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EFFECTS OF SEQUENTIAL VARIABLES

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

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By

JEFFREY A. SEYBERT

Norman, Oklahoma

1974

SPACED TRIAL INSTRUMENTAL ESCAPE CONDITIONING:

EFFECTS OF SEQUENTIAL VARIABLES

A DISSERTATION

APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

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Spaced Trial Instrumental Escape Conditioning:

Effects of Sequential Variables

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Abstract

The present experiment was designed to investigate the effects of level of training and schedule of reinforcement in instrumental escape conditioning using wide spacing of trials (intertrial interval = 24 hrs). Two levels of acquisition training (12 and 60 trials) were factorially combined with three schedules of reinforcement (continuous reinforcement - CRF; 50% partial reinforcement with alternated reinforced and nonreinforced trials - SA; and 50% partial reinforcement with 3 consecutive nonreinforced trials followed by a reinforced trial - 3N). During the late stages of acquisition Group SA-60 trials ran faster on reinforced trials than on nonreinforced trials (i.e., patterned running was observed), however Group SA-12 trials did not exhibit this behavior. The major result in extinction was the occurrence of a Level of Training X Schedule of Reinforcement interaction, i.e., following limited acquisition, SA was more resistant to extinction than 3N, while, following extended acquisition, 3N was more resistant to extinction than SA. The results were

interpreted as further support for the hypothesis that Capaldi's (1967) sequential theory can account for escape conditioning and spaced trials data.

Spaced Trial Instrumental Escape Conditioning:

Effects of Sequential Variables

Jeffrey A. Seybert

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Although there have been a large number of studies reported which have utilized massed trial escape conditioning procedures, there are surprisingly few published reports of escape conditioning experiments using wide spacing of trials. Franchina (1969) found, using an intermittent shock-escape procedure in a hurdle box apparatus, that a 100% shock group evidenced higher asymptotic performance than a 50% shock group at short, but not long intertrial intervals (ITIs). The intermittent shock procedure, however, has a number of shortcomings, one of which is the absence of primary motivation on nonshock trials. This basic dissimilarity between the intermittent shock procedure and appetitive procedures involving the manipulation of reinforced (R) and nonreinforced (N) trials leads to difficulties when theoretical comparisons of the results of the two procedures are attempted (cf. Seybert, Mellgren, Jobe, & Eckert, 1974; Woods, Markman, Lynch, & Stokely, 1972). Thus one purpose of the present experiment was to examine different schedules of reinforcement in an escape paradigm with wide spacing of trials using procedures for N and R trials analogous to those employed in appetitive instrumental conditioning.

A second purpose of the present study was to examine the efficacy of Capaldi's (1967) sequential hypothesis in explaining spaced trial escape data. Although sequential theory has been quite successful in accounting for data from appetitive instrumental conditioning situations (e.g., Robbins, 1971), only recently has it been applied to aversive conditioning situations. A number of studies have demonstrated the importance of sequential variables in punishment procedures (e.g., Capaldi & Levy, 1972; Dyck, Mellgren, & Nation, 1974; Wroten, Campbell, & Cleveland, 1974), but only one published report (Seybert, et al., 1974) has indicated that sequential variables operate in instrumental escape conditioning. Also, some authors (e.g., Amsel, 1967; Gonzalez & Bitterman, 1969; Surridge & Amsel, 1966) have stated that sequential theory may not be appropriate for data collected at widely spaced trials, while others (e.g., Mellgren & Seybert, 1973; Seybert, Mellgren, & Jobe, 1973) have presented data which indicates that sequential theory can explain spaced, as well as massed trial results.

The present experiment represents an attempt to provide further evidence that sequential theory can account for data collected using instrumental escape conditioning procedures with wide spacing of trials. Two reliable results from appetitive and escape massed trial sequential procedures are the occurrence of patterned responding and of a Level of Training X Schedule of Reinforcement interaction. Patterned responding or patterning refers to a situation where Ss learn to discriminate N from R trials and respond accordingly, i.e.,

they learn to run fast on R trials and slow on N trials. Patterning has been observed both in appetitive (Capaldi, 1967) and escape (Seybert, et al., 1974) paradigms when N and R trials are alternated, i.e., in a single alternation (SA) procedure, and when a relatively large number of training trials are used. The Level of Training X Schedules of Reinforcement interaction refers to a situation where, after a limited amount of acquisition training, Ss receiving short N-lengths (number of consecutive N trials followed by an R trial) are more resistant to extinction than Ss receiving long N-lengths, and after extended training Ss receiving long N-lengths are more resistant to extinction than Ss who experience short N-lengths; this interaction has also been demonstrated in appetitive (Capaldi, 1967) and escape (Seybert, et al., 1974) massed trial situations.

