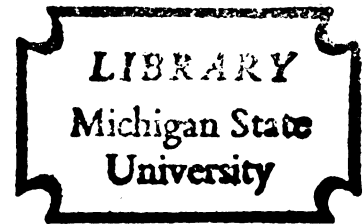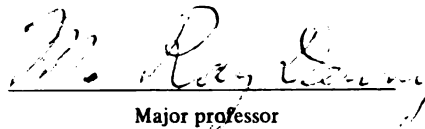This is to certify that the

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INHIBITION IN DIFFERENT SEGMENTS OF AN INSTRUMENTAL
RESPONSE CHAIN AS A FUNCTION OF ALLOWING
WITHDRAWAL FROM NONREINFORCEMENT

presented by

CARL MERLE JOHNSON

has been accepted towards fulfillment
of the requirements for

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INHIBITION IN DIFFERENT SEGMENTS OF AN INSTRUMENTAL

RESPONSE CHAIN AS A FUNCTION OF ALLOWING

WITHDRAWAL FROM NONREINFORCEMENT

By

Carl Merle Johnson

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Psychology

1979

ABSTRACT

INHIBITION IN DIFFERENT SEGMENTS OF AN INSTRUMENTAL
RESPONSE CHAIN AS A FUNCTION OF ALLOWING
WITHDRAWAL FROM NONREINFORCEMENT

By

Carl Merle Johnson

Three experiments were carried out to test the ef-
fects of competing responses, elicited by the removal of
reinforcement, on running· times of rats in a straight
alley. In Experiment I three groups of rats, one contin-
uous (100%) and two partial (50%) reinforcement groups,
were given four spaced trials daily for 72 trials. The
reinforced and nonreinforced trials for partial reinforce-
ment subjects varied according to a Gellerman series and
the reinforcement was four 97 mg pellets. Subjects in one
partial reinforcement group were permitted to withdraw
from the empty goal box on nonreinforced trials only
during acquisition. Each subject in this retrace group
was allowed 30 seconds to leave the white goal box and
was retrieved 10 seconds after withdrawing into the alley
or start box. The continuous and other partial reinforce-
ment group, employed as no-retrace controls, were captured
in the empty goal box on nonreinforced trials during
acquisition. Forty spaced trials of extinction over 10

days followed. The no-retrace condition was utilized during extinction trials for all three groups.

A runway with highly distinctive cues was employed in Experiment I. Subjects left a black start box and approached a gray alley and white goal box. The results indicated a typical partial reinforcement acquisition effect. Subjects in the no-retrace partial reinforcement group had greater start and alley speeds than the continuous reinforcement group. The results also showed that subjects allowed to withdraw during nonreinforced trials evidenced inferior running speeds on all trials during acquisition compared to both the no-retrace and the continuous reinforcement groups. Moreover, this inhibition in running speed appeared in each section of the runway: start, alley, and goal. During extinction the continuous group showed a decrease in start, alley, and goal speeds before the two partial reinforcement groups - the typical partial reinforcement extinction effect. However, the retrace group continued to exhibit lower speeds on all three measures compared to the no-retrace partial reinforcement group.

The same straight alley, without the distinctive cues, was used in Experiment II. Three similar groups of rats were subjected to an all-gray runway. Contrasted to the results of the first experiment, no differences were obtained between the three groups during acquisition. Although the continuous group demonstrated extinction effects first for alley and goal speed, there was no

difference between the retrace and no-retrace partial reinforcement groups during extinction.

The same straight alley used in the first experiment was used in Experiment III. Only the two partial reinforcement groups were employed during acquisition. Replication of the previous results was not fully obtained; the retrace group had a significantly slower start speed, a marginally slower alley speed, but the same goal speed. The two groups were subdivided for extinction. Some groups were allowed to retrace during extinction trials, others had the black start box and white goal box reversed during these trials, and some had both of these conditions. These manipulations were not strong enough to result in any overall differences between the six groups during extinction. The lack of consistent results during acquisition in Experiment III appeared to be due to the use of older rats not employed in the first two experiments.

An interference theory in which inhibition and extinction are largely due to competing responses elicited by the removal of reinforcement seems well supported by these results. When retracing is permitted to occur it effectively competes with approach responses to result in an overall decrease in performance. However, this only occurs when withdrawal is opposite of approach and in a well-differentiated straight alley.

ACKNOWLEDGEMENTS

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INTRODUCTION

Theories of the relationship of continuous and partial reinforcement to experimental extinction have been reviewed approximately every decade (Jenkins & Stanley, 1950; Lewis, 1960; Robbins, 1971). Generalization decrement, reactive inhibition (Hull, 1943), discrimination theory (Humphreys, 1939; Tyler, Wortz, & Bitterman, 1953), response decrement without active inhibitory processes (Skinner, 1938; Capaldi, 1967), cognitive dissonance theory (Lawrence & Festinger, 1962), sequential theory (Capaldi, 1966, 1967, 1970, 1971), and competing response theories (Amsel, 1958, 1962; Spence, 1960; Denny, 1971; Weinstock, 1954, 1958; Robbins, Chait, & Weinstock, 1968) have all been posited to explain the results during extinction, following either continuous or partial reinforcement.

The phenomenon of greatest interest has been the partial reinforcement effect (PRE). The PRE refers to better performance in acquisition as well as greater resistance to extinction following partial rather than continuous reinforcement. The acquisition effect is denoted as the partial reinforcement acquisition effect (PRAE) while the extinction effect is often termed the

1

partial reinforcement extinction effect (PREE). Although some of the PRE theories have more empirical support than others, it appears as though none can account for the entire range of results found in the literature (Robbins, 1971). Weinstock (1970) has suggested that perhaps the best approach would be to synthesize elements of many of these theoretical positions.

Two positions that seem to have generated most of the recent research directed at the PRE are the memory and competing response approaches. The memory position is dominated by the sequential theory of Capaldi (1966, 1967, 1970, 1971). Briefly, during partial reinforcement trials the memory of nonreward from the previous trial is present when running is reinforced; running in the presence of this memory cue is strengthened. Thus, subjects that had been under partial reinforcement continue to run faster during extinction than those that had been under continuous reinforcement. Subjects that had continuous reinforcement during acquisition have no memories of nonreward paired with reinforced running. These nonreward-reward sequences during acquisition appear to be the critical variable needed to produce the PREE (Spivey, 1967; McCain, 1965, 1966, 1969; Capaldi, 1966, 1967, 1970, 1971; Capaldi & Lynch, 1968; Capaldi & Minkoff, 1969; Leonard, 1969; Seybert, Mellgren, & Jobe, 1973).

The interference position on PRE is more diverse. Weinstock (1954, 1958) proposed that exploratory

tendencies which compete with running and other non-functional or incompatible behaviors habituate during the nonreinforced trials of acquisition. Therefore partially reinforced subjects perform faster than continuously reinforced subjects and are more resistant to extinction. Although there is some evidence supporting this habituation of competing responses hypothesis, there is considerable research that fails to support it (Harris, Smith, & Weinstock, 1962; Marx, 1963; McCoy & Marx, 1965; Robbins, Chait, & Weinstock, 1968; See Robbins (1971) for a review).

Another approach of the interference position is frustration theory (Amsel, 1958, 1962, 1967, 1972; Amsel & Ward, 1965; Amsel & Roussel, 1952; Spence, 1956, 1960). Nonreward which occurs in the presence of stimuli that previously accompanied reward results in an emotional or motivational response termed frustration. Frustration is a primary response assumed to be directly related in intensity to the magnitude of the anticipated reward (Wagner, 1969). This primary frustration results in withdrawal or avoidance tendencies to alley cues. Under 100% reinforcement during acquisition, frustration does not exist; during extinction the expected reward does not occur and primary frustration results. Avoidance occurs, and subjects quickly learn to slow down or stop running altogether.

Under partial reinforcement, frustration begins during acquisition. Initially frustration results in avoidance tendencies, which probably explains why partially rein- forced subjects run more slowly than continuously rein- forced subjects during early acquisition trials. Later the frustration is well associated with reinforcement on the rewarded trials and the energizing or motivational characteristics of it facilitate performance for partial reinforcement subjects. This energizing "frustration effect" has been well documented in the literature (Amsel & Roussel, 1952; Wagner, 1959; Patten, 1971, 1973; Hughes & Dachowski, 1973; See Scull (1973) for a review). During extinction, partial reinforcement subjects have learned to approach the goal box in the presence of anticipated frus- tration and therefore they continue to perform for many trials without reinforcement. However, frustration theory has problems explaining PREE with a small number of acquisition trials (Capaldi, Ziff, & Godbout, 1970; Robbins, 1971).

Elicitation theory (Denny & Adelman, 1955) explains the PRE and extinction in an interference framework also. Competing responses, elicited by the removal of reinforce- ment, interfere with approach and bring about extinction. Just as approach responses are associated with apparatus cues during acquisition, competing responses are classi- cally conditioned to alley cues during extinction. The

critical variable within the elicitation framework is the type of competing response that is conditioned during extinction (Denny, 1971).

Many of these theories can readily explain the same empirical findings. The present set of experiments is not designed to test one theoretical position against another, but to compare one type of competing response permitted during nonreinforcement to the standard procedure found in straight alley research. Specifically, the effect of withdrawal from the goal box on nonreinforced trials will be compared to the effect of capture in the goal box on these trials during both acquisition and extinction.

EXPERIMENT I

Adelman and Maatsch (1955) demonstrated that extinction of a runway response may be facilitated by allowing rats to retrace from the empty goal box. After continuous (100%) reinforcement during acquisition, subjects permitted to retrace to the alley or start box during extinction trials showed significantly longer runtimes than control subjects that were captured in the empty goal box. This occurred even though there were no differences between these groups during acquisition. Such results are consistent with an interference theory of extinction (Denny & Adelman, 1955; Denny, 1971) in which the omission of an established reinforcer elicits a response that is antagonistic to approach. When complete withdrawal is permitted, this response competes with approach. However, this should only occur when the withdrawal response is in a direction opposite to the approach response (Barrett & Carlson, 1966; Denny, 1971).

Marx (1967a) has found results that differed markedly from those of Adelman and Maatsch (1955). Subjects allowed to retrace during extinction in his experiments failed to evidence longer run times than no-retrace controls. His retracing subjects showed greater resistance to extinction

by demonstrating faster run times than subjects that could not retrace. Marx interpreted the difference between his results and those of Adelman and Maatsch (1955) as being a function of a secondary reinforcer. During acquisition a buzzer cue had been paired with reinforcement for his rats while Adelman and Maatsch did not employ such a cue. He concluded that this variable caused retrace subjects to run faster during extinction.

Marx (1967b) replicated his previous results when he compared both immediate and delayed reinforcement for groups of rats that were allowed to retrace or were confined in the goal box during extinction trials. Subjects that had been reinforced immediately and then allowed to retrace showed greater resistance to extinction than subjects that had been reinforced immediately and not allowed to retrace. Marx (1967b) interpreted these findings as serious contradictions to an interference theory of extinction (Adelman & Maatsch, 1955; Denny & Adelman, 1955). Yet retrace and no-retrace subjects under an imposed 20-second delay of reinforcement procedure during acquisition failed to show any difference in run times during extinction. From this he concluded that prolonged confinement in the goal box produced inhibition in run times during extinction, similar to the findings of Tombaugh (1966). In addition, Marx recorded start time for each of the four groups. These results also failed to

show any reliable differences between retrace and no-retrace groups.

In summarizing these results Denny (1971) noted that along with the buzzer cue, another procedural difference between Adelman and Maatsch (1955) and Marx (1967a, 1967b) was the use of color cues in the alley. Adelman and Maatsch used a gray start box, natural wood alley, and a black start box. Marx (1967a) used an all-gray alley or a gray start box and alley with black and white stripes in the goal box (Marx, 1967b). Denny (1971) concluded that this variable may have contributed to the observed dis-crepancies. When Adelman & Maatsch's (1955) subjects re-traced they ran from distinct alley cues whereas Marx's (1967a,b) rats were running in general. This interpreta-tion was supported by Marx's results since his subjects repeatedly ran in and out of the goal box during extinc-tion trials. Adelman and Maatsch's rats withdrew from the empty goal box and were not permitted to reenter once re-tracing was initiated. Empirical evidence supporting this conclusion is lacking, however.

The retrace variable may not only be implemented during extinction, but also during acquisition. Logan and Wagner (1965) suggested potential experiments in which partially reinforced rats would be permitted to retrace on nonrewarded trials during acquisition. They hypothesized that such training would result in greater resistance to

extinction in no-retrace controls, congruent with the con-
clusions of Adelman and Maatsch (1955).

