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AN ANIMAL MODEL FOR OVERJUSTIFICATION: PRELIMINARY INVESTIGATION

A Thesis Presented

By

VIVIAN PACKARD DORSEL

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Department of Psychology

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This thesis is dedicated

to my husband

A CLIFFORD DORSEL

and my son

MICHAEL ANDREW DORSEL

"To get things done, you must love the doing,
not the secondary consequences."

--The Fountainhead

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ABSTRACT

An Animal Model for Overjustification:
Preliminary Investigation
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In experiments with human subjects, social psychologists have found that intrinsically motivated (high-baseline) behavior decreases following the delivery of extrinsic rewards which are salient and expected by the subject--a phenomenon known as the "overjustification effect." The present study is an animal analog of the overjustification experiment by Lepper, Greene and Nisbett (1973), using rats as subjects and wheel-running as the target behavior. During the third phase of the ABA experimental design, the responding of subjects whose wheel-running had been reinforced with food on an FI 5 schedule did not show a decline below initial baseline rates, compared with no-food controls. Rather, both experimental and control animals showed increases in responding. It is argued that the present procedure did not meet necessary conditions for the formation of discrimination based on external stimulus

control and, consequently, did not correspond to the expected-reward condition of the human overjustification study.

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CHAPTER I

INTRODUCTION

For several years, social psychologists have been studying the effects of extrinsic reward on intrinsically motivated behavior (Deci, 1971, 1972a, 1972b; Greene and Lepper, 1974; Greene, Sternberg, and Lepper, 1976; Lepper and Greene, 1975). The well replicated finding that rewards lead to decreases in intrinsic motivation has provided a basis for what has come to be called the "overjustification" hypothesis: A person's intrinsic interest in an activity may be undermined by inducing him to engage in that activity as an explicit means to some extrinsic goal, provided the external justification is unnecessarily high and psychologically "oversufficient" (Lepper, Greene, and Nisbett, 1973). This hypothesis is based on self-perception theory (Bem, 1967), and attributional processes typically have been advanced as explanatory mechanisms.

The phenomenon of reduced intrinsic motivation following reward has thus come to be known as the overjustification effect. Although this term implies the self-perception theory interpretation of the effect, it

will be used here because of its currency in the literature. In this paper, however, overjustification effect will refer only to a below-baseline decrease in initially high-baseline behavior following presentation of a reward, and not to any particular theoretical interpretation of the effect.

In general, studies of the overjustification effect tend to be similar in structure. The target task is one for which the subjects' initial interest is either measured or assumed by the experimenter to be high. During the treatment phase, subjects are rewarded for performing the task. The reward usually consists of a single presentation of an item assumed or pretested to be desired by similar subjects. Following the treatment manipulation, subjects are given an opportunity to perform the same task in the absence of extrinsic reward. The amount of time they spend on the task during this post-treatment period is compared either with their own original baseline or the amount of time similarly spent by unrewarded control subjects. Any difference between baselines or treatment groups is interpreted as a difference in intrinsic motivation. Many studies have used self-reports of task interest, task enjoyment, or willingness to return for another session as measures of intrinsic motivation. However, this paper will be confined to consideration of

studies using behavioral dependent measures. For more comprehensive reviews of the overjustification literature, see Condry (1977) or Lepper and Greene (1978).

Expectation of Reward

One of the most frequently cited overjustification experiments is Lepper, Greene, and Nisbett (1973). The subjects were preschool children (3½-5½ years) who had shown initial intrinsic interest in a drawing activity during baseline observations. There were three conditions: Expected award (n = 18), Unexpected award (n = 18), and No-award control (n = 15).

In their regular classroom, children were free throughout the day to choose among a variety of activities, some available continuously, some periodically. For this study, a novel target activity (colored magic markers and white drawing paper) was made available during the first hour of three consecutive class days; highly similar materials were unavailable at this time. The children's intrinsic interest (% of total time spent playing with target materials) was measured unobtrusively. Those who remained in contact with the materials for four minutes (7% of the time) or longer were selected to serve as subjects.

Experimental sessions began within two weeks after the baseline period, and were completed on three consecutive days. Subjects were led individually to a separate room and seated at a table containing magic markers and paper. The Good Player Award--a 3" x 5" colored card with a gold star and red ribbon, with a space for the child's name and school--was shown beforehand to Expected award subjects only. The experimenter then asked the subject to draw, observing and timing him for 6-6½ minutes. When the time was up, the experimenter wrote the subject's name and school on the award, and escorted him to the bulletin board to pin it up. The subject was then taken back to the classroom.

In the Unexpected award condition, the procedure was the same, except that subjects were not shown the award before being asked to draw. No-award subjects were neither shown nor given an award, but were merely returned to the classroom after drawing.

The postexperimental measurement procedure and setting were the same as during baseline. Observers blind to subjects' conditions collected data 7-14 days after the last subject was run in a given class (four classes).

The results showed a significant preexperimental-to-postexperimental decrease in interest in the target activity among Expected award subjects; both Unexpected

award and No-award subjects showed a nonsignificant increase. During the treatment session, there was no difference among conditions in the number of pictures drawn; however, drawings produced by Expected award subjects were rated by judges as significantly lower in overall quality than those of the Unexpected award or No-award subjects.

Greene and Lepper (1974) replicated the above study, again using preschool children as subjects. The target materials and methodology were the same, but no baseline measure of intrinsic interest was taken. On the postexperimental measure of interest in the drawing task, Expected award subjects were significantly below the Unexpected and No-award subjects, which did not differ from one another. During the treatment period, the Expected award subjects produced a larger number of drawings than those in the other two groups, and they were again rated as being lower in quality. There was a significant correlation between the quality of drawings during the treatment session and subsequent interest in the activity.

In Lepper and Greene (1975), the target activity was the assembly of a set of multicolored geometric inset puzzles, and the reward was the opportunity to play with a collection of attractive toys. There was no

preexperimental measure of task interest; the postexperimental measure was the amount of time the children spent playing with the puzzles in their nursery school classroom. During the treatment session, the children were shown how to solve the puzzles and given four practice puzzles to work on. The actual experimental task consisted of six other puzzles, which the Unexpected reward subjects were asked to solve as fast as they could, ringing a bell when they were finished. In addition, Expected reward subjects were told that the amount of time they would be allowed to play with the toys would depend on how quickly they completed the task. After the bell had been rung, each child was allowed to play with the toys for ten minutes. There was no No-reward group. During the posttest, the Expected reward subjects again showed less interest than the Unexpected reward subjects. Children in the Expected reward group tended to work more quickly than those in the Unexpected reward group during the treatment session.

In all three of the above studies, the Expected reward subjects were shown the prize prior to task engagement. Reiss and Sushinsky (1975, Experiment 1) varied the promise of a reward and exposure to the reward orthogonally. Subjects were first-grade girls, and the reward was the opportunity to play with an attractive doll. The target task was listening to a taped song for five minutes. There

was no baseline measure of initial interest, and no No-reward control group. Subjects in Exposure conditions were shown the doll and had its attractive properties pointed out to them, after which it was placed in a closet. Subjects in the Promise conditions were told they could play with the doll if they engaged in the target task. (No Exposure-Promise subjects had the doll described to them, but did not see it.) For Exposure subjects, there was also a timer with a buzzer present during the five-minute task engagement period. Following this period, each subject was allowed to play with the doll for three minutes.

The five-minute posttest took place 3-5 hours later on the same day. During this period the subjects could choose to listen to the target song or two other songs, while their behavior was observed and recorded. Subjects in the Exposure-Promise condition listened to their target song significantly less than those in the No-Exposure-No Promise group. This is a conceptual replication of the Lepper, Greene, and Nisbett (1973) overjustification effect. In addition, there was a significant main effect for Promise, but not for Exposure. Thus, the expectation of reward was found to have a greater effect on subsequent free-choice behavior than the presence of salient, distracting stimuli prior to and during treatment.

As of this writing, the four studies described above are the only published overjustification experiments to have included manipulation of the expectation variable as part of their design. Based on these results, it has become generally accepted in the overjustification literature that, in order to result in a below-baseline decrement in intrinsic motivation, a reward must be expected by the subject (Anderson, Manoogian, and Reznick, 1976; Condry, 1977; Smith and Pittman, 1978). Other studies in which an overjustification effect has been obtained have used only expected rewards (Dollinger and Thelen, 1978; Pritchard, Campbell, and Campbell, 1977; Williams, 1980).

Salience of Reward and Distraction

Ross (1975) conducted two experiments to test whether the overjustification effect is a function of the salience of the reward. In Experiment 1, the nursery school children were taken individually to a room separate from their classroom and asked to accompany an animal-sounds record on a drum. Subjects in the Nonsalient reward condition were told they would receive a reward at the end of the period if they played. Salient reward subjects were given the same instructions, but told that the reward was under a box directly in front of them. No subjects in

either condition were told the nature of the prize. Control subjects were neither promised nor given a reward.

When the five-minute record was over, each experimental subject received the candy, which was usually consumed immediately. The child was then told that he could play with any of the toys in the room until it was time to go back to the classroom. The experimenter, who was blind to the experimental hypotheses but not to treatment conditions, observed the child's behavior from the corner of the room.

During the five-minute free-play period, a significantly lower proportion of the Salient reward subjects contacted the drum first among the available toys, compared with Nonsalient reward and Control subjects, which did not differ from one another. Salient subjects also spent significantly less time with the drum during this period than Nonsalient or Control subjects.

In a delayed assessment 4-5 weeks later, the children were again observed during a five-minute free-play period with the same toys. At this time, there were no longer any differences among treatment groups in their first contact with the drum, but the differences for duration of contact were maintained.

Experiment 2 was conducted to differentiate between attention to the reward and distraction. Subjects were

again nursery school children, the procedure was the same as in Experiment 1, and the experimental manipulation was designed to control the subjects' covert behavior during task performance. Think-reward subjects were told that the prize was two marshmallows, and that they could think about them all they liked while playing the drum. Non-ideation subjects were told that the prize was two marshmallows, but given no ideation instructions. Distraction subjects were told the prize was two marshmallows, and to think about snow all they liked while playing the drum. Control subjects were neither promised nor awarded a prize, and were given no ideation instructions.

