible resolution for the discrepancy between response and discrimination scores may be in the generally unpredictable pattern of DRL extinction. Carter and Bruno (1968a) and Kramer and Rilling (1970) have noted that resistance to extinction for DRL schedules does not seem to be related to any consistent parameters other than the ratio of reinforced to non-reinforced responding

during acquisition. Unless this ratio measure is used, these authors report a wide range of extinction performance on DRL schedules. In the investigations reported here, the ratio of reinforced to non-reinforced responding could not be easily calculated during training and so was not used. Perhaps the response score differences reported in these experiments would not be as diverse if groups had been matched on the basis of the ratio suggested by some authors.

The final experiment concerned the amount of training necessary to produce accurate non-drive discrimination performance. Once again, response scores seem to show a great degree of variability. Not only do the groups of Experiment III show no clear cut relationship between drive level and number of responses, but groups from all experiments do not indicate a relationship between drive level and responding during extinction. It seems reasonable to assume that some other factor like the ratio measure discussed plays a critical role in DRL extinction rate. Discrimination scores, however, do indicate that a minimal amount of reinforced discrimination practice is necessary for accurate discrimination performance during extinction.

In general, it appears that alleviation of the organism's motivational state results in improved performance during extinction. Improved performance may result from phenomena as complex as a change in valence associated with the reinforcing stimulus or as simple as a decrease in animal activity level (Lachman, 1961; Choate, 1964). Wide variations in responding during extinction, however, make an activity hypothesis seem tenuous. At present, a concept of cue valence seems to be a potential route for investigation of discrimination performance during extinction.

Finally, concepts of state-dependent or "dissociated" learning would not seem to apply when considering discrimination performance under changes in food-motivated "states." Such theories would have predicted a decrease in performance when drive states were altered (Grossman and Miller, 1961; Overton, 1964). The investigations reported here show a decrease in performance when drive states remain unaltered from training conditions and a stable pattern of transfer across drive levels. Notions concerning state-dependent effects relational to food-motivated learning, however, cannot be rejected from these data because of the use of extensive training sessions. State-dependent effects may have been obscured by over-training in these experiments. At any rate, if concern is directed towards accurate operant discrimination performance and not state-dependent learning, extended training and manipulation of the organism's motivational level seems to significantly contribute to accuracy during extinction testing. Motivational research may provide solutions for cue-searching behavior or a need to limit extinction test periods.

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