Denny (Note 1) conducted such a study and obtained
rather unexpected results. Using a black start box, gray
alley, and a white goal box, he trained two partially
reinforced groups of rats (50%) and one continuously rein-
forced group (100%). One partially reinforced group (50%
Retrace) was allowed to withdraw from the goal box on
nonreinforced trials during acquisition only. The other
partial reinforcement group (50% No-Retrace) and the con-
tinuously reinforced group (100% No-Retrace) were captured
in the goal box on all trials. The Retrace and No-Retrace
subjects showed no significant differences in resistance
to extinction. These results supported neither Adelman
and Maatsch's (1955) results nor the results of Marx
(1967a,b). However, Denny did find significant differences
between the groups during acquisition. Rats allowed to
withdraw from nonreinforcement during acquisition (50%
Retrace) showed marked inhibition in run time on all
trials compared to both No-Retrace groups (50% & 100%),
which did not differ from one another. Although these
results supported an interference theory (Denny & Adelman,
1955; Adelman & Maatsch, 1955; Denny, 1971), no PRAE was
observed between the 50% No-Retrace group and the 100%
No-Retrace group. Nor was a PREE shown between the
100% No-Retrace group and either 50% group. Superior

resistance to extinction by partially reinforced rats has
been well documented in the literature (Weinstock, 1954;
Lewis, 1956, 1960; Wilson, Weiss, & Amsel, 1955; Robbins,
1971; Sutherland & Mackintosh, 1971). It is not clear why
Denny (Note 1) failed to find a PRAE or PREE; however,
the groups were beginning to diverge at the end of the
eight day extinction phase (PREE).

The results of Denny (Note 1) failed to resolve the
conflict in the literature between Adelman and Maatsch
(1955) and Marx (1967a,b) concerning the effects of re-
tracing during extinction. Moreover Denny (Note 1) raised
new questions about the retrace variable when it is per-
mitted on nonreinforced trials during acquisition. The
present experiment attempted to resolve these discrepancies
in the literature by exploring the effects of retracing on
nonreinforced trials during acquisition in the straight
alley.

An experimental group of rats was exposed to a 50%
reinforcement schedule. During acquisition subjects were
permitted to withdraw from the goal box to the alley or
start box on nonreinforced trials only. Two control groups
were employed. One group received 100% reinforcement
during acquisition. Another group received 50% reinforce-
ment, but was not permitted to retrace during the non-
reinforced trials.

In addition, the present investigation measured the
effects of retracing at different points of the approach

response chain. Adelman and Maatsch (1955) and Denny (Note 1) used a combination of start and alley minus goal time as a measure for run time for each trial while Marx (1967a,b) separated both start time and run time. The present study employed three measures for each trial: start speed, alley speed, and goal speed (Goodrich, 1959; Daly, 1969).

These same measures were taken during extinction also. To determine if a PREE might be obtained, extinction lasted 10 rather than eight days as Denny (Note 1) used. In order to develop a larger frustration from nonreward response, four 97 mg food pellets were used for reinforcement. Adelman and Maatsch (1955) used one 200 mg pellet, Marx (1967a, b) used one 45 mg pellet, and Denny (Note 1) used one 97 mg pellet. The size of the PRE is usually increased by larger rewards (Hulse, 1958; Wagner, 1961; Amsel, 1962; Likely, Little, & Mackintosh, 1971; Ratliff & Ratliff, 1971). Therefore, the larger reward should facilitate the resulting effects of the retrace variable.

<div align="center">Method</div>

Subjects

Eighteen 4- to 5-month-old female hooded rats (Long-Evans strain), bred in the colony maintained by the Psychology Department at Michigan State University, served as subjects. The rats were experimentally naive. Free feeding weights were determined for each subject and the rats were gradually reduced to 80% of their ad lib weights.

The subjects were randomly divided into three groups:
100% No-Retrace (C), 50% No-Retrace (P-NR), and 50% Retrace
(P-RT).

Apparatus

The apparatus consisted of a straight alley with a
30.5 cm start box, a 91.5 cm alley, and a 30.5 cm goal box.
The sections were 10 cm wide and 15 cm deep. The top was
covered with hardware cloth and the entire alley was
painted gray. A black start box was inserted into the
gray start box area of the alley so that the rats saw
black walls and a black floor. Similarly, a white goal box
contained a small, brown food cup. A gray guillotine door
separated the black start box from the gray alley and
another gray guillotine door separated the alley and the
white goal box.

Start, alley, and goal box time measures were provided
by three timing circuits activated by interruption of photo-
cell beams. The photocells were connected to Hunter
silent relays. Three Lafayette sweep hand timers measured
each of the three behaviors forming the approach response
chain. The start time clock commenced when the start box
door opened and activated a switch. This timer stopped when
a rat interrupted the first photocell beam. The photocell
and light source were located 5 cm beyond the start box
door. This same photocell also started the alley time
clock. This clock stopped when the second photocell beam
was interrupted. This second photocell and light source

were located 5 cm before the goal box door and it activated the goal box timer. This last clock stopped when a rat broke a third photocell beam located directly before the food cup in the white goal box. The entire apparatus was located equidistant from end walls in a 3 m X 3.25 m room with no windows and overhead fluorescent lighting.

Procedure

Pretraining. Subjects were randomly assigned to one of three groups: C, P-NR, or P-RT. The rats were handled and deprived of food. They were allowed to explore the apparatus in groups of three for a single session. Once a subject attained target weight, it was placed directly in the white goal box with the door closed and fed two 97 mg food pellets. After each experimental session, subjects were fed measured food portions in order to maintain their 80% free feeding weights.

Acquisition. Four trials were conducted each day for 18 days. Reinforced and nonreinforced trials each occurred twice a day for subjects in the partial reinforcement groups (P-NR & P-RT). These trials varied according to a Gellerman (1933) series (See page 127, Flaherty, Hamilton, Gandelman, & Spear (1977)). To control for possible pheromone effects, subjects from each of the three groups were run in scrambled orders. The intertrial interval (ITI), spent in barred holding cages, was approximately four minutes.

For reinforced trials four 97 mg Noyes food pellets were located in the food cup. Subjects were placed in the start box and once they were facing the guillotine door, it was opened activating the first timer. Each subject's start time was recorded up to a maximum of 60 seconds. During the first day only, if the rat did not leave the start box within 60 seconds, it was forced by hand into the alley. Alley time was also recorded up to a maximum of 60 seconds. Any alley time longer than the maximum was recorded as 60 seconds and the subject was removed from the alley. Similarly, goal box time was recorded up to a maximum of 60 seconds. On reinforced trials subjects were kept in the goal box with the door closed until the four food pellets had been consumed. Subsequently, the subjects were removed from the goal box and returned to a holding cage for the duration of the ITI. During non-reinforced trials subjects in the P-NR group were captured in the empty goal box for approximatley 10 seconds, which was the time it normally took to eat four pellets. Subjects in the P-RT group were permitted to withdraw from the empty goal box to the alley or start box. They were allowed 30 seconds to withdraw. If they did not retrace in this time period they were directly removed from the goal box. If they retraced, the goal box door was closed behind them and they were allowed 10 seconds to complete this withdrawal response. At the end of the 10 second

period they were removed from wherever they were in the apparatus.

Extinction. Ten days of extinction were conducted after acquisition had been completed. Four extinction trials per day were run with the same four minute ITI. The procedure for extinction was the same for all three groups. All subjects were captured in the empty goal box for approximately 10 seconds and removed to the holding cages. In the event that some subjects became sufficiently inhibited so that they failed to leave the start box within the 60 second time period, they were removed direclty and returned to the holding cages for the ITI. Sixty seconds was recorded for start, alley, and goal box times. Similarly, subjects failing to leave the alley or returning to the start box before entering the goal box within the 60 second maximum were removed directly and 60 seconds was recorded for both alley and goal box times.

Results

Each of the three running time measures were converted to speed scores. Start speed was computed from the recipricol of the start box time. Similarly, runway speed and goal speed were derived from running time and goal box time respectively. Start speed, alley speed, and goal speed were each subjected to two-way repeated measures analysis of variance. Blocks of four trials was the repeated factor and the group effect was the second (random) factor. Tests for simple main effects were computed

when significant group X trial block interactions were
found (Kirk, 1968; Winer, 1971).

Start speed is plotted in Figure 1 for the three
groups in blocks of four trials. Start speed indicated
reliable differences between the groups during acquisition

Insert Figure 1 about here

$(F(2,15)=22.48$, $p < .001)$. Reliable trial block (TB)
differences $(F(17,255)=38.41$, $p < .001)$ and a significant
group X trial block interaction $(F(34,255)=1.67$, $p < .015)$
were also obtained. Tests for simple main effects revealed
that all three groups demonstrated learning by increasing
mean speed across trial blocks (TB): C $(F(17,255)=13.02$,
$p < .001)$, P-NR $(F(17,255)=16.78$, $p < .001)$, P-RT $(F(17,255)$
$=12.23$, $p < .001)$. Tests for simple main effects demonstrated
no group differences within the first TB $(F(2,270) < 1)$, thus
the three groups appeared equal before training commenced.
However, subsequent tests for group differences within
trial blocks were all significant (TB 2 through TB 18) at
$p < .05$ or more except TB 3 $(F(2,270)=1.53$, $p > .05)$ and TB
14 $(F(2,270)=2.86$, $p > .05)$. Newman-Keuls multiple com-
parisons revealed that the mean speed for the P-RT group
was significantly less than the mean speed for both the
P-NR $(p < .01)$ and the C groups $(p < .01)$. The P-NR group
was also reliably faster than the C group $(p < .05)$.

Figure 1. Mean start speed (1/start time) for each group in blocks of 4 trials during both acquisition and extinction.

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FIGURE 1

Start Speed (1/sec.)

ACQUISITION   EXTINCTION

Blocks of 4 Trials

○ C
● P-NR
▲ P-RT
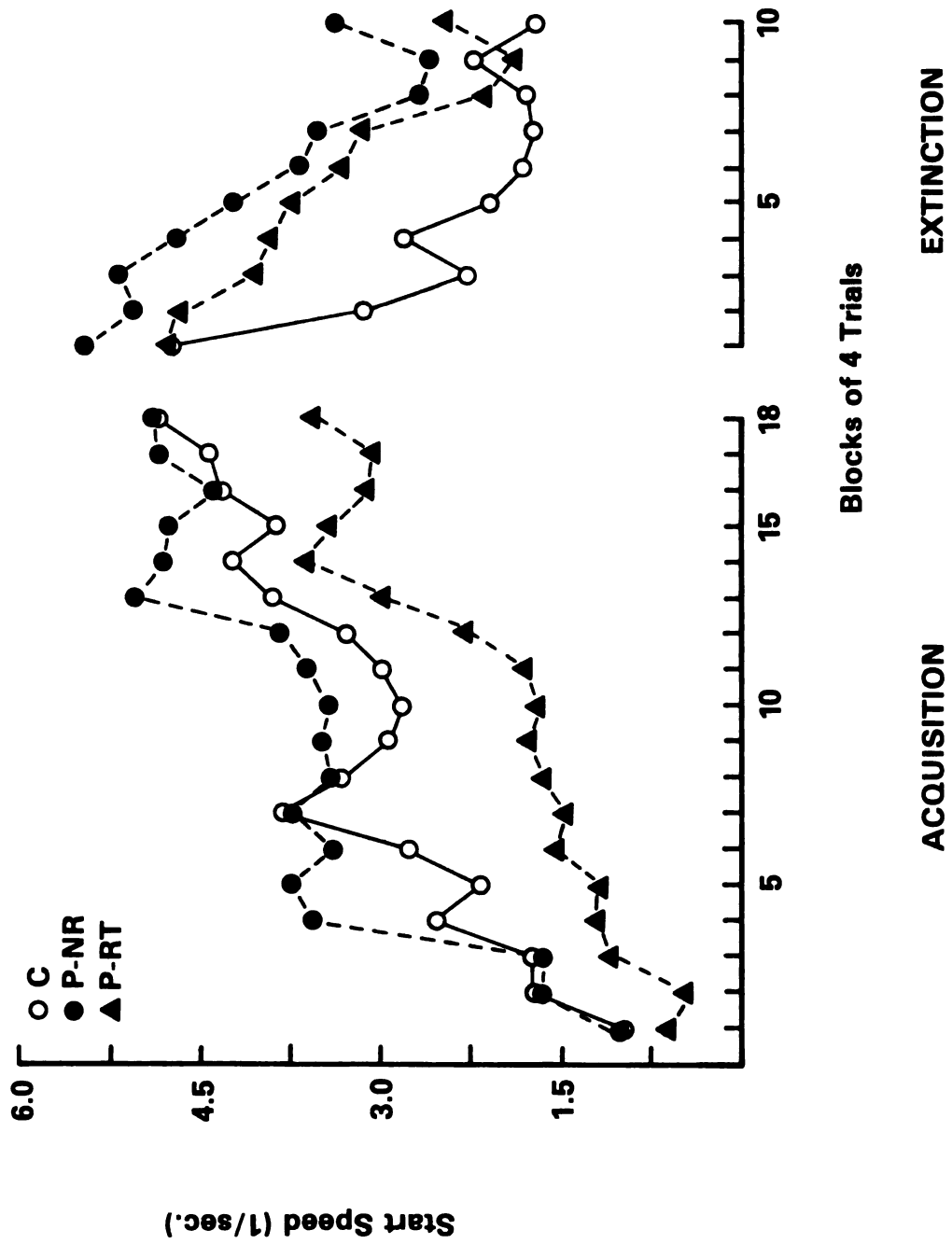
Extinction data for start speed are also presented in Figure 1. A significant group effect ($F(2,15)=11.93$, $\underline{p} < .001$) and trial block effect ($F(9,135)=12.06$, $\underline{p} < .001$) were obtained during extinction. The group X trial block interaction was not significant ($F(18,135) < 1$). Newman-Keuls comparisons showed that the C group demonstrated extinction effects first by being reliably less than the P-NR group ($\underline{p} < .01$) and the P-RT group ($\underline{p} < .01$). The two partial reinforcement groups also differed significantly with the P-NR group running faster than the P-RT group ($\underline{p} < .01$).