During the five-minute free-play period, there were no significant differences among treatment groups in their first contact with the drum. However, the Think-reward and Nonideation subjects spent significantly less time with the drum than the Distraction and Control subjects. In both experiments, there were no significant differences among conditions in the rated intensity of target behavior during the treatment phase. The author's conclusion is that the subjects' intrinsic motivation is decreased by attention to the reward during task performance, rather than by distraction *per se*.

Smith and Pittman (1978) compared the effects of reward and distraction on college students' interest in

a Labyrinth skill game. There was no baseline measure of intrinsic interest; subjects received either 10, 25, or 50 training trials. In the Reward condition, subjects were paid a sum based on their game score following each trial. Subjects in the Distraction condition were required to listen closely to a tape recording on the history of abnormal psychology during training. Control subjects were neither paid nor required to listen to the tape.

Following training, there was a ten-minute free-choice period during which the experimenter left the room and a hidden video camera recorded the number of games initiated and the subject's performance. During this period, Reward subjects initiated significantly fewer games than Distraction or Control subjects, which did not differ. Within the Reward and Control conditions, the number of games initiated increased with the number of training trials, indicating that the effect of distraction dissipated with practice. There were no differences among treatment groups in quality of task performance during the free-choice period. Although average scores improved as the number of training trials increased, this practice effect was uninfluenced by reward or distraction.

Based on these studies, it appears that, while a more salient reward may increase the likelihood that overjustification will occur, the presence of a nonreward

distraction during task engagement will not lead to similar decrements in interest.

Reward Contingency

In a study by Deci (1972b), subjects were college students, each of whom participated in a single one-hour session. The target task was a Soma puzzle, consisting of seven pieces which can be fitted together to form many different configurations. Subjects were asked to produce four configurations drawn on paper. Those in the Money After condition received $1.00 for each puzzle solved within the ten minutes allotted to it; those in the No Money condition were not paid. Following the treatment manipulation, but prior to payment of the reward, the experimenter left the room for eight minutes, telling the subject he could do whatever he wished. On the table were two additional puzzle problems, some magazines, and an ashtray. Subjects were observed from behind a one-way mirror. During this period, subjects in the Money After group spent significantly less time working on the puzzle than those in the No Money group. The paid subjects received an average of $2.38 each (reported in Deci, Cascio, and Krusell, 1975) at the end of the experimental session.

This study, in which payment was contingent on quality

of task performance (solution of the puzzle within ten minutes), was compared with another study in Deci (1972a). In the latter experiment, the task and procedure were the same, but payment was contingent on task participation rather than on level of performance. Experimental subjects received $2.00 each, regardless of the number of puzzles solved; Control subjects were not paid. There was no difference between conditions in the amount of time spent working on the puzzle during the free-choice period. From these data, Deci (1972a, p. 227) concludes that "money does not decrease intrinsic motivation if it is paid noncontingently."

Karniol and Ross (1977) manipulated reward contingency and level of performance on "the slide game" with elementary school pupils. Subjects were asked to choose which of two stimuli on a slide would make a green light go on. Feedback was independent of the children's actual responses, with 10 of the 20 trials designated as "success" trials. Low-performance (unsuccessful) subjects were told that a score of less than 16 correct was below average; high-performance (successful) subjects were told that more than six correct was above average. Subjects in the performance-irrelevant (noncontingent) condition were told that they would receive two marshmallows for playing the game, while those in the performance-relevant (contingent) group

were told that the number they received (also two) was contingent on the quality of their performance. There was also a no-reward control group.

Following the treatment manipulation and the dispensing of rewards, there was a six-minute free-play period with four toys available in addition to the target activity. During this period, the amount of time each subject spent playing with the slide game was measured. While there were no significant main effects for either contingency or level of performance, there was an interaction effect. Among the successful subjects, those who received noncontingent rewards showed less free-play time than the other two groups. Contingent reward subjects did not differ from controls in either performance condition. These results are inconsistent with the Deci (1972a, 1972b) studies.

In the Greene and Lepper (1974) study, described above, the Expected award subjects were further divided into two performance-demand conditions. Subjects in the Low-demand (noncontingent) group were merely asked to draw some pictures for the experimenter. High-demand (contingent) subjects were told that only those children who drew the "very best" pictures would receive an award. There was no significant difference between the Low- and High-demand conditions on the amount of time spent drawing during the postexperimental free-choice period.

Other experiments have not directly compared contingent with noncontingent reward. However, overjustification effects have been obtained in studies where the rewards were contingent upon quality or level of performance (Dollinger and Thelen, 1978; Pritchard, Campbell, and Campbell, 1977; Smith and Pittman, 1978), as well as in cases where the rewards were given merely for engaging in the target task for a period of time (Anderson, Manoogian, and Reznick, 1976; McLloyd, 1979; Williams, 1980).

Level of Initial Interest

In an effort to determine the role of initial interest level in the production of the overjustification effect, Lepper, Greene, and Nisbett (1973), described above, divided each of their experimental groups in two based on the subjects' initial interest in the target activity. Among the No-award subjects, both those above and below the median in initial interest showed a slight increase during the postexperimental period. In the Unexpected award group, the below-median subjects increased slightly, while those above the median showed a substantial decrease. Both above-median and below-median subjects in the Expected award group declined in interest, but those above the

median showed a greater decline. This suggests that the effect is more likely to occur when the level of initial interest is high.

Greene, Sternberg, and Lepper (1976) manipulated initial interest level in a multiple-trial reinforcement procedure with fourth- and fifth-graders. Four novel math games, specially designed for the study, were introduced into the school's ongoing individualized math program. These activities were available for a half-hour period during each school day, and the amount of time each child spent on each game was recorded during a 13-day baseline period.

Based on these data, four treatment groups were formed. For subjects in the High-interest group, the target activities were the two games with which they had spent the most time during baseline. For Low-interest subjects, target activities were the two games with which they had spent the least time. Choice subjects were allowed to choose two of the four games as their target activities. During the 13-day treatment period, children in these three experimental groups were differentially rewarded for playing with their two target games, while Control subjects were nondifferentially rewarded for playing with all four games. The reward consisted of credit for completing one Math Lab level for each three

hours spent on the target games. Levels completed were recorded on a large posterboard chart in the classroom, and counted toward the earning of awards and certificates at the biweekly Awards Assembly. Following treatment, there was a 13-day withdrawal phase. Children were told that there would be no further Math Lab credit for the games, and all discriminative cues for reward were removed from the classroom.

Within-group comparisons showed a significant increase from baseline to treatment in the time spent on target activities for all three experimental groups. This reinforcement effect occurred for 31 of the 33 experimental subjects. All three experimental groups showed a decrease from baseline to withdrawal phase in the time spent with their target games. This decrease reached significance for the High-interest and Choice groups, but not for the Low-interest group. This latter result, however, should take into account the extremely low original baseline in the Low-interest group.

For the between-groups analyses, experimental subjects' performance was compared with the time spent by Control group subjects on appropriately matched or yoked activities. During the original baseline phase, experimental and control subjects did not differ in the time spent with the activities. During treatment, subjects in

all three experimental groups spent significantly more time on their target games than did matched or yoked control subjects. During the withdrawal phase, subjects in the Low-interest and Choice groups spent significantly less time with their target games than did Controls. Although the High-interest subjects' time was significantly below baseline, it did not differ from that of Control subjects. This lack of an overjustification effect among High-interest subjects is partly due to the tendency of control subjects' preferences to change over time.

Although the within-group and between-groups comparisons in this study are inconsistent with respect to the role of initial interest level in overjustification, subjects who were allowed to choose their own target games showed a clear decrement in both analyses. Withdrawal-phase data for the Choice group show no overlap either with the group's own baseline data, or with similar data for the Control group.

McLloyd (1979) examined the effects of initial interest level and reward value on reading among second- and third-graders. Subjects were given a brief description of and shown an illustration from six storybooks, and asked to rank order them according to how much they would like to read them. For those in the High-interest group, their first-choice book served as the target activity; those in

the Low-interest group were asked to read their last-choice book. Children in the reward conditions were shown six items and asked to rank them according to how much they would like to have them in exchange for reading. For subjects in the High-value reward group, their first choice served as the reward; those in the Low-value group received their last choice. There was also a No-reward control group. The most frequent first-choice reward (58%) was a Good Reader Award; a metal washer was the most frequent last-choice reward (58%).

Each child was asked to read about 250 words in his target storybook. There were no significant differences among groups in the amount of time required to read the material. After the child had finished, the appropriate reward was taped to a card and placed on the bulletin board. Following this procedure, there was a ten-minute free-choice period during which the book and three other activities were available.

The dependent measures were the time the child spent with the book and the approximate number of words read during the free-choice period. Of the children who read their first-choice book, both the High-value and Low-value reward groups were significantly lower on both measures than the No-reward group. Of those who read their last-choice book, High-value subjects were significantly higher

on both measures than Low-value or No-reward subjects. These data indicate that initial interest level does play a role in overjustification, and that this factor interacts with the value of the reward to the subject. Both the High- and Low-value reward decreased the amount of time spent with and the number of words read from the High-interest book. However, the High-value reward increased both measures of interest in the Low-interest activity, while the Low-value reward had no effect.

Reward Value and Constraint

Williams (1980) examined reward value in a study with elementary pupils. Two sets of comic books, rated as attractive or unattractive, were used as rewards. During Session 1 of the experiment, each subject was asked to rank four games from most to least favorite; the highest ranked game was used as the target activity, and the other three as alternatives. The time the subjects spent with all four games was then unobtrusively measured for a ten-minute baseline period.