Correlated sample t-tests were used to compare TB 18 of acquisition to TB 1 of extinction for possible enhanced start speeds due to extinction-induced frustration. None of the groups evidenced this effect: Group C ($t(5) < 1$), Group P-NR ($t(5)=1.23$, $\underline{p} > .05$), and Group P-RT ($t(5)=1.53$, $\underline{p} > .05$).

Blocked in groups of four trials, alley speed is presented in Figure 2. Alley speed also showed differences

---

Insert Figure 2 about here

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between the three groups ($F(2,15)=9.41$, $\underline{p} < .002$), between the trial blocks ($F(17,255)=59.57$, $\underline{p} < .001$), and a significant group X TB interaction ($F(34,255)=2.76$, $\underline{p} < .001$). Tests for simple main effects revealed increases in mean alley speed across TB: C ($F(17,255)=22.96$, $\underline{p} < .001$), P-NR

Figure 2. Mean alley speed (1/alley time) for each group in blocks of 4 trials during both acquisiton and extinction.

FIGURE 2
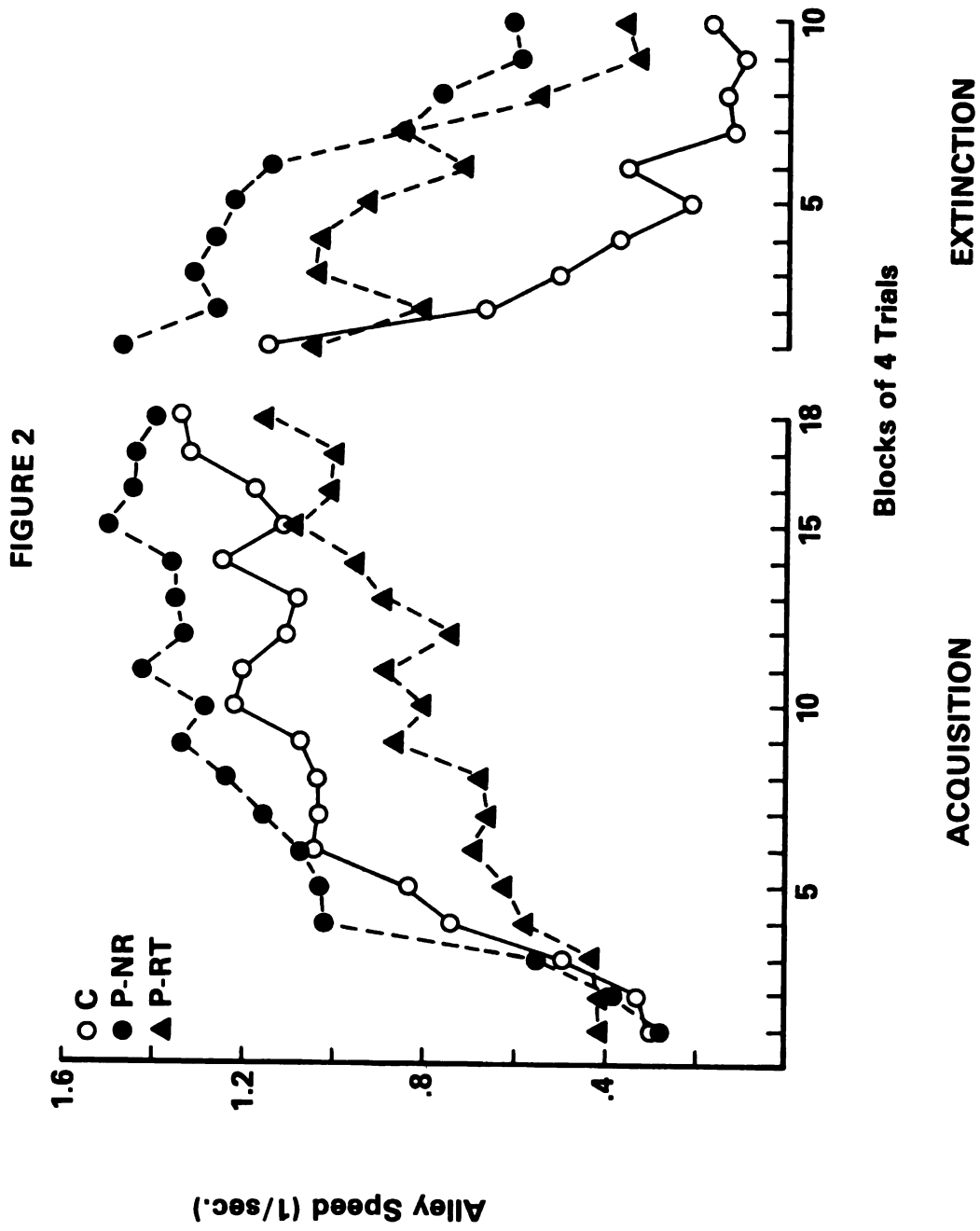
$(F(17,255)=30.74$, $\underline{p} < .001)$, and P-RT $(F(17,255)=12.22$,

$\underline{p} < .001)$. Tests for simple main effects demonstrated no

group differences for neither the first three TB

$(F(2,270) < 1)$ nor TB 18 $(F(2,270)=1.70$, $\underline{p} > .05)$. Sig-

nificant group differences existed for TB 4 through 17 at

$\underline{p} < .01$ or more. Newman-Keuls multiple comparisons showed

that the mean alley speed for the P-RT group was less than

the C group $(\underline{p} < .05)$ and the P-NR group $(\underline{p} < .01)$. The C

and P-NR groups did not differ from one another.

Alley speed during extinction also demonstrated

significant group differences $(F(2,15)=16.54$, $\underline{p} < .001)$, TB

differences $(F(9,135)=32.08$, $\underline{p} < .001)$, and a significant

group X TB interaction $(F(18,135)=3.23$, $\underline{p} < .001)$. Tests

for simple main effects revealed that all three groups

demonstrated extinction effects by decreasing mean alley

speed across TB: C $(F(9,135)=14.77$, $\underline{p} < .001)$, P-NR

$(F(9,135)=13.86$, $\underline{p} < .001)$, and P-RT $(F(9,135)=10.23$, $\underline{p} < .001)$.

These tests also revealed significant group differences

during TB 1, 9, and 10 at $\underline{p} < .05$, TB 2 at $\underline{p} < .005$, and TB

3 through 8 at $\underline{p} < .001$. Newman-Keuls multiple comparisons

showed that the mean alley speed for the C group was sig-

nificantly lower than the P-RT $(\underline{p} < .01)$ and the P-NR

$(\underline{p} < .01)$ groups. In turn, the P-RT group was significantly

lower than the P-NR group $(\underline{p} < .01)$.

Goal speed is presented in Figure 3. Goal speed also

indicated significant differences between the three groups

_____

Insert Figure 3 about here

_____

during acquisition ($F(2,15)=9.12$, $\underline{p} < .003$). Significant
TB differences ($F(17,255)=32.06$, $\underline{p} < .001$) and a group X
TB interaction ($F(34,255)=2.38$, $\underline{p} < .001$) were also
exhibited. Tests for simple main effects revealed in-
creases in mean goal speed across TB: C ($F(17,255)=17.875$,
$\underline{p} < .001$), P-NR ($F(17,255)=11.56$, $\underline{p} < .001$), and P-RT
($F(17,255)=6.81$, $\underline{p} < .001$). Tests for simple main effects
revealed no group differences for TB 1, 2, 3, 5, 17, and
18 ($\underline{p} > .05$). Thus no group differences existed in goal
speed for the beginning and end of acquisition. TB
differences were found for TB 4 and TB 6 through 16
($\underline{p} < .05$ or more). Subsequent Newman-Keuls multiple com-
parisons demonstrated significant differences between
the lower P-RT group and the P-NR group ($\underline{p} < .01$) as well
as the C group ($\underline{p} < .01$). The P-NR and C groups failed
to differ from one another during acquisition.

Goal speed during extinction is also presented in
Figure 3. Significant group differences ($F(2,15)=20.20$,
$\underline{p} < .001$), TB differences ($F(9,135)=23.40$, $\underline{p} < .001$), and
a group X TB interaction ($F(18,135)=3.14$, $\underline{p} < .001$) were
all obtained. Tests for simple effects revealed de-
creasing goal speeds across TB for the C, P-NR, and P-RT
groups ($F(9,135)=14.14$, 8.14, 7.52; all $\underline{p} < .001$). Tests

Figure 3. Mean goal speed (1/goal time) for each group
in blocks of 4 trials during both acquisition and
extinction.

FIGURE 3

Goal Speed (1/sec.)

ACQUISITION   EXTINCTION

Blocks of 4 Trials

○ C
● P-NR
▲ P-RT
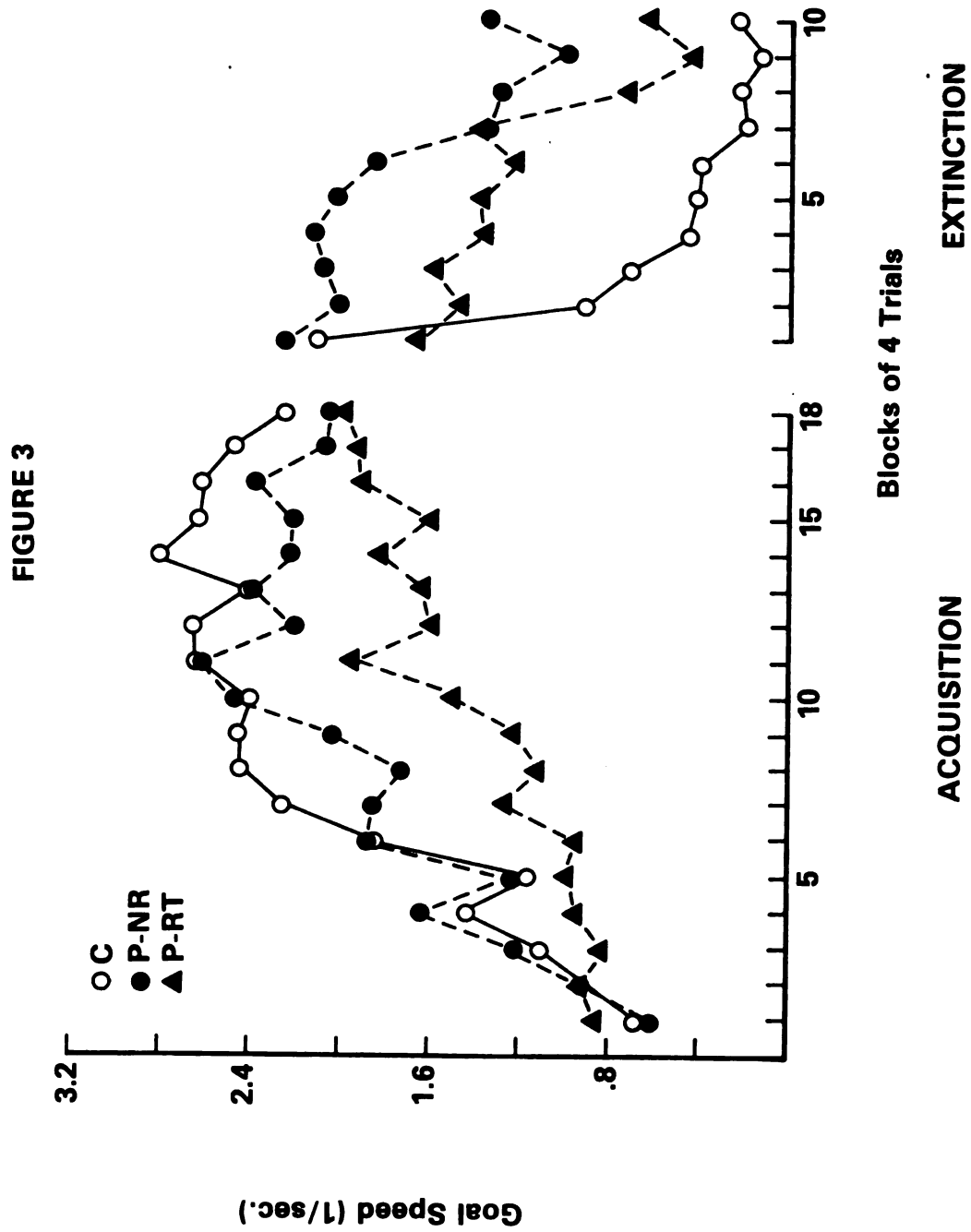
for simple effects showed no group differences during TB 1 (F(2,150)=2.46, $\underline{p}$ > .05). However, significant group differences were obtained for TB 2 through 10 ($\underline{p}$ < .01 or more). Newman-Keuls multiple comparisons demonstrated overall differences during extinction between the slower C group and the P-RT group ($\underline{p}$ < .01) as well as the P-NR group ($\underline{p}$ < .01). Moreover the P-RT group was slower than the P-NR group ($\underline{p}$ < .01).

Discussion

The three groups appeared equal during initial training. Trial block 1 of start speed, TB 1 through 3 of alley speed, and TB 1 through 3 of goal speed revealed no group differences.

Both partial reinforcement groups demonstrated greater resistance to extinction than the C group, thus the anticipated PREE was obtained for all three measures. Why a PREE was obtained in the present experiment and not for Denny (Note 1) is not clear. Perhaps it was due to a larger reward (four rather than one 97 mg pellet). Nevertheless, the obtained PREE appears consistent with the literature (See Lewis (1960) or Robbins (1971) for reviews).

During acquisition, however, the present results extend the results of Denny (Note 1). P-NR subjects ran significantly faster than P-RT subjects. Denny's retracing subjects evidenced this inhibition for a total run time measure. The present experiment showed

that this difference between partially reinforced Retrace and No-Retrace subjects occurs in each section of the runway: start box, alley, and goal box. Moreover these differences continued during extinction, P-NR subjects showed faster start, alley, and goal speeds than P-RT subjects.

At asymptotic levels during acquisition, generally, partial reinforcement subjects show faster start and alley speeds than continuous subjects (Haggard, 1959; Goodrich, 1959; Wagner, 1961; Robbins, 1971). The P-NR and C groups in the present experiment replicated this effect. However, the P-RT subjects were not only slower than subjects with equated reinforcement schedules (P-NR), but they were significantly slower than the C subjects for both start and alley speed as well.

Partial reinforcement subjects are generally slower than continuous subjects in the goal region - opposite of start and alley areas (Freides, 1957; Goodrich, 1959; Wagner, 1961; McCoy & Marx, 1965; Badia, 1965; But see Robbins, Chait, & Weinstock (1968) or Robbins (1971) for contrary results and possible confounding variable). The present study found no overall differences between C and P-NR groups in goal speed. However, the P-RT group was significantly slower than both the C and P-NR groups - demonstrating further the inhibitory effects of retracing on nonreinforced trials.

The results support the conclusions of Adelman and Maatsch (1955), Denny (Note 1), and the interference theory in general (Denny & Adelman, 1955; Denny, 1971). In addition, they concur with the findings of Johnson and Denny (1979) who found that rats allowed to retrace after errors showed an impairment in learning a black-white discrimination. That is, a decrement in learning and performance seems to result from allowing rats to retrace after nonreinforced trials. However, the results cannot resolve the discrepancies between Adelman and Maatsch (1955) and Marx (1967a,b). Retracing was permitted during extinction only in these studies while it was permitted on nonreinforced trials during acquisition only in the present experiment. Nevertheless, it is possible to determine what role alley cues may have when allowing rats to retrace.

EXPERIMENT II

Experiment I was conducted with highly distinctive cues in the alley. Experiment II was designed to determine whether the results obtained in Experiment I were a function of these alley cues. In this experiment the distinctive stimuli in the runway, a black start box and a white goal box, were eliminated. Extra-maze cues were minimized to prevent the rats from orienting by these stimuli. The same three groups, C, P-NR, and P-RT were subjected to an all-gray straight alley.

Method

Subjects

A group of eighteen 4- to 5-month-old male and female hooded rats (Long-Evans strain), bred at Michigan State University, served as subjects. The rats were experimentally naive. Free feeding weights were determined for each subject and the rats were gradually reduced to 80% of their ad lib weights. The subjects were randomly divided into three groups with three males and three females in each group.

Apparatus

The same straight alley used in Experiment I was employed in Experiment II. However, both the black start

box insert and white goal box insert were removed, leaving

the entire apparatus gray. In addition, extra-maze cues

were minimized by making the walls in the room at the

ends of the runway similar and also by centering the

apparatus in the room.

Procedure

The same procedure used in Experiment I was used in

Experiment II.

Results

Start speed is plotted in blocks of four trials in

Figure 4. During acquisition the three groups failed to

Insert Figure 4 about here

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show reliable differences in start speed ($F(2,15)=1.24$,

$p > .05$). A significant TB difference was obtained ($F(17,$

$255)=18.52$, $p < .001$), but the group X TB interaction was

not significant ($F(34,255) < 1$).

Extinction data for start speed, also presented in

Figure 4, revealed no group differences ($F(2,15) < 1$).

The groups did decrease significantly across TB ($F(9,135)$

$=15.39$, $p < .001$). The group X TB interaction was not

significant ($F(18,135) < 1$).

Blocked in sets of four trials, alley speed is pre-

sented in Figure 5. Alley speed showed no significant

differences between the three groups ($F(2,15) < 1$). The

Figure 4. Mean start speed (1/start time) for each group
in blocks of 4 trials during both acquisition and extinc-
tion.

FIGURE 4

Start Speed (1/sec.)

ACQUISITION   EXTINCTION

Blocks of 4 Trials

○ C
● P-NR
▲ P-RT
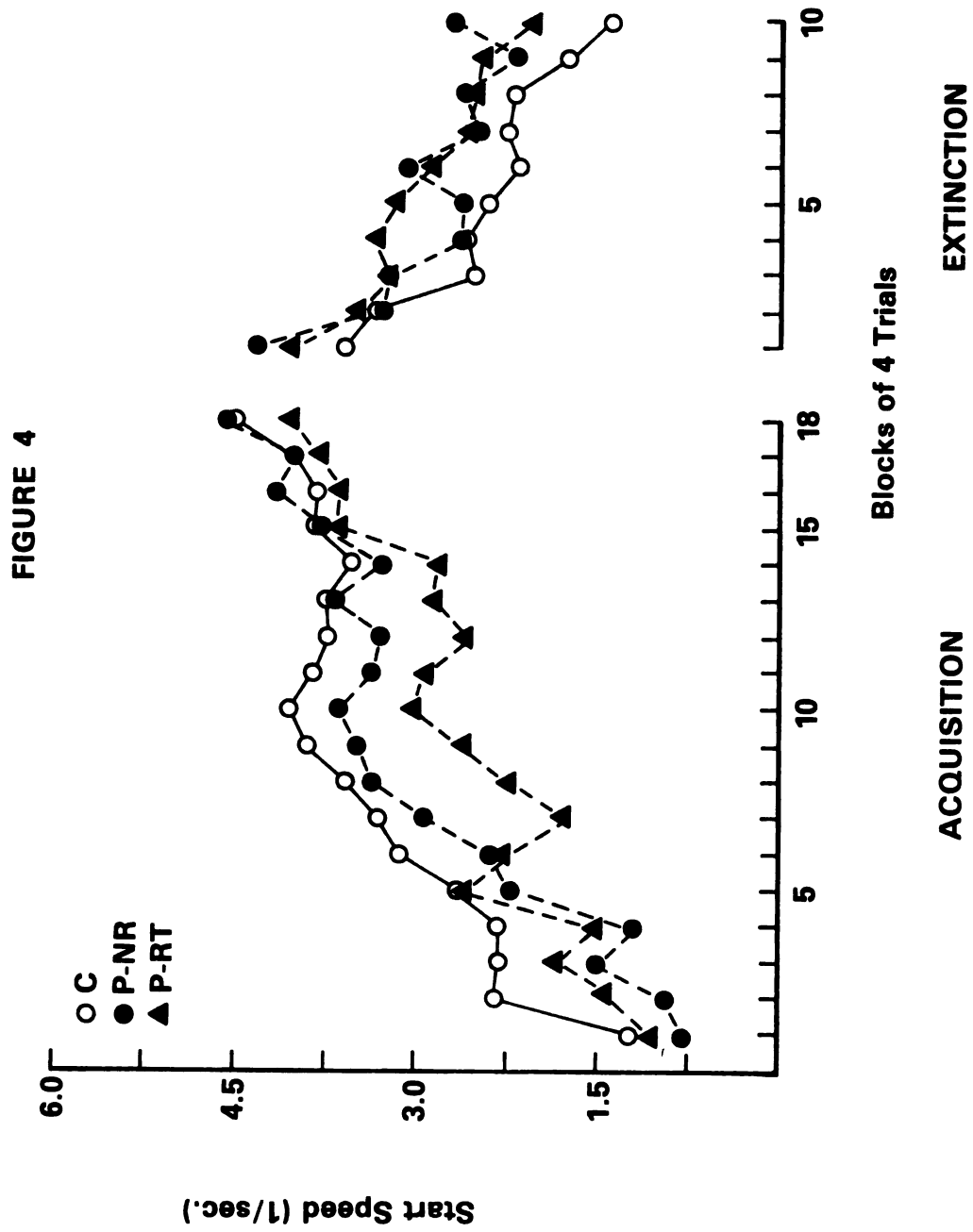
Insert Figure 5 about here

groups did evidence learning during acquisition by significantly increasing alley speed across TB $(F(17,255) =29.39$, $p < .001$). The group X TB interaction was not significant $(F(34,255)=1.05$, $p > .05$).

Alley speed during extinction is also presented in Figure 5. A significant difference was obtained between the groups $(F(2,15)=10.16$, $p < .002$). The groups also decreased significantly across the 10 TB $(F(9,135)=15.09$, $p < .001$). The group X TB interaction was not significant $(F(18,135)=1.00$, $p > .05$). Newman-Keuls multiple comparisons revealed that the C group was reliably slower than the P-RT group $(p < .01)$ and the P-NR group $(p < .01)$. The two partial reinforcement groups, P-RT and P-NR, failed to differ from one another.

Goal speed for the second experiment is graphed in Figure 6. A significant group effect was not discovered

Insert Figure 6 about here

during acquisition $(F(2,15)=2.63$, $p > .05$). The groups increased significantly across the 18 trial blocks $(F(17, 255)=39.53$, $p < .001)$ and they did not evidence a group X TB interaction $(F(34,255) < 1)$.

Figure 5. Mean alley speed (1/alley time) for each group
in blocks of 4 trials during both acquisition and extinc-
tion.