Session 2 (2-7 days later) followed a three-phase overjustification paradigm, consisting of a ten-minute baseline, a ten-minute manipulation, and a ten-minute free-choice period. The experimenter was absent from the

room during all three phases. Prior to the manipulation, subjects in the Attractive-reward group were shown four comic books and told that they could keep two of them for playing with their target game in the experimenter's absence. Unattractive-reward subjects were given the same instructions, with a different set of comics. Request group subjects were merely asked to play with their target game, and Control subjects were given no instructions. During Session 3 (3-11) days later), each subject was again observed for a ten-minute free-choice period.

During the Session 1 and 2 baseline periods, the four groups did not differ significantly from one another on the amount of time spent on their target activities. However, all groups spent less time on these activities during the Session 2 baseline than they did during Session 1, indicating some degree of satiation. This shows that changes may occur as a function of exposure to the target activity, or simply due to the passage of time, and underscores the importance of the unrewarded control group in overjustification studies.

During Session 2 the Attractive-reward group showed a significantly greater increase from baseline to treatment in time spent with the target game than the Control group, while the Unattractive-reward and Request groups did not differ significantly from Controls. Within-group

comparisons were consistent with these results: The Attractive reward produced a significant reinforcement effect, while the Unattractive reward and Request groups produced nonsignificant increases. On the change from baseline to free-choice period, there was a significant difference between the Attractive-reward group and the Unattractive-reward and Request groups, which did not differ. Both of these latter groups showed a significant decline in time on target relative to the Control group, which showed an increase. There was no suggestion of an overjustification effect for the Attractive-reward group. During Session 3, the four groups did not differ significantly from their Session 2 baselines.

To further investigate the effects of high- and low-value rewards, Williams divided each reward group in half based on the amount of time the subjects had spent looking at comics during Session 1. When these groups were ordered along the attractiveness-of-reward dimension, it was found that the reinforcement effect increased in magnitude with the attractiveness of the reward, and that the size of the overjustification effect was inversely related to reinforcement. Williams concludes that these data are consistent with a two-component model of the reward procedure. According to this model, the behavior constraint component (request to perform) leads to overjustification, but the

addition of a high value of reward counteracts this effect.

In addition to manipulating expectation of reward, Lepper and Greene (1975), described above, examined the effect of adult surveillance on the amount of time the preschool subjects spent working on puzzles. In the Surveillance condition, a television camera beside the table was equipped with a zoom lens pointed directly at the area where the child would be working, and there was a small light on the table. Subjects were told that the light would turn on when they were being watched. In the Nonsurveillance condition, the camera was turned away from the table, the lens and light were absent, and no mention was made of the camera.

During the postexperimental free-choice period, the Surveillance subjects spent significantly less time on the target activity than the Nonsurveillance group; this factor did not interact with expectation of reward. These data indicate that surveillance during task engagement is sufficient to decrease intrinsic motivation, whether or not a reward is expected.

Amabile, DeJong, and Lepper (1976) examined the effect of deadline constraints on the amount of time college students spent on an Ad-Lib crossword game. In the Control condition, subjects were told to play with the game only as much as they wished. Those in the Work-fast condition were

asked to work as fast as they could. Implicit-deadline subjects were asked to work fast and told they would have 15 minutes to work at the task. Explicit-deadline subjects were told that the task must be completed within 15 minutes to be of any use to the experiment.

Following the 15-minute treatment, there was a 15-minute free-choice period in a second room, which contained the target game and a Soma puzzle. Subjects in the Explicit- and Implicit-deadline groups did not differ significantly on the amount of time spent playing the game during this period. However, those in the two deadline conditions spent significantly less time than those in the two nondeadline conditions. In addition, 60% of the nondeadline subjects chose to play with Ad-Lib first, while only 20% of the deadline subjects played with it first.

Only five of the 40 subjects failed to complete the experimental task during the 15-minute treatment phase. During this period, Control subjects took longer to complete the task than did those in the other three groups. There were no significant differences among groups in the quality of task performance.

The above studies show that actual reward is not necessary for the overjustification effect to occur, but that nonreward constraints imposed during task performance can lead to postexperimental decreases in intrinsic

motivation.

Performance during Treatment

It has been suggested that the key to the overjustification effect may lie in the influence of the experimental manipulation on the subject's performance during the treatment phase (Calder and Staw, 1975; Reiss and Sushinsky, 1975; Scott, 1975). Condry (1977) argues that the imposition of a reward or other constraint alters the context in which the behavior occurs, and that "both the process and the products of an individual's interaction with a task are different under intrinsic as opposed to extrinsic motivating conditions. The activities themselves are different (p. 472)." Differences in task performance during treatment have been found in several of the studies described above (Amabile, DeJong, and Lepper, 1976; Greene and Lepper, 1974; Greene, Sternberg, and Lepper, 1976; Lepper and Greene, 1975; Lepper, Greene, and Nisbett, 1973; Williams, 1980).

In other studies, however, no differences have been observed during this phase (Dollinger and Thelen, 1978; McLloyd, 1979; Ross, 1975; Smith and Pittman, 1978). Lepper and Greene (1976) have therefore concluded that "performance differences during the experimental phase

are not necessary to produce subsequent decrements in intrinsic motivation" (pp. 29-30).

Rationale

Despite the quantity of human research on the topic, the conditions prerequisite to the overjustification effect have not been precisely defined. It appears that a reward or other constraint which is present during task engagement can lead to posttreatment performance decrements in previously high-baseline behavior, provided it is salient and expected by the subject. Issues which remain to be resolved, however, include the nature of the contingency required, the role of initial interest level, the relative importance of reward and constraint, and the effects of the experimental manipulations on the subject's behavior during the treatment phase.

The search for variables which control and maintain human social behavior has sometimes been assisted by animal experiments (e.g., Grosch and Neuringer, 1981; Epstein, Lanza, and Skinner, 1980). The present experiment was conducted in the hope that an animal model of overjustification might provide a format for clarifying unresolved issues. It was designed as an analog of Lepper, Greene, and Nisbett (1973), using rats as subjects. In

order to appropriately parallel the human study, it was concluded that this experiment must meet the following conditions:

(1) The target behavior must be one which occurs at a sufficiently high operant level to qualify as "intrinsically motivated." According to Premack and Premack (1963), rats spend approximately 12% of their active hours running in a wheel, if given the opportunity. Therefore, wheel-running appeared to meet this requirement.

(2) Pretreatment and posttreatment baselines must be measured in an environment which provides several response opportunities other than the target behavior.

(3) The treatment phase must be conducted in an environment discriminably different from that in which the baselines are measured, and the additional response opportunities must be absent.

The present experiment differed from the human study in the following ways:

(1) Multiple-trial reinforcement was used rather than a single "reward", whose reinforcing character is unknown. Skinner and Morse (1958) have shown that a rat's wheel-running can be influenced by the presentation of food on a

fixed-interval schedule.

(2) The expectation variable was not manipulated. Since a multiple-trial procedure was used, treatment corresponded to the Expected award condition in Lepper, Greene, and Nisbett (1973).

CHAPTER II

METHOD

Subjects

Eight experimentally naive male Sprague-Dawley rats (Charles River Breeding Laboratories) were approximately 90 days old when the experiment began. These subjects were maintained at about 85% of their free-feeding weights, and housed individually on a 12-hour light/dark cycle, with free access to tap water.

Apparatus

Sessions were conducted in two multioperant chambers modified from those constructed for a previous experiment (Tyson, 1982). Each unit consisted of an area 41cm wide x 16cm deep x 13 cm high. The two clear plastic end walls were 18cm wide x 15.5cm high, and the sheet metal front wall measured 41cm wide x 13cm high, with a 2.5cm lip at the bottom which held the floor. The fourth side consisted of a 41cm wide x 38cm high metal frame which housed a 11cm wide x 35cm diameter Wahmann activity wheel. The wheel was entered from the chamber through a space, 29cm wide at the top and 7cm high at midpoint, which matched the

bottom portion of the wheel. A clear plastic roof, 42cm wide x 15cm deep, was attached by hinges to the wheel frame. This entire unit was mounted, with braces on the end walls, to a plywood base. A floor of perforated sheet metal, covering the area of the chamber, was suspended about 2.5cm above the plywood base. The rear of the floor pivoted on bolts attached to each of the two end walls, and a bolt at the center front was attached to a spring which rested on the lip at the bottom of the front wall. A microswitch under the floor recorded the amount of time spent on the floor.

A 5cm wide x 1cm thick lever, extending 2.8cm into the chamber, was mounted in the front wall 6.5cm from the right plastic wall and 6cm above the floor. A downward force of 0.15N on the lever was required to operate a 28v white jewel light, which was mounted at the same height, halfway between the lever and the left wall. An 8cm long chain hung from the ceiling, 7cm from the right wall and 4cm from the front wall. The chain was attached to a microswitch, mounted on the roof, which recorded the amount of time the chain was held down. A drinking tube was mounted behind the front wall with its tip fitting through a 1cm diameter hole in a plastic plate mounted behind the sheet metal, then through a 1.3cm diameter hole in the wall itself, 5cm to the left of the lever and 5.4cm above the

floor. The tube extended 1.2cm into the chamber. The drinking tube was attached to a Grason-Stadler drinkometer for recording the time spent drinking water. Two magnets, mounted at each pole of the activity wheel, operated a proximity switch mounted on the frame and gave a count of each half-revolution of the wheel. The wheel hub turned a gear which revolved against a ratchet, allowing the wheel to turn in only one direction. A force of 17.5-20.0g was required to turn Wheel AA, and 20.0-22.5g to turn Wheel BB.

The experimental chambers were housed in sound- and light-attenuating enclosures 75cm wide x 60cm deep x 75cm high. A 25w, 110v AC red bulb at the midpoint of the ceiling of each enclosure served as houselight. Small exhaust fans in the rear of the enclosure ventilated the chambers and provided approximately 70dB masking noise. A speaker on each enclosure wall provided approximately 80dB of white noise.

During treatment phases, subjects were confined to the activity wheel by means of a sheet metal panel which covered the wheel entrance and contained a 4.7cm square opening, behind which was mounted a food magazine. Standard electromechanical relay equipment, located in an adjacent room, was programmed to control stimulus events, deliver reinforcers, and record data.

Procedure

The experiment consisted of four phases: Baseline 1 (33 days), Treatment 1 (27 days), Baseline 2 (13 days), and Treatment 2 (9 days). During the Baseline periods, four response opportunities were available to the subject: a running wheel, a drinking tube, a lever which turned on a light when pressed, and a chain which produced a clicking sound when pulled. During Treatment periods, the subject was confined to the wheel by means of a removable panel containing a food dispenser. Feeder training consisted of a single session during which the wheel was immobilized and pellets were delivered by pushbutton. Subjects reliably responded to the events signaling food delivery after 30 deliveries of two to three pellets each.

Subjects were run in four pairs, one animal in each of the two treatment conditions. Pairs were run in succession and in the same order, seven days a week, during the dark portion of the light/dark cycle. One animal of each pair was assigned to Wheel AA, and the other to Wheel BB, counterbalanced to avoid confounding Wheel with condition (see Table 1). In the Experimental condition, wheel-running responses (half-turns of the wheel) produced food on a fixed-interval schedule of 5 minutes (FI 5) during both Treatment phases. Each food presentation consisted

TABLE 1

TREATMENT CONDITION AND WHEEL FOR EACH SUBJECT

	Experimental	Control
Wheel AA	T1, T3	T5, T7
Wheel BB	T6, T8	T2, T9

of two or three 45mg pellets, and the houselight and white noise were briefly interrupted to signal the delivery of each pellet. During the first Treatment phase, subjects in the Control condition were confined to the wheel for the same length of time and exposed to interruptions of white noise and houselight at the same time as the Experimental subjects, but received no food. During the second Treatment phase, Control subjects received pellets and their accompanying signals whenever the Experimental subjects did, irrespective of whether a wheel-running response had occurred. On the final day of the experiment, a test for resistance to extinction was conducted for all subjects by disconnecting the feeder from the foodcup. In all other respects, including the presence of events signaling food delivery, this session was the same as the

Treatment sessions.

During Baseline phases, each half-turn of the running wheel was counted, as were interresponse times (IRT's) of one to nine seconds for running responses; IRT's of greater than nine seconds were accumulated on an overflow counter. Records were also kept of the aggregate amount of overflow (greater than nine seconds' IRT) time, the amount of time spent on the floor (out of the wheel), the amount of overflow time spent on the floor, and the amounts of time spent in contact with the chain, lever, and drinking tube. During Treatment phases, the number of running responses and reinforcing events (intervals) were counted. In addition, a count was made of the number of running responses which occurred during each successive tenth (30 seconds) of the five-minute fixed interval. During many sessions, a cumulative record of wheel-running responses was also obtained from one of the two boxes.

Each Baseline session lasted 40 minutes; Treatment sessions were terminated at the end of the eighth five-minute fixed interval.

CHAPTER III

RESULTS

Initial Differences

In order to determine whether there were initial differences in performance between animals in the two Treatment Conditions, *t* tests were conducted on the mean difference between Experimental and Control subjects for the last five days of Baseline 1 on three different measures. For Total Wheel Responses (number of half-turns of the wheel during a session), Experimental subjects showed a mean of 525.1, while Control subjects averaged 427.4. For Wheel Time (number of seconds in the wheel during a session), Experimental subjects averaged 1941.25 and Control subjects 2110.55. On the Rate measure (responses per minute in the wheel), the mean for Experimental subjects was 16.41 and for Control subjects 12.02. None of these differences was statistically significant (all $p > .10$).

Because of the difference in the amount of force required to turn the two running wheels, similar *t* tests were performed for AA and BB wheel subjects. For Total Wheel Responses, subjects in Wheel AA showed a mean of 776.45, while Wheel BB subjects averaged 176.05. This

difference was statistically significant ($t(6) = 4.83$, $p < .01$). For Wheel Time, Wheel AA subjects averaged 2027.00 and BB subjects 2024.80, a nonsignificant difference ($t(6) = 0.01$, $p > .10$). On the Rate measure, the mean for AA subjects was 23.29 and for BB subjects 5.14, a significant difference ($t(6) = 5.87$, $p < .01$).

The difference in effort required to turn the two wheels thus provided a range of Baseline response levels over which the Treatment manipulation could be tested. For example, the slowest-running rat (T9) averaged 185.53 feet per session during the last five days of Baseline 1, while the fastest animal (T1) averaged 1908.13 feet--more than one-third of a mile in 40 minutes.

Baseline-to-Baseline Changes

The principal experimental question was whether there was an overjustification effect; that is, whether a decrease in wheel-running occurred following a period of contingent food delivery. To answer this question, the last five days of Baseline 1 were compared with the first five days of Baseline 2 for both Total Wheel Responses and Rate. Similar comparisons were also made for the Wheel Time and Overflow Time measures, and for the amount of time each subject spent on the three alternative

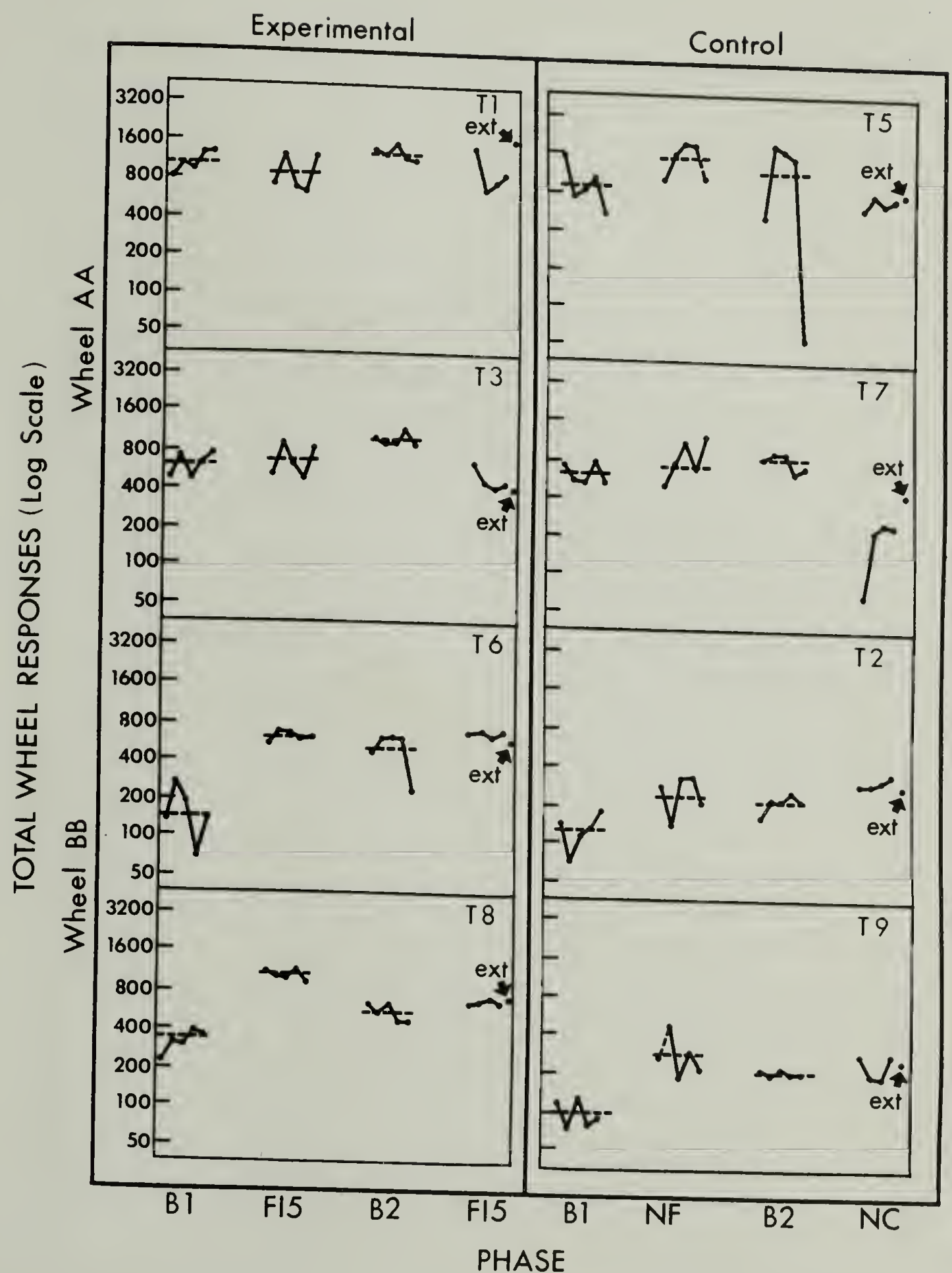
responses (lever pressing, chain pulling, and drinking). Group analyses of variance on Total Wheel Responses, Rate, Wheel Time, and Overflow Time were performed for both the absolute difference between the five-day means of the two phases (Baseline 2 - Baseline 1), and the percent change in each measure from the first to the second Baseline phase [(Baseline 2 - Baseline 1)/Baseline 1]. For individual subjects, t tests were conducted on the difference between the five-day means of the two phases for all seven measures of Baseline activity.

Analyses of variance on the baseline-to-baseline change in Total Wheel Responses (Table 2) showed overall increases significantly greater than zero for both percent change ($F(1,4) = 12.25$, $p < .05$) and absolute mean difference ($F(1,4) = 85.19$, $p < .001$). However, there was no significant main effect of either Treatment Condition or Wheel, and no interaction effect.

Figure 1 shows Total Wheel Responses for each subject during the four phases of this experiment. For Baseline 2, the data points represent the first five sessions; for the other three phases, the last five sessions are shown. Because of the extreme variability at higher levels of responding, logarithms rather than absolute numbers are used for graphic representation in order to facilitate visual comparison. Of the t tests conducted for individual

Figure 1

Log of Total Wheel Responses for All Four Phases. The graph for each subject shows the total number of wheel-running responses (log scale) for 5 days of each phase. Data points represent the first 5 days of the Baseline 2 phase, and the last 5 days of the other three phases. The last session of the final phase was a test for resistance to extinction. Note: For Control subjects, NF = No Food, NC = Noncontingent Food.