FIGURE 5
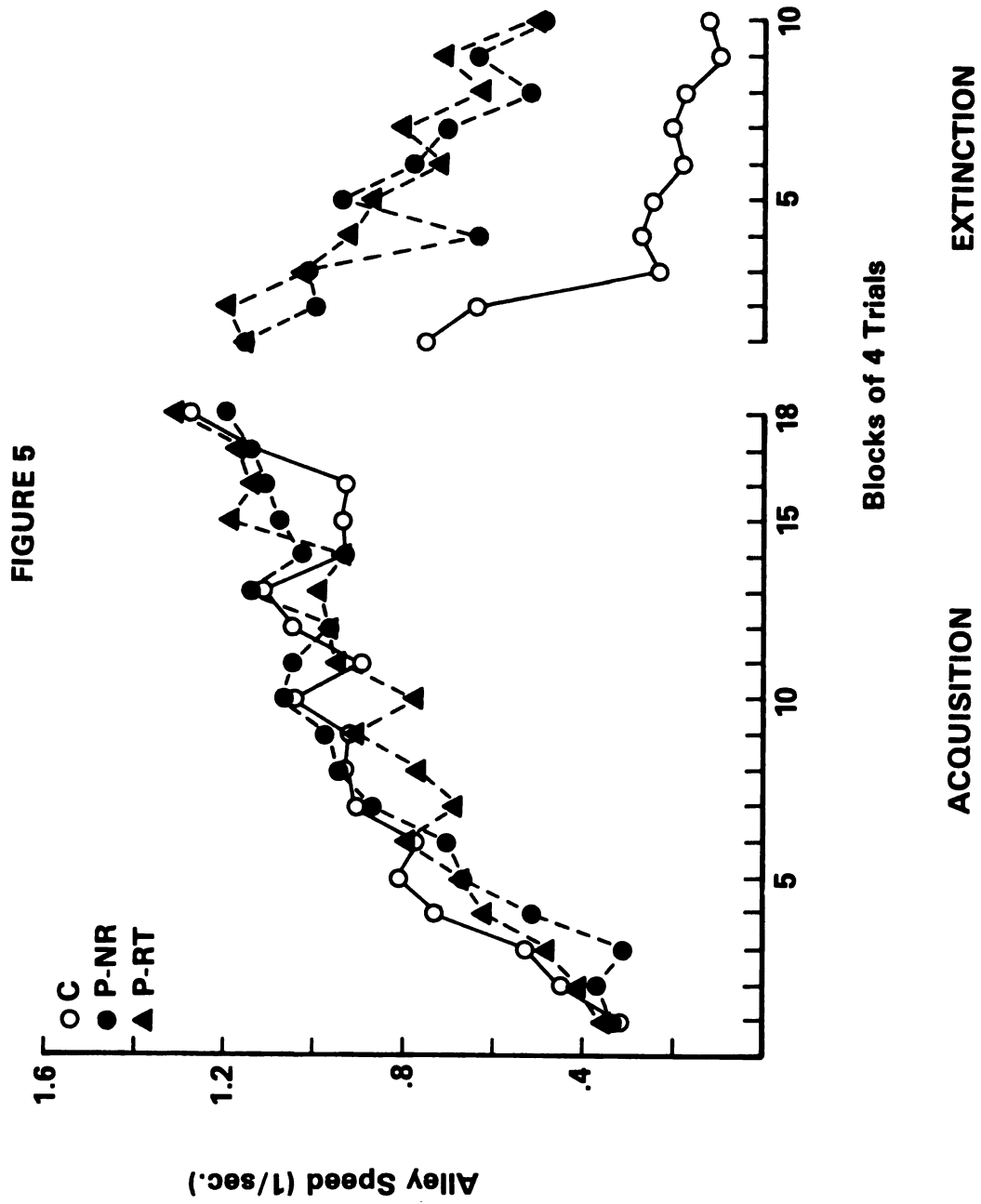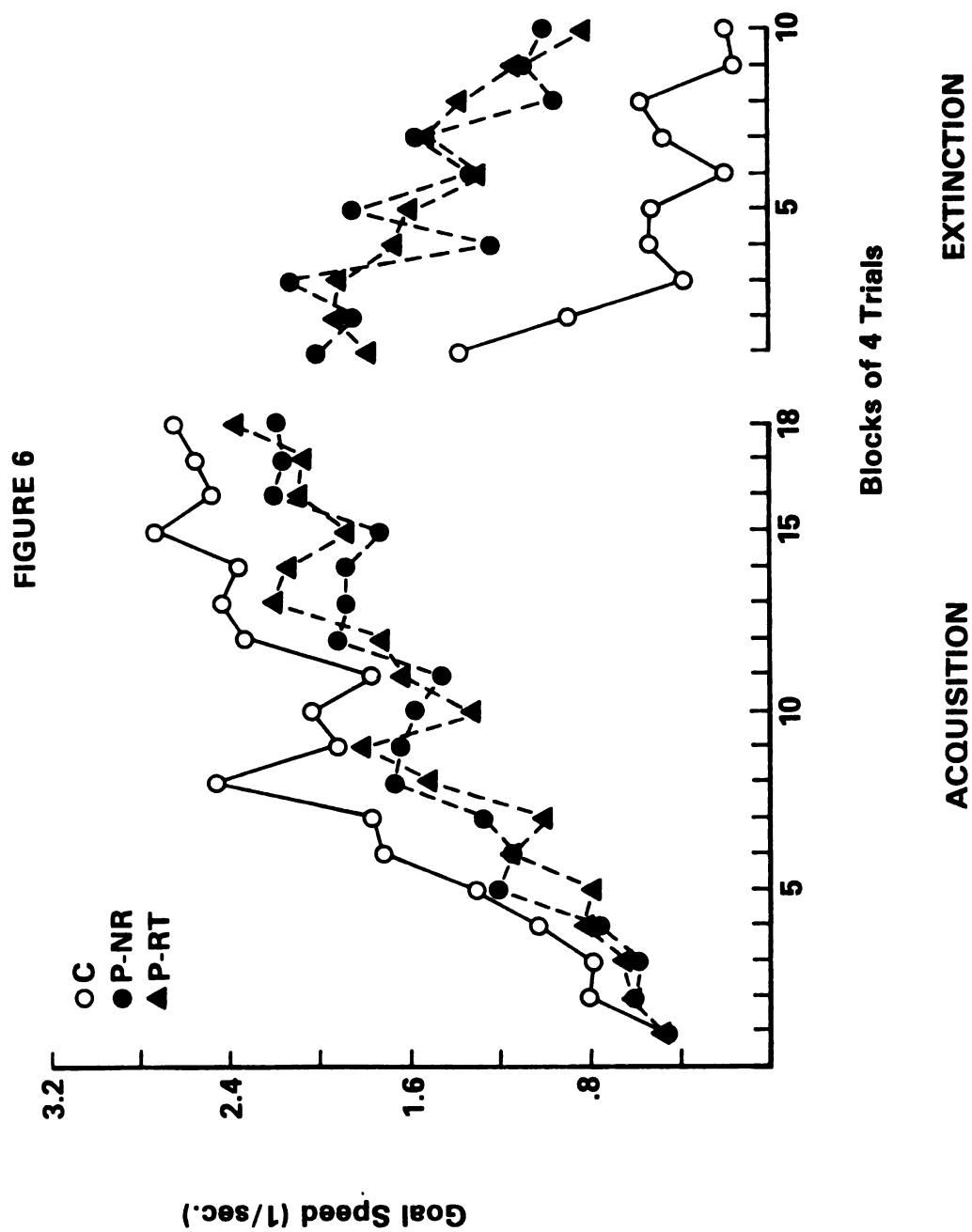
Figure 6. Mean goal speed (1/goal time) for each group in
blocks of 4 trials during both acquisition and extinction.

FIGURE 6

Goal Speed (1/sec.)

Blocks of 4 Trials

ACQUISITION

EXTINCTION

○ C
● P-NR
▲ P-RT

During extinction goal speed was found to contain a significant group effect ($F_{(2,15)}=13.79$, $p < .001$), as shown in Figure 6. The TB effect was also highly significant ($F_{(9,135)}=11.66$, $p < .001$). The group X TB interaction was not significant ($F_{(18,135)}=1.66$, $p > .05$). Subsequent Newman-Keuls multiple comparisons revealed, like alley speed during extinction, that the C subjects were reliably slower that both the P-RT subjects ($p < .01$) and the P-NR subjects ($p < .01$). Again, the P-RT and P-NR subjects failed to differ from one another during extinction.

Discussion

No PREE or PRAE was demonstrated for start speed when an all-gray alley was employed in the present experiment. Moreover the P-NR group failed to differ from the P-RT group during both acquisition and extinction, contrary to the findings in Experiment I when distinctive alley cues were employed. During acquisition the start speed of the C group was above the two partial groups until the 16th session. At this point the P-NR group surpassed the C group. This cross-over effect has been well documented in the literature (Goodrich, 1959; Haggard, 1959; Weinstock, 1958; Wagner, 1961; Robbins, 1971). When alley cues were employed in Experiment I, the cross-over effect occurred earlier (session 4) compared to the all-gray alley in Experiment II (session 16).

Alley speed failed to demonstrate a PRAE during the present experiment - contrary to the results of Experiment I. However, during extinction a PREE was evidenced - similar to the results of Experiment I. More importantly, the P-NR and P-RT groups failed to differ from one another either during acquisition or during extinction. Thus similar to the effects on start speed, removing the distinctive cues in the runway eliminated alley speed differences between the two partial reinforcement groups.

No PRAE was evidenced for goal speed. Also, the two partial groups failed to differ from one another during acquisition; demonstrating the powerful effects of alley cues again. This was evidenced further during extinction - P-RT and P-NR subjects did not vary from one another. A PREE was clearly shown for goal speed, however. The continuous subjects were significantly slower than both groups of partial reinforcement - similar to alley speed in the present experiment and to goal speed in the first experiment.

One comment concerns the sex of the subjects. Experiment I employed female hooded rats while Experiment II employed both male and female subjects. Denny (Note 1) found similar results to Experiment I using male hooded rats, thus the male and female subject mixture in Experiment II should not have been responsible for the obtained findings. Moreover Johnson and Denny (1979) found that

neither sex nor strain (hooded or albino) affected their results when retracing was permitted in a two-choice discrimination. Male-hooded, female-hooded, male-albino, and female-albino subjects all showed impairment in learning if they were allowed to retrace after errors compared to no-retrace controls.

The results of both Experiments I and II lend support to Denny's (1971) interpretation of the conflicting findings between Adelman and Maatsch (1955) and Marx (1967a,b). Distinctive alley cues appear to be partially responsible for these discrepancies in the literature. Removing alley cues eliminates differences between Retrace and No-Retrace groups under partial reinforcement. Moreover the differences were eliminated for both acquisition and extinction in all sections of the straight alley: start box, alley, and goal box. However, Marx's rats that were allowed to retrace were significantly faster than his No-Retrace controls. Perhaps the buzzer cue as a secondary reinforcer (Marx, 1967a, b) or being allowed to enter and leave the goal box more than once on each trial (Denny, 1971) were responsible for his different findings. Nevertheless, it is clear from the present study that distinctive alley cues were at least partially responsible for the conflicting findings.

EXPERIMENT III

Although Experiment I and II demonstrated the effects
of retracing with and without alley cues, withdrawal was
permitted on nonreinforced trials during acquisition only.
The third experiment investigated the effects of allowing
subjects to retrace during the extinction phase. This
manipulation was carried out to determine the effects of
withdrawal from nonreinforcement when it was continued
into the extinction phase (P-RT) or when it was initiated
during extinction (P-NR).

Experiment III also examined the effects of changing
the alley cues during extinction. The start box and goal
box colors were reversed when extinction was initiated.
Therefore some of the subjects were placed in a start box
that had cues previously associated with the goal box
(white walls and floor) and they approached a goal box
that had cues associated with the start box (black walls
and floor).

Method

Subjects

Forty-eight male hooded rats (Long-Evans strain) were
obtained from Blue Spruce Farms in Altamont, New York.
The subjects were approximately 5- to 9-months-old
($\overline{X}$=7.25) and were experimentally naive. Once reduced to

80% of their ad lib weights, they were randomly divided
into six groups of eight subjects each.

Apparatus

The same straight alley and timing circuits used in
Experiments I and II were employed in Experiment III.
The runway was similar to the arrangement used during
Experiment I, with both the black start box and the
white goal box inserts included. The apparatus was
placed in the center of a 2.6 X 3.5 meter room at
Central Michigan University. Overhead fluorescent light-
ing and other features of the room were similar ro the
room used at Michigan State University. The only differ-
ence was that the present room contained windows on one
wall, but these windows had closed draperies over them.

Procedure

The subjects were handled and allowed to explore the
runway in groups of four for a single session. The pro-
cedure during acquisition was similar to the procedure of
the first two experiments. Two groups of partially
reinforced rats, P-RT and P-NR, were trained for 18
sessions. Twenty-four subjects were included in each of
the two experimental groups rather than six in each of
three experimental groups as was the case in the first
two studies.

During extinction, the two experimental groups were
subdivided into six groups. Ten days of extinction were
carried out with four extinction trials per day as before.

For four of the six groups subjects were permitted to withdraw from the goal box on all extinction trials. This allowed the P-RT subjects to continue to withdraw throughout the extinction phase as they could on nonreinforced trials during acquisition. P-NR subjects were permitted to begin to retrace during this extinction phase.

The second manipulation carried out during extinction was a reversal of alley cues. Four of the six experimental groups had the black start box insert and white goal box insert switched when extinction was initiated. Therefore subjects in two of the four groups were permitted to withdraw from the new black goal box to the alley or new white start box during extinction trials. Subjects in the other two groups were captured in the new black goal box.

Recapitulating, two groups had two manipulations during extinction. One group had a no-retrace condition during acquisition and a retrace condition as well as switched start and goal boxes during extinction (P-NR-RT(S)). The other went from retrace during acquisition to no-retrace and switched start and goal boxes during extinction (P-RT-NR(S)). Two more groups had the start and goal boxes switched when extinction was initiated, but the retrace variable remained constant from acquisition: P-NR-NR(S) and P-RT-RT(S). The last two groups did not have the start and goal boxes changed when extinction commenced. The fifth group went from no-retrace during acquisition to retrace during extinction (P-NR-RT). The last group had no

changes from the conditions during acquisition to the con-
ditions during extinction (P-RT-RT).

Results

Start speed during acquisition for the two partially
reinforced groups, P-NR and P-RT, is plotted in Figure 7.

Insert Figure 7 about here

Blocked in groups of four trials, start speed indicated
reliable differences between the two groups $(F(1,46)=13.13,$
$p<.001)$. Significant TB differences $(F(17,782)=67.32,$
$p<.001)$ and a significant group X TB interaction $(F(17,$
$782)=1.68,$ $p<.04)$ were also obtained. Tests for simple
main effects revealed that both groups increased start
speed across TB: P-NR $(F(17,782)=19.75,$ $p<.001)$ and P-RT
$(F(17,782)=13.86,$ $p<.001)$. No group differences existed
for TB 1, 2 $(F(1,828)<1)$, 3, 4, and 18 $(F(1,828)=2.26,$
2.16, 1.94; all $p>.05)$, thus the groups were equal before
training began.   Significant group differences existed for
TB 5 through 17 $(p<.05$ or more).

Extinction data for start speed is also presented in
Figure 7. The six groups showed no significant differences
in start speed during extinction $(F(5,42)=1.95,$ $p>.05)$.
Significant TB differences $(F(9,378)=10.74,$ $p<.001)$ as
well as a significant group X TB interaction $(F(45,378)=$
1.68, $p<.005)$ were obtained. Tests for simple main ef-
fects revealed that five of the six groups decreased start

Figure 7. Mean start speed (1/start time) for each group
in blocks of 4 trials during both acquisition and extinc-
tion.