Experimental
Control
TOTAL WHEEL RESPONSES (Log Scale)
Wheel AA
Wheel BB
3200
1600
800
400
200
100
50
T1
T3
T6
T8
T5
T7
T2
T9
ext
B1
FI5
B2
NF
NC
PHASE

subjects (Table 3), all eight showed a baseline-to-baseline increase in Total Wheel Responses, six of which were significant beyond the .05 level. Of these six, half were Experimental (FI 5) and half Control (No Food) subjects; four of the six were in Wheel BB.

TABLE 2

ANALYSES OF VARIANCE ON BASELINE-TO-BASELINE CHANGES

	F (1,4)			
Measure	Overall Change	Treatment Condition	Wheel	Cond x Wheel Interaction
Total Wheel Responses				
Percent change	12.25*	0.46	3.54	0.26
Mean difference	85.19***	4.49	2.30	1.66
Rate (R/min in Wheel)				
Percent change	771.73***	0.34	5.51	0.69
Mean difference	54.17*	2.45	0.49	6.22
Wheel Time (sec)				
Percent change	0.30	0.19	5.00	3.63
Mean difference	0.59	0.20	5.39	3.77
Overflow Time (sec)				
Percent change	0.28	2.45	0.38	1.31
Mean difference	0.42	1.85	0.46	0.61

*$p < .05$ $F(.05, 1,4) = 7.71$

**$p < .01$ $F(.01, 1,4) = 21.20$

***$p < .001$ $F(.001, 1,4) = 74.14$

Note: Group means on which these analyses are based appear in Table 7 of the Appendix.

Interresponse time (IRT) distributions are generally consistent with the Total Wheel Responses data. Distributions for Wheel AA subjects during Baseline 1 showed a peak at one second, with 60-75% of responses occurring within one second and very few occurring at IRT's greater than two seconds. The distributions for Baseline 2 were essentially unchanged from this original pattern. For Wheel BB subjects, Baseline 1 distributions tended to peak at two seconds, with responses more evenly distributed among the other IRT's and a relatively large number occurring at greater than nine seconds. Baseline 2 distributions were substantially the same as those for Wheel AA subjects. Figure 2 shows IRT distributions for all eight subjects, averaged over five days of each Baseline phase.

On the change in Rate across baselines (Table 2), the overall increases were also significantly above zero for both percent change ($F(1,4) = 771.73$, $p < .001$) and absolute mean difference ($F(1,4) = 54.17$, $p < .01$). Again, there were no significant main or interaction effects. For individual subjects, all eight $\underline{t}$ tests (Table 3) showed an increase in Rate across baselines, five of which were significant beyond the .05 level. Of these five, two were Experimental and three Control subjects; four of the five were in Wheel BB.

Both the Wheel Time and Overflow Time (total of IRT's

Figure 2

Interresponse Time Distributions for Baseline Phases. Each distribution shows the relative frequency of IRT's of 1-9 seconds during a 40-minute Baseline session. Frequencies represent the means of the last 5 days of Baseline 1, and the first 5 days of Baseline 2. Numbers in parentheses indicate the relative frequency of IRT's longer than 9 seconds.

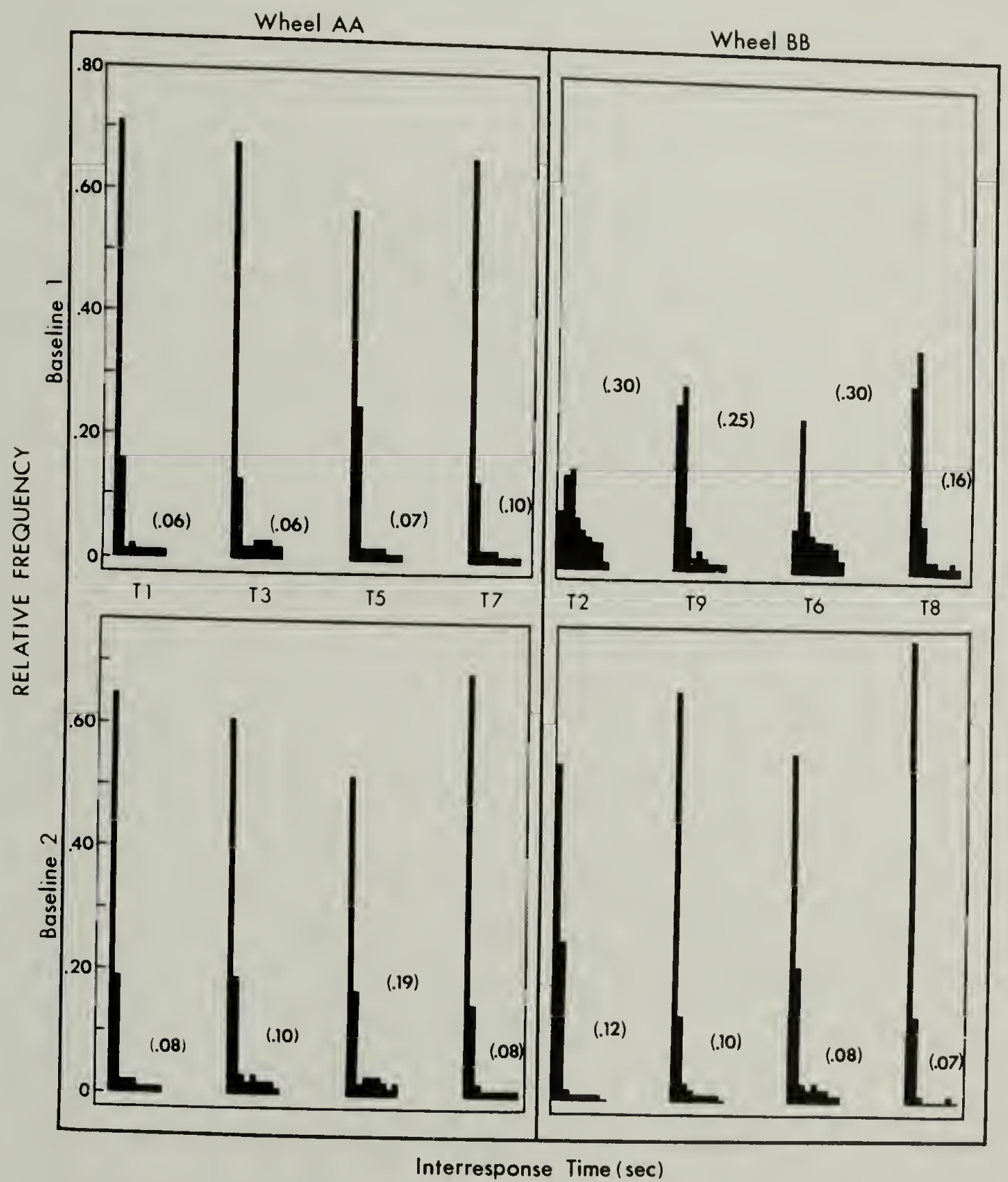

Wheel AA
Wheel BB
RELATIVE FREQUENCY
Baseline 1
Baseline 2
.80
.60
.40
.20
0
(.06)
(.06)
(.07)
(.10)
(.30)
(.25)
(.30)
(.16)
T1
T3
T5
T7
T2
T9
T6
T8
(.08)
(.10)
(.19)
(.08)
(.12)
(.10)
(.08)
(.07)
Interresponse Time (sec)

TABLE 3

t TESTS ON BASELINE-TO-BASELINE CHANGES FOR INDIVIDUAL SUBJECTS

t(8), two-tailed (Baseline 2 - Baseline 1)

Subject	Total Wheel Responses	Rate (R/min in Wheel)	Wheel Time	Overflow Time	Lever Time	Chain Time	Drink Time
+ T1	2.05	1.78	1.11	- 0.63	- 2.21	0.66	-0.84
T2	4.22**	3.76**	- 0.04	1.00	- 2.62*	- 0.11	2.04
+ T3	4.80**	1.77	2.64*	- 3.13*	1.71	- 1.42	3.36**
T9	10.83***	8.16***	- 1.82	- 0.05	1.11	1.48	2.38*
T5	0.72	0.70	- 1.06	0.33	1.47	0.13	2.08
+ T6	4.42**	4.31**	- 1.63	- 1.52	- 2.77**	-0.25	5.51***
T7	2.84*	3.42**	- 0.24	- 0.24	- 0.66	-0.56	- 3.62**
+ T8	5.25***	6.56***	- 1.15	1.44	- 1.15	1.12	1.72