FIGURE 7
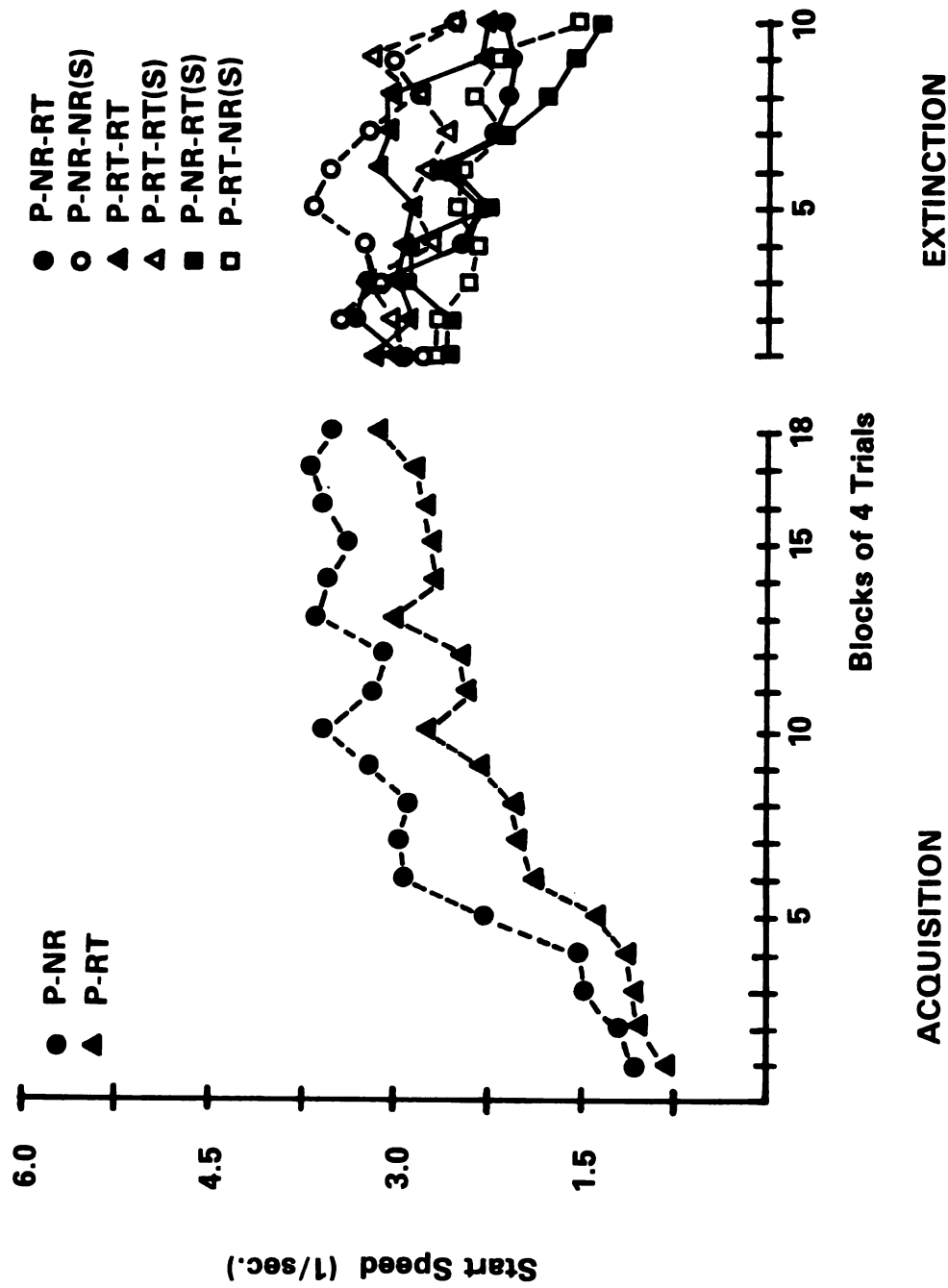
speed during extinction: P-NR-RT(S), P-NR-RT, P-NR-NR(S), P-RT-NR(S), and P-NR-RT(S) (F(9,378)=6.34, 4.67, 2.58, 2.30, 2.12; $p <$ .001, $p <$ .001, $p <$ .01, $p <$ .025, $p <$ .025, respectively). The last group, P-RT-RT(S), showed no signs of extinction across the ten trial blocks (F(9,378)=1.25, $p >$ .05). Tests for simple effects showed that no significant differences existed between groups during TB 1, 2, 3, 4, and 6 (all $p >$ .05). Group differences were found for TB 5, 7, 8, 9, and 10 ($p <$ .05 or more). Newman-Keuls multiple comparisons were computed on these significant TB. Comparisons of interest revealed that the P-NR-NR(S) group was significantly greater than the five other groups during TB 5 ($p <$ .05 or more). P-NR-NR(S) was also greater than P-NR-RT(S), P-RT,NR(S), and P-NR-RT during TB 7 ($p <$ .05). During TB 8 P-NR-NR(S) was greater than P-NR-RT(S) ($p <$ .05). P-NR-NR(S) was greater than both P-NR-RT ($p <$ .05) and P-NR-RT(S) ($p <$ .01) during TB 9 and this group was greater than both P-NR-RT(S) and P-RT-NR(S) (both $p <$ .05) during TB 10.

Mean alley speed for Experiment III is plotted in Figure 8. Differences between P-NR and P-RT, the two main

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Insert Figure 8 about here

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groups during acquisition, were found to approach significance (F(1,46)=3.05, $p <$ .087). The differences between TB during acquisition were significant (F(17,782)=121.34,

Figure 8. Mean alley speed (1/alley time) for each group
in blocks of 4 trials during both acquisition and extinc-
tion.

FIGURE 8

● P-NR-RT
○ P-NR-NR(S)
▲ P-RT-RT
△ P-RT-RT-(S)
■ P-NR-RT(S)
□ P-RT-NR-(S)

● P-NR
▲ P-RT

Alley Speed (1/sec.)

1.6
1.2
.8
.4

ACQUISITION

EXTINCTION

Blocks of 4 Trials

5   10   15   18

5   10

$p < .001$) as was the group X TB interaction ($F(17,782)=2.08$, $p < .006$). Tests for simple main effects showed both groups, P-NR and P-RT, increased mean alley speed during acquisition ($F(17,782)=68.10$, 53.81; both $p < .001$). Tests for simple effects also revealed no group differences for TB 1, 2, 3, 4, 5, 8, 10, 11, 12, 13, 14, 15, 16, and 18 (all $p > .05$). P-NR was reliably greater in mean alley speed on TB 6, 7, 9, and 17 ($F(1,828)=8.60$, 4.00, 6.70, 6.00; $p < .005$, $p < .05$, $p < .01$, $p < .025$, respectively).

Mean alley speed during extinction is also presented in Figure 8. No reliable differences were obtained between the six groups ($F(5,42)=1.91$, $p > .05$). The differences between TB were significant ($F(9,378)=33.14$, $p < .001$), and the group X TB interaction was not significant ($F(45,378) =1.09$, $p < .05$).

Goal speed, blocked in groups of 4 trials, is presented in Figure 9. During acquisition the two partially reinforced groups did not vary significantly from one another ($F(1,46) < 1$). The groups both increased across the TB ($F(17,782)=82.74$, $p < .001$). The group X TB interaction was not significant ($F(17,782)=1.14$, $p > .05$).

Insert Figure 9 about here

Goal speed during extinction is also plotted in Figure 9. The six groups did not differ significantly from each other ($F(5,42)=1.65$, $p > .05$). A significant

Figure 9. Mean goal speed (1/goal time) for each group in blocks of 4 trials during both acquisition and extinction.

FIGURE 9
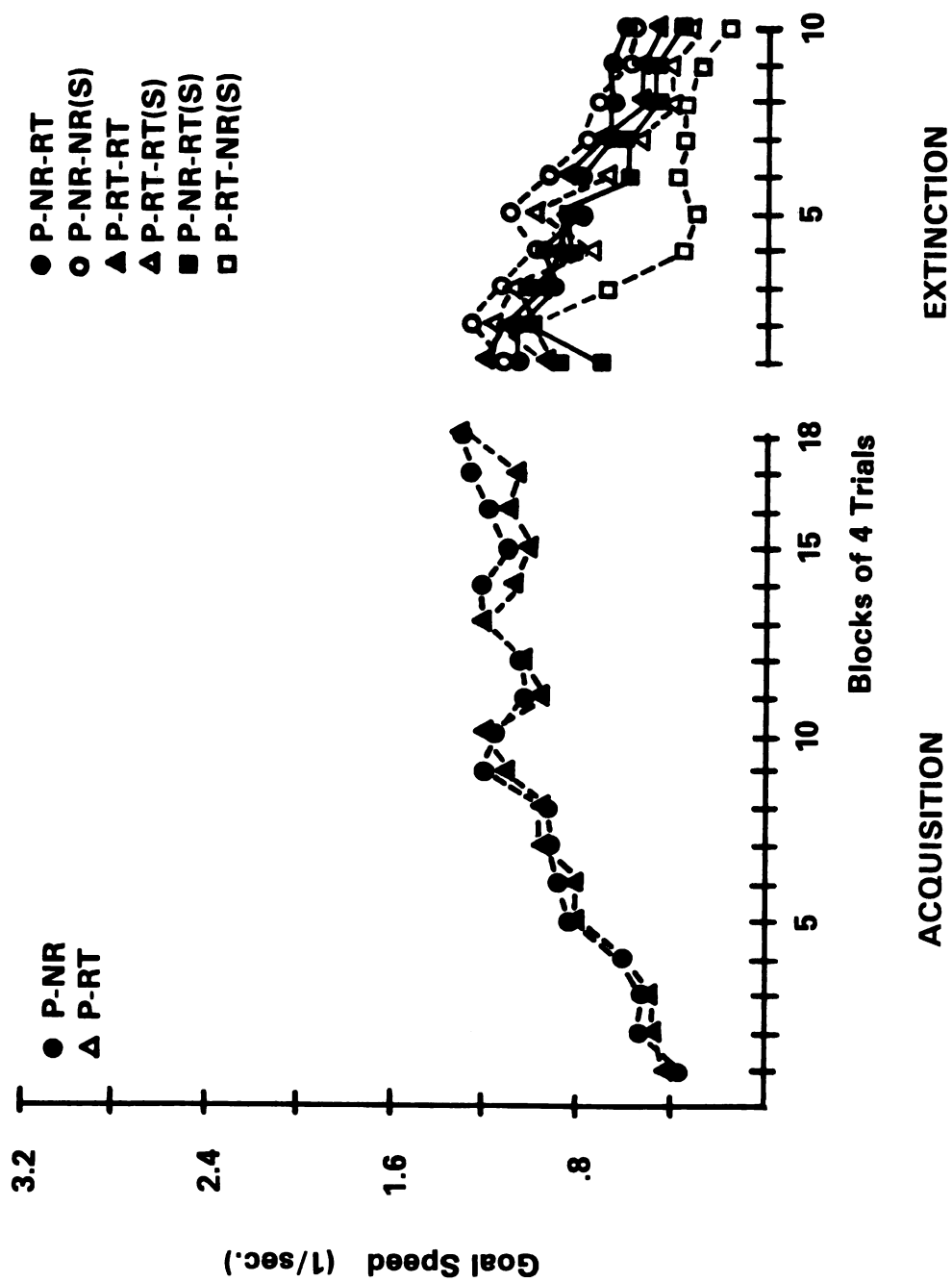
decrease across TB was evident $(F(9,378)=12.11$, $p < .001)$ and the group X TB interaction was not significant $(F(45, 378)=1.21$, $p > .05)$.

Discussion

The results of start speed during acquisition replicate the findings in Experiment I. The two groups, P-NR and P-RT appeared equal before training began since no differences were evidenced during the first four TB. Later, retracing subjects demonstrated slower start speed than no-retrace controls.

During extinction, when the two groups were subdivided into six groups, no overall differences were found between the groups. Five of the groups decreases start speed across trials, but the last group, P-RT-RT(S), failed to extinguish. Why this group failed to show extinction is not clear, especially since a similar group during extinction, P-NR-RT(S), decreased readily and had the lowest start speed by the end of extinction. For the five TB where group differences were noted, only group P-NR-NR(S) was consistently above other groups. Thus the group without any history of retracing showed more trial blocks of greater start speed than groups with retracing conditions during acquisition, extinction, or both.

Alley speed, unlike start speed, fell short of replicating the results in Experiment I. Overall, the two groups did not differ from one another during acquisition.