*p < .05
**p < .01
***p < .001
\+ indicates Experimental (FI 5) animals

t(.05, 8) = 2.31
t(.01, 8) = 3.36
t(.001, 8) = 5.04

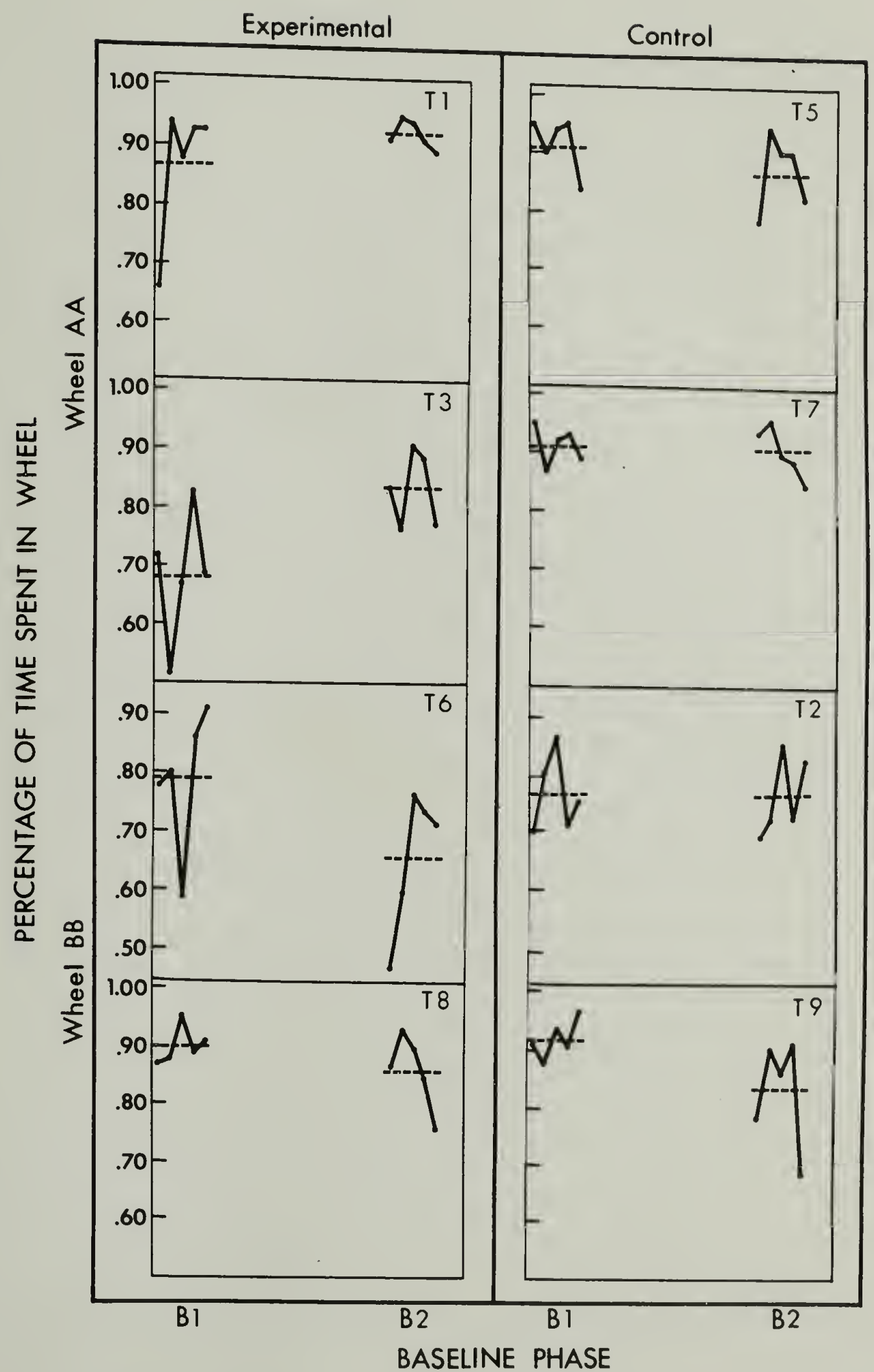
Note: Individual means on which these tests are based appear in Table 8 of the Appendix.

greater than nine seconds) measures showed nonsignificant overall decreases across baselines (Table 2), and no main or interaction effects. Six of the eight subjects decreased their Wheel Time, but not significantly; one of the two increases was statistically significant (Table 3). Of the five subjects which showed a decrease in Overflow Time, one was significant; none of the three increases was significant (Table 3). Figure 3 shows the percentage of time spent in the wheel for each subject during the last five days of Baseline 1 and the first five days of Baseline 2.

Baseline-to-baseline comparisons were conducted on the number of seconds individual subjects spent in contact with each of the three activities available as alternatives to wheel-running (Table 3). Five subjects showed a decrease in Lever Time, two of which were significant and one of which (T1) approached significance; none of the three increases was significant. In Chain Time, half of the subjects increased and half decreased; none of these changes was significant. Six subjects showed an increase in Drink Time, three of which were significant; of the two decreases, one was significant.

Figure 3

Percentage of Time Spent in Wheel during Baseline Phases. The graph for each subject shows the percentage of a 40-minute Baseline session spent in the wheel. Data points represent the last 5 days of Baseline 1, and the first 5 days of Baseline 2.


Experimental
Control
PERCENTAGE OF TIME SPENT IN WHEEL
Wheel AA
Wheel BB
1.00
.90
.80
.70
.60
.50
T1
T3
T6
T8
T5
T7
T2
T9
B1
B2
BASELINE PHASE

Baseline-to-Treatment Changes

In order to determine whether the reinforcement contingency was effective, the last five days of Baseline 1 were compared with the last five days of the Treatment 1 phase for both Total Wheel Responses and Rate.

Analyses of variance on the baseline-to-treatment change in Total Wheel Responses (Table 4) showed overall increases significantly greater than zero for both percent change ($F(1,4) = 2280.06$, $p < .001$) and absolute mean difference ($F(1,4) = 10.56$, $p < .05$).

TABLE 4

ANALYSES OF VARIANCE ON BASELINE-TO-TREATMENT CHANGES

	F (1,4)			
Measure	Overall Change	Treatment Condition	Wheel	Cond x Wheel Interaction
Total Wheel Responses				
Percent change	2280.06***	0.97	24.45**	4.77
Mean difference	10.56*	0.01	2.07	6.84
Rate (R/min in Wheel)				
Percent change	17.72*	0.21	19.90*	4.01
Mean difference	3.57	0.24	6.49	10.14*

*p < .05
**p < .01
***p < .001

F(.05, 1,4) = 7.71
F(.01, 1,4) = 21.20
F(.001, 1,4) = 74.14

Note: Group means on which these analyses are based appear in Table 7 of the Appendix.

There was a significant main effect of Wheel for percent change in Total Wheel Responses ($F(1,4) = 24.45$, $p < .01$), but not for absolute mean difference ($F(1,4) = 2.07$, $p > .05$). There was no significant effect of Treatment Condition, and no interaction effect. Seven of the eight *t* tests conducted for individual subjects showed a baseline-to-treatment increase in Total Wheel Responses (Table 5); five of these were significant beyond the .05 level. Of these five, two were Experimental and three Control subjects; four of the five were in Wheel BB.

On the change in Rate from baseline to treatment (Table 4), the increase was significantly above zero for percent change ($F(1,4) = 17.72$, $p < .05$), but not for absolute mean difference ($F(1,4) = 3.57$; $p > .05$). There was a significant main effect of Wheel for percent change ($F(1,4) = 19.90$, $p < .05$); the Wheel BB subjects increased more than those in Wheel AA. The significant Treatment Condition x Wheel interaction for absolute mean difference in Rate ($F(1,4) = 10.14$, $p < .05$) indicates that the FI 5 subjects in Wheel BB showed the largest increase. All other effects were nonsignificant. For individual subjects, three of the five baseline-to-treatment increases were significant beyond the .05 level (Table 5). Two of these were Experimental subjects; all three were in Wheel BB. Of the three decreases in Rate, one was significant.

TABLE 5

t TESTS ON BASELINE-TO-TREATMENT CHANGES FOR INDIVIDUAL SUBJECTS

	Total Wheel Responses			Rate (R/min in Wheel)		
Subject	Baseline 1 Mean	Treatment 1 Mean	t(8)	Baseline 1 Mean	Treatment 1 Mean	t(8)
+ T1	1040.8	865.4	- 1.18	29.98	21.12	- 2.61*
T2	126.0	241.0	3.17*	4.15	5.87	1.71
+ T3	582.6	642.4	0.61	22.00	15.42	- 1.75
T9	101.2	303.0	3.64**	0.48	1.28	3.30*
T5	884.2	1481.4	2.52*	24.80	35.94	1.73
+ T6	142.0	578.6	10.86***	5.07	13.98	7.07***
T7	598.2	693.6	0.82	16.39	16.02	- 0.15
+ T8	335.0	1075.8	20.43***	8.58	25.10	12.83***

*p < .05
**p < .01
***p < .001
\+ indicates Experimental (FI 5) animals

t(.05, 8) = 2.31
t(.01, 8) = 3.36
t(.001, 8) = 5.04

Note: All *t* tests are two-tailed.

During the first Treatment period, the Experimental animals reliably responded to the discriminative stimuli and collected the pellets as soon as they were delivered. Early in this phase, there was an observable change in their pattern of responding not shown by the Controls. The cumulative records (Figure 4) show that responding during Treatment 1 for Experimental subjects T1 and T3 is much more evenly spread out and consistent throughout the session than it was during Baseline 1. For Control subjects T2 and T9, however, the Treatment 1 record shows substantially the same pattern of long pauses punctuated by bursts of rapid responding as that which occurred during Baseline 1.

Figure 5 shows the distribution of wheel-running responses across successive tenths of the five-minute fixed interval. Although the typical "scallop" pattern characteristic of fixed-interval schedules did not develop in the FI 5 subjects, there was a tendency for them to pause following pellet delivery and increase responding as the interval progressed. In contrast, subjects in the No Food condition displayed an essentially random distribution of responses across the interval. During Baseline 2, both Experimental and Control subjects showed the same response pattern as during Baseline 1 (Figure 4).