But on the four trial blocks which did exhibit significant differences, P-NR subjects were above the slower P-RT subjects as was the case graphically from TB 3 on. Another apparent difference between the alley speed of Experiment I and Experiment III was the asymptotic level during acquisition. P-NR subjects reached a mean alley speed of approximately 1.45 in Experiment I. However, P-NR subjects in Experiment III only reached a mean alley speed of .95. P-RT subjects also differed in alley speed attained by the end of acquisition, 1.10 in Experiment I to .85 in Experiment III. Moreover subjects in Experiment III were also lower than both P-NR and P-RT subjects in Experiment II, which reached alley speeds of approximately 1.20. Typically, rats running in a differentiated alley (alley and goal box different colors) show faster running speeds than those in a homogeneous alley (Saltz, Whitman, & Paul, 1963). Start and alley speed in Experiments I and II confirm this relationship. However, start and alley speed in Experiment III were considerably lower than the two previous experiments. It is likely that the use of older subjects in Experiment III resulted in overall depressed running speeds which may have attenuated the effect of the retrace variable.

The lower running rates became more apparent for goal speed. No differences were obtained between P-NR and P-RT subjects during acquisition in Experiment III,

contrary to the results of Experiment I. The terminal goal speed was approximately 1.20 for both groups in Experiment III. Contrasted to goal speeds in Experiment I (P-NR=2.30, P-RT=1.90) and Experiment II (both approximately 2.20), the older rats in the last study were considerably slower. Thus Experiment III subjects were slower in start, alley, and goal speed and this may explain why throughout acquisition the P-NR and P-RT subjects only differed significantly in start speed rather than all three measures as was anticipated. Alley speed showed significant differences on certain trial blocks and goal speed, the most depressed of the three measures, evidenced no differences during acquisition.

Alley and goal speed during extinction also resulted in no statistical differences between the six groups. Graphically, the group without a history of retracing, P-NR-NR(S), appeared above the other five groups in alley speed. While this supports the results of start speed during extinction, statistical analyses do not warrant a firm conclusion. Goal speed resulted in no graphic or statistical differences. Whether the use of older rats affected start, alley, and goal speed during extinction is speculative at best. No strong trends or differences were obtained in these measures during extinction that would allow conclusions to be drawn.

GENERAL DISCUSSION

Adelman and Maatsch (1955) demonstrated that extinc-
tion of an approach response may be facilitated by allow-
ing rats to withdraw from nonreinforcement. The with-
drawal response must be in a direction opposite to the
approach response and must be controlled by salient
stimuli in the runway (Denny, 1971). Otherwise, extinc-
tion may be prolonged as Barrett and Carlson (1966) demon-
strated when rats continued to run in the same direction
past the goal box or as Marx (1967a,b) demonstrated when
rats withdrew from nonreinforcement in an alley in which
there were no distinctive cues. The results of the
present study supported and extended the findings of
Adelman and Maatsch (1955). Rats allowed to withdraw on
nonreinforced trials during acquisition showed inhibition
in the approach response chain. The findings of Denny
(Note 1) were confirmed and extended since the retrace
group exhibited inhibition of approach in each link of
the chain: start, alley, and goal.

The present study also supported Denny's (1971) in-
terpretation for the differences between Adelman and
Maatsch (1955) and Marx (1967a,b) as being a function of
alley and room stimuli. When the alley and extra-maze

cues were distinctively different at the goal and start
ends of the alley, inhibition occurred in the retrace
groups with all three measures in Experiment I and with
start speed and alley speed (marginal) in Experiment III.
But when the alley was homogeneous and the same at either
end (Experiment III), no inhibition developed on any
measure in the retrace group. Although it is likely that
the failure to obtain inhibition in goal speed in Experi-
ment III was due to the use of aged rats, the effect in
the goal section may be less robust in general since the
P-NR and P-RT groups in Experiment I were converging at
the end of acquisition for goal speed but not for start
or alley speed.

Combining the start and alley speeds into a single
total run time measure for Experiment III yields a signifi-
cantly slower run time in the retrace group. This result
directly replicates Denny's findings (Note 1). Both the
male rats of Experiment III and the female subjects of
Experiment I were inhibited in the retrace condition. In
summary, allowing rats to retrace from nonreinforcement in
a well-differentiated straight alley clearly produced poor
performance.

Letting rats retrace only on nonreinforced trials would
probably not affect performance, although this research
has yet to be carried out. Frustration from nonreinforce-
ment (Amsel, 1958; 1962) would not be present and thus

there would be no withdrawal from frustration. Allison (1967) carried out an experiment in which he allowed continuously and partially reinforced rats to retrace on all trials. Partial reinforcement subjects retraced significantly faster on nonreward trials than on rewarded trials throughout training. Since retracing for partially reinforced subjects was permitted during both reinforced and nonreinforced trials, alley stimuli were not only associated with frustration but also with reinforcement. Moreover like Experiment II, an all-gray alley was employed. Therefore no differences were found between the groups during acquisition and the extinction data revealed a typical PREE. Withdrawal in the present set of experiments consistently followed nonreinforcement, and when this occurred in a well-differentiated runway, the retracing subjects exhibited impaired performance.

An interference theory of extinction (Denny & Adelman, 1955; Adelman & Maatsch, 1955; Denny, 1971) contends that extinction is largely due to competing responses elicited by the removal of reinforcement. When complete withdrawal is permitted to occur, this response effectively competes with approach, even when approach is intermittently reinforced. In the present study an originally conditioned approach response and a competing withdrawal response presumably summated to produce poor performance in the retracing rats.

A possible alternative interpretation of the present findings is based on an information-processing model of animal learning. Stimuli presented after the completion of a conditioning trial appear to influence the rate of learning. For instance, Kamin (1969), Wagner (1971), Rescorla and Wagner (1972), and Wagner and Rescorla (1972) have proposed that classical conditioning occurs only to the degree that the unconditioned stimulus, or its absence, is unexpected or surprising. The mechanism used to account for this, borrowed extensively from information-processing models used in human learning and memory (Atkinson & Shiffrin, 1968; Atkinson & Wickens, 1971; Estes, 1970), is rehearsal (Wagner, Rudy, & Whitlow, 1973). Thus a surprising unconditioned stimulus commands rehearsal which results in an association between the conditioned stimulus and unconditioned stimulus being transferred from short-term store to long-term store.

However a post-trail episode (PTE) may occur which can effectively compete for the animal's rehearsal activity and therefore impair learning about the original condition-ing trial or other contemporaneous training episodes (Wagner, Rudy, & Whitlow, 1973). PTEs have been used in a variety of classical conditioning studies recently, al-though most have been aversive control experiments (Kamin, 1969; Wagner, Rudy, & Whitlow, 1973; Gray & Appingnanesi, 1973; Wagner & Terry, 1975; Heth, 1976; Dickinson, Hall,

& Mackintosh, 1976; Mackintosh, Bygrave, & Picton, 1977; Donegan, Whitlow, & Wagner, 1977; Kremer, 1979; Dickinson & Mackintosh, 1979).

In an instrumental learning situation, PTEs can also impair performance. LeVere (1967) demonstrated that post-response stimulus information (PTE) could cause deficits in learning by monkeys - presumably by some influence on memory processes. LeVere and Bartus (1973) and Bartus and LeVere (1976) trained monkeys on a simultaneous visual discrimination problem in which relevant and irrelevant stimulus information was presented subsequent to a choice response. PTEs mainly influenced nonrein-forced rather than reinforced choices, and performance declined more when the PTEs were irrelevant than when they were relevant. The authors interpreted these find-ings as though if a choice is not reinforced, subjects continue to process available stimulus information. If the PTE is irrelevant, than performance suffers more than if it were relevant. Relevant or irrelevant PTEs pre-sented after reinforced correct choices has little or no effect since reinforcement serves as a signal that the information processed in that trial has been adequate and that no further stimulus processing is necessary (Bartus & LeVere, 1976). In addition, the more similar the irrelevant PTE was to the relevant negative stimulus, the more interference there was during learning (Bartus & Johnson, 1976).

Retracing can readily be considered a PTE since it follows a training trial. Johnson and Denny (1979) allowed rats to retrace after errors in a two-choice discrimination situation and compared them to no-retrace controls. Retracing after errors by the rats, a PTE following nonreinforcement, resulted in slower learning of the discrimination and the subsequent reversal. The retracing PTE was similar to the stimuli of the original choice, but not relevant to solving the discrimination. Therefore this PTE impaired learning whereas direct removal from the apparatus to an entirely different stimulus situation, the PTE for another group of rats, did not impair learning.

In the present study retracing might also be considered a PTE. In Experiments I and III, the PTE in the retrace groups contained irrelevant stimulus information that was sequentially opposite to the approach response chain, white to gray to black rather than the normal black to gray to white. This similar but irrelevant information may have impaired the performance of the retracing sub-jects in what was a "go, no-go" discrimination situation. Subjects in Experiment II, however, retraced in a homo-geneous alley. The PTE was a gray stimulus condition - identical to the relevant stimulus complex in the approach chain. Therefore, according to Bartus and LeVere (1976), this PTE would not impair learning.

Both the competing response theory (Denny, 1971) and the retracing variable as an example of a PTE (Johnson & Denny, 1979) can explain the present findings. Future research in this area should be directed at determining which interpretation is more valid. Two related experiments may reveal the better hypothesis. In a well-differentiated alley, one group of rats would be permitted to retrace as in the present study. A second group would be picked up after a nonreinforced trial and carried to the alley and then the start box. Both groups would be subjected to the reverse sequence of alley cues (PTE), but only the retrace group would be making a withdrawal response. If no differences would be found, the PTE interpretation would be supported. If the retrace group learned slower, the competing response position would be supported. This potential experiment suffers from a handling problem which, as a salient stimulus to the rat, may overshadow the reverse sequence of alley stimuli. Handling of subjects after trials has been shown to be an important variable with rats (Lieberman, McIntosh, & Thomas, 1979).

The second potential experiment does not contain handling of subjects which may be a confounding variable. Similarly, one group of rats would be allowed to retrace after nonreinforced trials in a well-differentiated alley. The second group would be allowed to withdraw

from nonreinforcement, but in a direction that is compatible to the approach response. The rats would traverse beyond the empty goal box into a second alley (Amsel & Roussel, 1952; Wagner, 1959; McHose, 1963) that would contain the same reverse sequence of stimuli that retracing subjects encountered. If no differences would be found, the PTE hypothesis would be supported. However, the competing response hypothesis would be supported if retracing subjects still evidenced inhibition. These and other systematic replications should be carried out in the future in order to more fully understand what the rat is learning when allowed to retrace after a conditioning trial.

LIST OF REFERENCES

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Reference Note

1. Denny, M. R. Allowing withdrawal from nonreinforce-
    ment: Inhibition of runway performance in partially
    reinforced rats. Paper presented at the meeting
    of the Midwestern Psychological Association,
    Chicago, May 1977.

References

Adelman, H. M. & Maatsch, J. L. Resistance to extinction as a function of the type of response elicited by frustration. Journal of Experimental Psychology, 1955, 50, 61-65.

Allison, J. Time spent in the goal box: Effects of frequency and schedule of reinforcement. Psychonomic Science, 1967, 7, 165-166.

Amsel, A. The role of frustrative nonreward in noncontinuous reward situations. Psychological Bulletin, 1958, 55, 102-119.

Amsel, A. Frustrative nonreward in partial reinforcement and discrimination learning. Psychological Review, 1962, 69, 306-328.

Amsel, A. Partial reinforcement effects on vigor and persistence. In K. W. Spence and J. T. Spence (Eds.), The psychology of learning and motivation. Vol. 1. New York: Academic Press, 1967.

Amsel, A. Inhibition and mediation in classical, Pavlovian and instrumental learning. In R. A. Boakes and M. S. Halliday (Eds.), Inhibition and learning. London: Academic Press, 1972.

Amsel, A. & Roussel, J. Motivational properties of frustration: I. Effect on a running response of the addition of frustration to the motivational complex. Journal of Experimental Psychology, 1952, 43, 363-368.

Amsel, A. & Ward, J. S. Frustration and persistence: Resistance to discrimination following prior experience with the discriminanda. Psychological Monographs, 1965, 79, No. 4, (Whole No. 597).

Badia, P. Effects of drive, reinforcement schedule, and change of schedule on performance. Journal of Experimental Psychology, 1965, 69, 292-297.

Barrett, G. V. & Carlson, N. J. Effect of escape versus non-escape responses from the goal box during extinction. Psychological Reports, 1966, 19, 447-454.

Bartus, R. T. & Johnson, H. R. Effects of postresponse visual stimuli on visual discrimination learning in the rhesus monkey. Learning and Motivation, 1976, 7, 431-445.

Bartus, R. T. & LeVere, T. E. Storage and utilization of information within a discrimination trial. In D. Medin, W. Roberts, & R. Davis (Eds.), Processes of animal memory. Hillsdale, NJ: Erlbaum.

Capaldi, E. J. Partial reinforcement: A hypothesis of sequential effects. Psychological Review, 1966, 73, 459-477.

Capaldi, E. J. A sequential hypothesis of instrumental learning. In K. W. Spence and J. T. Spence (Eds.), The psychology of learning and motivation, Vol. 1, New York: Academic Press, 1967.