In order to determine whether this change in pattern

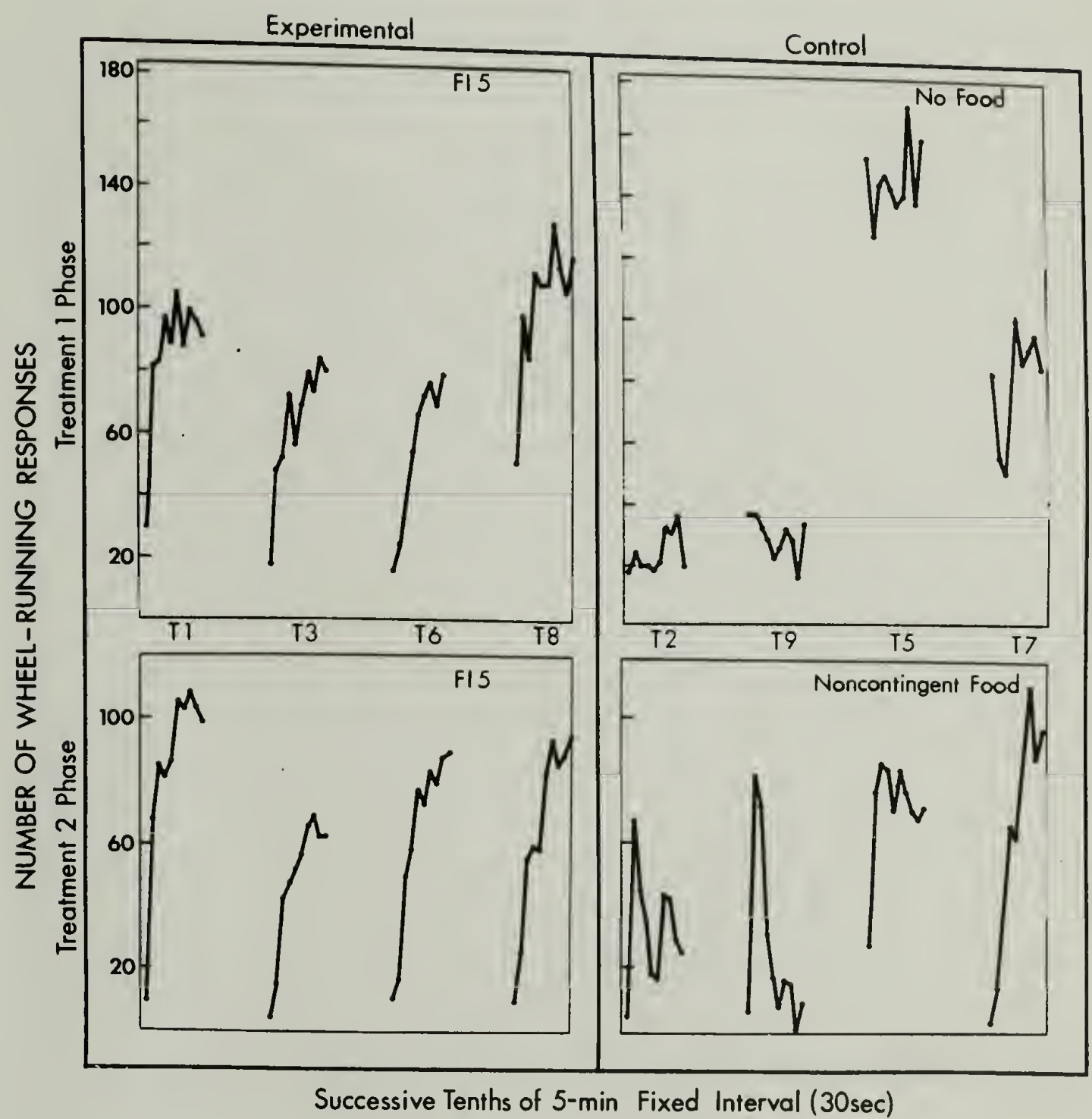
Figure 4

Cumulative Records of Wheel Responses for All Four Phases. Each of the four records illustrates typical patterns of wheel-running during all four phases for a single subject. T1 and T3 are Experimental animals; T2 and T9 are Controls. Note: For Control subjects, NF = No Food, NC = Noncontingent Food.

T1
B1
FI5
B2
FI5
T3
B1
FI5
B2
FI5
T2
B1
NF
B2
NC
T9
B1
NF
B2
NC
200 RESPONSES
5 MINUTES

Figure 5

Distribution of Wheel Responses across Successive Tenths of Five-Minute Fixed Interval. Individual curves for each subject show the average number of wheel-running responses occurring during successive 30-second periods of the 5-minute fixed interval (accumulated over 8 intervals), for both Treatment phases. In the Noncontingent Food graph (lower right), data points represent the means of the last 2 days of the Treatment 2 phase. All other curves show the means of the last 5 days of the appropriate phase.


Experimental
Control
FI 5
No Food
FI 5
Noncontingent Food
NUMBER OF WHEEL-RUNNING RESPONSES
Treatment 1 Phase
Treatment 2 Phase
180
140
100
60
20
100
60
20
T1
T3
T6
T8
T2
T9
T5
T7
Successive Tenths of 5-min Fixed Interval (30sec)

was due to the FI schedule or was simply the result of periodic food delivery, the Treatment 2 phase was instituted. During this phase, Control animals were yoked to FI 5 subjects such that they received pellets at the same time, noncontingently. The cumulative records for Treatment 2 appear similar to those for Treatment 1, for both Experimental and Control subjects (Figure 4). For FI 5 subjects, the distribution of wheel responses across successive tenths of the interval during Treatment 2 appears the same as during Treatment 1 (Figure 5). The Noncontingent Food subjects' distributions differ from the Treatment 1 phase in that they show a lower rate of responding during the first 30 seconds of the interval. This pause, however, could be accounted for by the consumption of food. If the first point is ignored, only subject T7 shows a tendency to increase responding across the interval.

The final session of the second Treatment phase consisted of a test for resistance to extinction. Table 6 shows the resulting extinction ratios, calculated by dividing the Total Wheel Responses for this session by the average of the Total Wheel Responses for the two preceeding sessions. Of the two subjects whose ratios are greater than 1.50, one was an Experimental and one a Control animal; both were in Wheel AA. Examination of the cumulative

records available for this session (those for the FI 5 subjects) uncovered no tendency for running rates to decrease in the latter part of the session.

TABLE 6

EXTINCTION RATIO FOR EACH SUBJECT

BY TREATMENT CONDITION AND WHEEL

	Experimental		Control	
Wheel	Subject	Extinction Ratio	Subject	Extinction Ratio
AA	T1	1.94	T5	1.16
	T3	0.95	T7	1.71
BB	T6	0.90	T2	0.84
	T8	1.07	T9	1.05

CHAPTER IV

DISCUSSION

Overjustification

Both Total Wheel Responses and Rate increased across Baselines for the entire subject group, and for all eight subjects taken individually. In general, the FI 5 subjects increased as much as the Controls. There is therefore no evidence of an overjustification effect in this experiment.

All of the rats ran more during Bseline 2, even though most of them spent less time in the wheel than they had during Baseline 1. The tendency of the subjects to run faster during this phase is partly reflected in the decreased Overflow Times. Among the three animals whose absolute Overflow Time increased during this phase, a smaller proportion of total responses occurred at IRT's greater than nine seconds. The increased running does not appear to have led to corresponding decreases in the three alternative activities, nor has the decreased Wheel Time resulted in increased Lever or Chain Time. Of the six animals which spent less time in the wheel, however, five showed increases in Drink Time.

Skinner and Morse (1958) investigated the effects of reinforcing wheel-running on an FI 5 schedule. Each

session began with a baseline period during which running in the dark was recorded. After 30 minutes, a six-watt white light came on, and running was reinforced on the FI 5 schedule for 20 or 40 intervals. Operation of the food magazine was accompanied by a loud noise. Before the session was terminated, the light was turned off and unreinforced running was again recorded for 30 minutes. The rats were confined to the wheel for the entire session, and no alternative activities were provided.

Visual inspection of the cumulative records published in the Skinner and Morse article reveals--in some cases very clearly--that the rats' running rate during the period following reinforcement was lower than it had been during the initial baseline period. This appears similar to the overjustification phenomenon found in the human studies, and the feasibility of constructing an animal model for this effect was largely predicated on the data in Skinner and Morse (1958).

The purpose of the Skinner and Morse experiment was different from that of the present study; it was a within-subject design and there were no controls for changes in unreinforced responding over time. Since the sessions were very long (either 2 hrs., 10 min. or 3 hrs., 50 min. before the light was turned back on, depending on the number of intervals), it is of course possible that the

decline in responding was due to fatigue. This seems unlikely, however, since the cessation of responding was so abrupt. In three of the cumulative records, the slope of the line becomes horizontal as soon as the light signaling the FI period is turned off (Skinner and Morse, 1958, Figs. 4, 5, and 7).

Wheel Differences

Precise measures of the amount of force required to turn the two running wheels are not available. According to the approximate measures obtained, the difference between them was not more than 5.0g, with Wheel BB requiring the greater effort. While this difference does not seem very large, it appears to have had a significant impact on the responding of the subjects in this experiment. During the initial Baseline phase, the Wheel AA rats ran more than four times as smuch as those in Wheel BB, even though they spent the same amount of time in the wheel. This is consistent with the finding of Collier (1970) that the distance a rat runs in a wheel is a linear decreasing function of torque (p. 569), and also with that of Skinner and Morse (1958): "In general, the rate of running decreases as the force required to turn the wheel increases (p. 379)."

There was an effect of Wheel during the first Treatment phase, probably due to the lower Baseline responding of the Wheel BB subjects. Wheel BB animals increased both Total Wheel Responses and Rate more than those in Wheel AA. In addition, the Experimental contingency had a greater impact on the Wheel BB subjects than on those in Wheel AA; the two Wheel BB/FI 5 animals showed the largest increase of all. While there was no effect of Wheel on either Responses or Rate during the second Baseline phase, and no interaction, the Wheel BB animals' running increased sufficiently to show a change in their IRT distributions, which came to resemble those of the Wheel AA subjects.

Deprivation

The rats in this experiment were kept at approximately 80-85% of their free-feeding weights at 90 days of age. At the time this decision was made, the experimenter believed that rats' weights stabilized at 90 days. This is not the case, however. Assimon (1984) shows a 135-day growth curve for a group of male Sprague-Dawley rats kept on an unrestricted diet. These data indicate that, at 135 days, the free-feeding weights of rats are 119% of their 90-day weights. Therefore, rats maintained at

80-85% of their 90-day weights become functionally more deprived as time passes. By the final day of the present experiment, the subjects actually weighed 67-71% of what they would have weighed had their food not been restricted.

In the present experiment, the animal's running tended to increase over time and across phases. It is a common observation that rats on restricted feeding schedules run more than those allowed to feed ad libitum (Gross, 1968). According to Hall and Hanford (1954), activity increases as a negatively accelerated function of the number of days of restricted feeding. Collier (1970) shows that not only does activity increase with the severity of deprivation, but the effect of deprivation on running increases as the force required to turn the wheel decreases (p. 564). Interpolating from his data, it appears that rats maintained at 70% would run almost three times as much as those kept at 80%, in a wheel whose torque was 20g (Collier, 1970, Fig. 23). Given this information, it seems likely that the increasing deprivation state of the rats in this experiment militated against their showing a baseline-to-baseline decrease in wheel running. In the Skinner and Morse (1958) study, this was not a factor, since all three phases were run within one session.

Reinforcement

While there were significant overall increases in both Total Wheel Responses and Rate during the first Treatment phase, there was no difference between Experimental and Control subjects, indicating that these increases were not a function of the FI 5 contingency. In fact, the only subject which showed a decrease in Total Wheel Responses (T1) was an Experimental animal, as were two of the three which decreased in Rate (T1, T3). It is likely, therefore, that the overall increase is primarily a result of the animals' confinement to the wheel during the Treatment phase.

The most distinctive effect of the reinforcement schedule on the subjects' running was the change in response pattern which occurred in the Experimental animals during the Treatment 1 period. From very early in this phase, it was possible to discriminate between the FI 5 and Control (No Food) subjects merely by looking at the pattern of running shown on their cumulative records. This was also true during the Treatment 2 phase, when the Control (Noncontingent Food) animals were yoked to the FI 5 subjects, indicating that the difference in pattern was a function of the reinforcement contingency. These results are similar to those of Skinner and Morse (1958), who also

reinforced rats' wheel running on an FI 5 schedule: "Although reinforcing the animal on a fixed-interval schedule may not greatly change the momentary rate of running, it makes the behavior orderly with respect to the schedule of reinforcement (pp. 377-378)."

In the present experiment, the behavior of the FI 5 rats never developed the scallop configuration characteristic of fixed-interval responding, whereas the subjects in Skinner and Morse (1958) showed a scallop pattern as early as the thirteenth session. Since those animals received 40-50 intervals per session, however, they had been exposed to more than 520 fixed intervals by the time the scallop developed. In the present study, the rats received only eight intervals per day during each Treatment phase--a total of 288 fixed intervals during the entire experiment. Had the experimental sessions--or the experiment itself--been longer, it is probable that the scallop pattern would have developed.

During the final day of the Treatment 2 phase, there was no evidence of resistance to extinction in the usual sense (a temporary elevation in response rate which precedes a return to the operant level of responding). By the end of this session, however, the FI 5 animals' responding had begun to return to its Baseline pattern. This also is consistent with the findings of Skinner and

Morse (1958) that " . . . the extinction of reinforced running reveals itself as a gradual increase in erratic running and pausing (p. 378)."

Although the present data do not show a reinforcement effect in the classic sense (an increase in response rate following the contingent presentation of food), this may have been partly due to a ceiling effect; the Wheel AA animals' Baseline running rates were extremely high. Skinner and Morse (1958) also observed that " . . . reinforcement sometimes suppresses the rate of running below the unreinforced rate (p. 377)." There is evidence, however, that the Experimental subjects' pattern of responding changed systematically as a function of the FI 5 schedule. It is therefore concluded that the reinforcement contingency was effective in controlling wheel-running behavior in this experiment.

Discrimination

In order for an overjustification effect to occur during the posttreatment period, the organism must discriminate that it is no longer in a situation where reward is forthcoming. In the human studies, this is accomplished either by physically removing the subject from the treatment environment, or by explicitly stating

that the treatment-phase conditions are no longer in effect.

In the Skinner and Morse (1958) experiment, discriminative control over the animals' behavior was established by a differential training procedure in which reinforcement was scheduled during the light (S+) and nonreinforcement during darkness (S-). The stimulus periods were very long (30 minutes for S-, 100 or 200 minutes for S+) compared with those commonly used in discrimination training, and there were only two S- periods and one S+ period in each daily session. However, since the reinforcement phase was sandwiched between two periods of nonreinforcement, there was one S-S+ transition and one S+S- transition in each session. This is a sufficient condition for the development of discrimination based on external stimulus control (Ellis, 1970). Examination of the cumulative records in Skinner and Morse (1958) shows that the transitions between phases are very abrupt--the rats' fixed-interval responding begins as soon as the light goes on, and stops as soon as it goes off.

In the present experiment, the S+ was a complex condition consisting of confinement to the wheel, the presence of the foodcup, and the absence of the three manipulanda. The S- consisted of access to the outer chamber, the presence of the three manipulanda, and the absence of the foodcup. Each daily experimental session

constituted a single stimulus period of 40 minutes; there were no stimulus transitions within a session. In the only S-S+ transition occurring before the test for overjustification, the stimulus periods were 23 hours apart. Ellis (1970) has shown that an S-S+ sequence within the daily session is a necessary condition for the development of discrimination based on external stimulus control. In his study, a group receiving massed daily S+ trials, with massed S- trials on days prior to testing, did not show discrimination as measured by generalization tests and transfer to a random order of stimulus presentations.

Based on the above, it seems unlikely that stimulus control by the discriminanda ever developed in this experiment. However, when multiple reinforcers occur within a single stimulus period, " . . . the reinforcer may serve as a discrimative stimulus for continued responding within the remainder of that same period (Couch, Collins, and Donahoe, 1982, p. 345)." The reinforcer may develop this discriminative function when reinforcement occurs only during one discriminandum, and the stimulus sequence is nonrandom (Couch, Collins, and Donahoe, 1982). All of these conditions are met in the present experiment. Therefore, the change in pattern shown by the FI 5 rate during Treatment phases was probably a result of the discriminative function of the

reinforcer itself.

If the rats' "expectation of reward" was not controlled by the stimuli characterizing the Treatment phase, then the conditions of this experiment may be analogous to the Unexpected reward manipulations in the human studies. These studies have shown clearly that the overjustification effect occurs only under Expected reward conditions (Greene and Lepper, 1974; Lepper and Greene, 1975; Lepper, Greene, and Nisbett, 1973).

Future Research

The failure of the present experiment to demonstrate an overjustification effect does not, of course, rule out the possibility that such effects may occur in nonhuman organisms. The topic is certainly worthy of further investigation. Future experiments in this area must be designed so as to insure that the animals discriminate the conditions during which the contingency is in effect. This can best be accomplished by running all three phases within a single session, and using distinct cues which differentiate baseline and treatment phases. This procedure would have the additional advantage of preventing the animals' running rate from being influenced by increased deprivation over a long period of time.

To facilitate changing from one condition to another, the animals should be confined to the wheel throughout the session, and the alternative response opportunities eliminated. The design should also include unrewarded and/or yoked noncontingent-food controls, as in the present study. The length of the treatment phase could be varied to assess the possible role of fatigue in the production of the postreinforcement declines in responding found in Skinner and Morse (1958). In addition, attempts could be made to determine whether schedules other than fixed interval produce similar posttreatment effects. It is hoped that, by these means, more light may be cast upon the interesting and important phenomenon of overjustification.

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APPENDIX

TABLE 7

GROUP MEANS USED FOR ANALYSES OF VARIANCE

Measure	All Subjects	Experimental	Control	Wheel AA	Wheel BB
Total Wheel Responses					
Baseline 1	476.3	525.1	427.4	776.5	176.1
Treatment 1	735.2	790.6	679.8	920.7	549.6
Baseline 2	705.4	806.9	603.9	1043.3	367.5
Rate (R/min in Wheel)					
Baseline 1	14.22	16.41	12.02	23.22	5.21
Treatment 1	17.59	18.91	16.27	22.13	13.05
Baseline 2	20.61	24.17	17.06	29.09	12.14
Wheel Time (sec)					
Baseline 1	2025.9	1926.3	2125.6	2027.0	2024.8
Treatment 1	1976.2	1920.7	2031.8	2127.3	1825.2
Overflow Time (sec)					
Baseline 1	1461.8	1419.4	1504.1	1153.0	1770.5
Treatment 1	1411.8	1288.7	1535.0	1066.5	1757.2

TABLE 8

INDIVIDUAL MEANS USED FOR *t* TESTS

Subject	Total Wheel Responses	Rate (R/min in Wheel)	Wheel Time	Overflow Time	Lever Time	Chain Time	Drink Time
+ T1							
Baseline 1	1040.8	29.98	2084.8	972.4	2.24	1.28	41.30
Baseline 2	1262.8	33.95	2229.8	896.8	0.68	3.40	34.68
T2							
Baseline 1	126.0	4.15	1851.8	1825.8	35.82	1.86	0.50
Baseline 2	219.6	7.15	1847.4	1908.6	14.00	0.86	48.90
+ T3							
Baseline 1	582.6	22.00	1641.0	1474.2	2.56	0.60	20.22
Baseline 2	935.4	28.00	2005.6	1098.2	10.54	0.04	37.82
T9							
Baseline 1	101.2	2.75	2208.2	2025.2	7.34	0.48	2.44
Baseline 2	221.2	6.70	2006.2	2021.8	10.68	1.28	34.84

+ indicates Experimental (FI 5) animals.

TABLE 8 CONTINUED

Subject	Total Wheel Responses	Rate (R/min in Wheel)	Wheel Time	Overflow Time	Lever Time	Chain Time	Drink Time
T5							
Baseline 1	884.2	24.80	1293.8	844.4	6.58	2.58	23.30
Baseline 2	1169.8	32.23	2099.4	972.8	12.56	3.74	47.74
+ T6							
Baseline 1	142.0	5.07	1885.8	1722.6	21.58	2.10	5.80
Baseline 2	480.2	18.79	1381.6	1493.4	8.62	1.56	47.20
T7							
Baseline 1	598.2	16.39	2188.4	1321.0	5.66	0.90	98.60
Baseline 2	805.0	22.16	2174.2	1298.0	4.26	0.38	29.90
+ T8							
Baseline 1	335.0	8.58	2153.4	1508.4	6.22	2.98	2.62
Baseline 2	549.0	15.93	2065.6	1666.2	4.24	7.66	14.34

+ indicates Experimental (FI 5) animals.