Capaldi, E. J. An analysis of the role of reward and reward magnitude in instrumental learning. In J. H. Reynierse (Ed.), Current issues in animal learning. Lincoln: University of Nebraska Press, 1970.

Capaldi, E. J. Memory and learning: A sequential viewpoint. In W. K. Honig and P. H. R. James (Eds.), Animal memory. New York: Academic Press, 1971.

Capaldi, E. J. & Lynch, A. D. Magnitude of partial reward and resistance to extinction: Effect of N-R transitions. Journal of Comparative and Physiological Psychology, 1968, 65, 179-181.

Capaldi, E. J. & Minkoff, R. Influence of order of occurrence of nonreward and large and small reward on acquisition and extinction. Journal of Experimental Psychology, 1969, 81, 156-160.

Capaldi, E. J., Ziff, D. R., & Godbout, R. C. Extinction and the necessity or non-necessity of anticipating reward on nonrewarded trials. Psychonomic Science, 1970, 18, 61-63.

Dachowski, L. & Dunlap, W. P. Frustrative non-reward effects in acuqisition under zero hours deprivation. Psychonomic Science, 1969, 14, 113-114.

Daly, H. B. Is instrumental responding necessary for non-reward following reward to be frustrating? Journal of Experimental Psychology, 1969, 80, 186-187.

Denny, M. R. A theory of experimental extinction and its relationship to a general theory. In H. H. Kendler and J. T. Spence (Eds.), Essays in neobehaviorism: A memorial volume to Kenneth W. Spence. New York: Appleton-Century-Crofts, 1971.

Denny, M. R. & Adelman, H. M. Elicitation theory: I. An analysis of two typical learning situations. Psychological Review, 1955, 62, 290-296.

Dickson, A., Hall, G., & Mackintosh, N. J. Surprise and the attenuation of blocking. Journal of Experimental Psychology: Animal Behavior Processes, 1976, 2, 313-322.

Dickinson, A. & Mackintosh, N. J. Reinforcer specificity in the enhancement of conditioning by posttrial surprise. Journal of Experimental Psychology: Animal Behavior Processes, 1979, 162-177.

Donegan, N. H., Whitlow, J. W., Jr., & Wagner, A. R. Posttrial reinstatement of the CS in Pavlovian conditioning: Facilitation or impairment of acquisition as a function of individual differences in responsiveness to the CS. Journal of Experimental Psychology: Animal Behavior Processes, 1977, 3, 357-376.

Estes, W. K. Learning theory and mental development. New York: Academic Press, 1970.

Flaherty, C. F., Hamilton, L. W., Gandelman, R. J., & Spear, N. E. Learning and memory. Chicago: Rand McNally, 1977.

Freides, P. Goal-box cues and pattern of reinforcement. Journal of Experimental Psychology, 1957, 53, 361-371.

Gellerman, L. W. Chance orders of alternating stimuli in visual discrimination experiments. Journal of Genetic Psychology, 1933, 42, 207-208.

Goodrich, K. P. Performance in different segments of an instrumental response chain as a function of reinforcement schedule. Journal of Experimental Psychology, 1959, 57, 57-63.

Gray, T. & Appignanesi, A. A. Compound conditioning: Elimination of the blocking effect. Learning and Motivation, 1973, 4, 374-380.

Haggard, D. F. Acquisition of a simple running response as a function of partial and continuous schedules of reinforcement. The Psychological Record, 1959, 9, 11-18.

Harris, S. J., Smith, M. G., & Weinstock, S. Effects of nonreinforcement on subsequent reinforced running behavior. Journal of Experimental Psychology, 1962, 64, 388-392.

Heth, C. D. Simultaneous and backward fear conditioning as a function of number of CS-UCS pairings. Journal of Experimental Psychology: Animal Behavior Processes, 1976, 2, 117-129.

Hughes, L. F., & Dachowski, L. The role of reinforcement and nonreinforcement in an operant frustration effect. Animal Learning and Behavior, 1973, 1, 68-72.

Hull, C. L. Principles of behavior. New York: Appleton-Century-Crofts, 1943.

Hulse, S. H., Jr. Amount and percentage of reinforcement and duration of goal box confinement in conditioning and extinction. Journal of Experimental Psychology, 1958, 56, 48-57.

Humphreys, L. G. Generalization as a function of method of reinforcement. Journal of Experimental Psychology, 1939, 25, 361-372.

Jenkins, W. O., & Stanley, J. C. Partial reinforcement: A review and critique. Psychological Bulletin, 1950, 47, 193-234.

Johnson, C. M., & Denny, M. R. Effect of withdrawal from the negative cue on learning a two-choice discrimination. The Psychological Record, 1979, 29, 85-91.

Kamin, L. J. Predictability, surprise, attention, and conditioning. In B. A. Campbell and R. M. Church (Eds.), Punishment and aversive behavior. New York: Appleton-Century-Crofts, 1969.

Kirk, R. E. Experimental design: Procedures for the behavioral sciences. Belmont, CA: Brooks/Cole, 1968.

Kremer, E. F. Effect of posttrial episodes on conditioning in compound conditioned stimuli. Journal of Experimental Psychology: Animal Behavior Processes, 1979, 5, 130-141.

Lawrence, D. H., & Festinger, L. Deterrents and reinforcement. Stanford: Stanford University Press, 1962.

Leonard, D. W. Amount and sequence of reward in partial and continuous reinforcement. Journal of Comparative and Physiological Psychology, 1969, 67, 204-211.

LeVere, T. E. The effects of pre- and post-response stimulus sampling on discrimination performance. In D. Stark, R. Schneider, & H. J. Kuhn (Eds.), Progress in primatology. Stuttgart, Germany: Gustav Fisher Verlag, 1967.

LeVere, T. E., & Bartus, R. T. Stimulus information and primate discrimination learning: The influence of postresponse stimulus information. Learning and Motivation, 1973, 4, 305-313.

Lewis, D. J. Acquisition, extinction, and spontaneous recovery as a function of percentage of reinforcement and intertrial intervals. Journal of Experimental Psychology, 1956, 51, 45-53.

Lewis, D. J. Partial reinforcement: A selective review of the literature since 1950. Psychological Bulletin, 1960, 57, 1-28.

Lieberman, D. A., McIntosh, D. C., & Thomas, G. V. Learning when reward is delayed: A marking hypothesis. Journal of Experimental Psychology: Animal Behavior Processes, 1979, 5, 224-242.

Likely, D., Little, L., & Mackintosh, N. J. Extinction as a function of magnitude and percentage of food or sucrose reward. Candaian Journal of Psychology, 1971, 25, 130-137.

Logan, F. A., & Wagner, A. R. Reward and punishment. Boston: Allyn & Bacon, 1965.

McCain, G. Partial reinforcement with a small number of acquisition trials: Modified extinction procedures. Psychonomic Science, 1965, 2, 133-134.

McCain, G. Partial reinforcement effects following a small number of acquisition trials. Psychological Monographs Supplements, 1966, 1 (Whole No. 12), 251-270.

McCain, G. The partial reinforcement effect after minimal acquisition: Single pellet reward, spaced trials. Psychonomic Science, 1969, 15, 146.

McCoy, D. F., & Marx, M. H. Competing responses and the partial reinforcement effect. Journal of Experimental Psychology, 1965, 70, 352-356.

McHose, J. H. Effect of continued nonreinforcement on the frustration effect. Journal of Experimental Psychology, 1963, 65, 444-450.

Mackintosh, N. J. The psychology of animal learning. New York: Academic Press, 1974.

Mackintosh, N. J., Bygrave, D. J., & Picton, B. M. B. Locus of the effect of a surprising reinforcer in the attenuation of blocking. Quarterly Journal of Experimental Psychology, 1977, 29, 327-336.

Marx, M. H. The need for more specific formulations of the competing response interpretation of extinction. Psychological Reports, 1963, 12, 729-730.

Marx, M. H. Resistance to extinction as a function of delay of reinforcement and the opportunity to retrace in the runway. Psychonomic Science, 1967, 8, 287-288. (a)

Marx, M. H. Increased resistance to extinction as a function of the opportunity to retrace in the runway. Psychonomic Science, 1967, 9, 397-398. (b)

Patten, R. L. Frustrative facilitation effects of non-zero reward magnitude reduction on goal box activity and runway locomotion. Journal of Experimental Psychology, 1971, 90, 160-162.

Patten, R. L. Facilitation effect of incomplete reward reduction in discrimination: Comparison of within-subject and between subject methods. Journal of Experimental Psychology, 1973, 100, 185-194.

Ratliff, R. G., & Ratliff, A. R. Runway acquisition and extinction as a joint function of magnitude of reward and percentage of rewarded acquisition trials. Learning and Motivation, 1971, 2, 289-295.

Rescorla, R. A. and Wagner, A. R. A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black and W. F. Prokasy (Eds.), Classical conditioning II: Current research and theory. New York: Appleton-Century-Crofts, 1972.

Robbins, D. Partial reinforcement: A selective review of the alleyway literature since 1960. Psychological Bulletin, 1971, 76, 415-431.

Robbins, D., Chait, H., & Weinstock, S. Effects of non-reinforcement on running behavior during acquisition, extinction, and reacquisition. *Journal of Comparative and Physiological Psychology*, 1968, *66*, 699-706.

Saltz, E., Whitman, R. N., & Paul, C. Performance in the runway as a function of stimulus-differentiation. *American Journal of Psychology*, 1963, *76*, 124-127.

Scull, J. W. The Amsel frustration effect. *Psychological Review*, 1973, *79*, 352-361.

Seybert, J. A., Mellgren, R. L., & Jobe, J. B. Sequential effects on resistance to extinction at widely spaced trials. *Journal of Experimental Psychology*, 1973, *101*, 151-154.

Skinner, B. F. *The behavior of organisms*. New York: Appleton-Century-Crofts, 1938.

Spence, K. W. *Behavior theory and conditioning*. New Haven: Yale University Press, 1956.

Spence, K. W. *Behavior theory and learning*. Englewood Cliffs, NJ: Prentice-Hall, 1960.

Spivey, J. E. Resistance to extinction as a function of number of N-R transitions and percentage of reinforcement. *Journal of Experimental Psychology*, 1967, *75*, 43-48.

Sutherland, N. S., & Mackintosh, N. J. *Mechanisms of animal discrimination learning*. New York: Academic Press, 1971.

Tombaugh, T. N. Resistance to extinction as a function of the interaction between training and extinction delays. *Psychological Reports*, 1966, *19*, 791-798.

Tyler, D. W., Wortz, E. C., & Bitterman, M. E. The effect of random and alternating partial reinforcement on resistance to extinction in the rat. *American Journal of Psychology*, 1953, *66*, 57-65.

Wagner, A. R. The role of reinforcement and nonreinforcement in an "apparent frustration effect". *Journal of Experimental Psychology*, 1959, *57*, 130-136.

Wagner, A. R. Effects of amount and percentage of reinforcement and number of acquisition trials on conditioning and extinction. *Journal of Experimental Psychology*, 1961, *62*, 234-242.

Wagner, A. R. Frustrative nonreward: A variety of punishment? In B. A. Campbell and R. M. Church (Eds.), Punishment and aversive behavior. New York: Appleton-Century-Crofts, 1969.

Wagner, A. R. Elementary associations. In H. H. Kendler and J. T. Spence (Eds.), Essays in neobehaviorism: A memorial volume to Kenneth W. Spence. New York: Appleton-Century-Crofts, 1971.

Wagner, A. R. Expectancies and the priming of STM. In S. H. Hulse, Jr., H. Fowler, & W. Honig (Eds.), Cognitive processes in animal behavior. Hillsdale, NJ: Erlbaum, 1978.

Wagner, A. R., & Rescorla, R. A. Inhibition in Pavlovian conditioning: Application of a theory. In R. A. Boakes and M. S. Halliday (Eds.), Inhibition and Learning. London: Academic Press, 1972.

Wagner, A. R., Rudy, J. W., & Whitlow, J. W. Rehearsal in animal conditioning. Journal of Experimental Psychology, 1973, 97, 407-426. (Monograph)

Wagner, A. R., & Terry, W. S. Backward conditioning to a CS following an expected vs. a surprising UCS. Animal Learning and Behavior, 1975, 3, 370-374.

Weinstock, S. Resistance to extinction of a running response following partial reinforcement under widely spaced trials. Journal of Comparative and Physiological Psychology, 1954, 47, 318-322.

Weinstock, S. Acquisition and extinction of a partially reinforced running response at a 24-hour intertrial interval. Journal of Experimental Psychology, 1958, 56, 151-158.

Weinstock, S. A contiguity analysis of learning in the runway. In M. H. Marx (Ed.), Learning: Theories. New York: MacMillan, 1970.

Wilson, W., Weiss, E. J., & Amsel, A. Two tests of the Sheffield hypothesis concerning resistance to extinction, partial reinforcement, and distribution of practice. Journal of Experimental Psychology, 1955, 50, 51-60.

Winer, B. J. Statistical principles in experimental design. (2nd edition). New York: McGraw-Hill, 1971.