The experiment to be reported employed a factorial design to investigate these sequential phenomena in a spaced trial instrumental escape conditioning paradigm. Two levels of training: 12 and 60 acquisition trials, were factorially combined with three schedules of reinforcement: continuous reinforcement (CRF); 50% partial reinforcement (PRF) on a single alternation basis (SA); and 50% PRF with N-lengths of 3 (3N). If sequential variables function in spaced trial escape conditioning the same as they do in massed trial situations, it would be expected that Ss in the SA-60 trial condition would pattern while those in the SA-12 trial condition would not, and that Group SA-12 should show greater resistance to extinction than Group 3N-12 while

Group 3N-60 should be more resistant than Group SA-60.

Method

Subjects.--The Ss were 60 male albino rats of the Sprague-Dawley strain purchased from the Holtzman Company. They were approximately 125 days old at the start of training and were randomly assigned to one of six groups ($N = 10/\text{group}$).

Apparatus.--The apparatus consisted of a straight alley runway manufactured by the Hunter Company. It was constructed of clear Plexiglas with a grid floor and was 150 cm long X 15 cm high X 9 cm wide. The alley was divided into a 30 cm start section, a 90 cm run section, and a 30 cm goal section. All sections were separated by guillotine doors and a cardboard insert painted with black and white vertical stripes 1.9 cm wide was attached to the outside of each section. The Ss progress in the alley was measured by three .01 sec Standard timers; the first timer, which recorded start time, was started by a microswitch at the start box door and stopped by a photocell located 11 cm into the alley; the second timer, which recorded run time, was started by the first photocell and stopped by a second photocell located 11 cm in front of the goal box; the third timer, which recorded goal time, was started by the second photocell and stopped by a third photocell located 9 cm inside the goal box. Start, run, and goal speeds were obtained by converting the start, run, and goal times to reciprocals. Shock was

automatically delivered to the start and run sections of the alley by a model 700 Grayson-Stadler shock generator which was activated by the microswitch at the start box door. Shock was delivered to the goal box by a second shock generator of the same type which was also activated by the microswitch at the start box door. Duration of shock and confinement time in the goal box was regulated by an automatic timer mounted in the apparatus control panel.

Procedure.--Throughout the experiment the Ss were individually housed and maintained on an ad lib schedule of food and water. Prior to the start of experimental training each S received two reinforced pretraining trials in the apparatus. Throughout the experiment the following procedure was employed on reinforced trials: The S was placed in the start box and after a period of 5 sec the start box door was raised activating the first timer and the shock generator which was set to deliver a .5 ma shock to the start and run sections of the runway. When S had traversed the runway and entered the goal box, to which a .1 ma shock was delivered by the second shocker, the goal box door was closed and S was confined for 30 sec, after which it was removed to the carrying cage. The procedure on nonreinforced trials was the same as that on reinforced trials except that the goal box was charged with a .5 ma shock. Thus reinforcement consisted of a .4 ma reduction in shock while nonreinforcement consisted of no reduction in the start-run shock level. Although the present nonreinforcement procedure is in reality a delay of reinforcement

technique, both nonreinforcement and delay of reinforcement have been postulated to involve similar theoretical mechanisms (Capaldi, 1967). Further justification for the present procedure may be found elsewhere (Bower, 1960; Seybert, et al., 1974; Woods, et al., 1972).

For the experiment proper two levels of acquisition training (12 and 60 trials) were factorially combined with three schedules of reinforcement (continuous reinforcement - CRF, single alternation - SA, and N-lengths of three - 3N). The SA and 3N groups received 50% PRF on the following schedules: SA - NRNRNRNRNRNR, 3N - RRNNRRRRNNNR. The 12 trial groups received the preceding schedules once and the 60 trial groups received these schedules 5 times. All groups received one acquisition trial per day (ITI - 24 hr). On days 1 and 2 of the experiment, the 60 trial groups received their pretraining trials and on days 3-62 their acquisition training trials. The 12 trial groups were transported to and from the experimental room and handled on days 1-48, received their two pretraining trials on days 49 and 50, and their acquisition training trials on days 51-62. Thus Ss in all groups were equated for age, amount of handling, and amount of experience outside the home cage. The Ss were run in squads of 12, two from each group in each squad. Following acquisition training all Ss received 24 extinction trials, one per day for 24 days (extinction ITI = 24 hr). The procedure for extinction trials was the same as for nonreinforced trials during acquisition.

Results

Acquisition.--The acquisition data was analyzed so that three factors could be examined: (1) patterning, (2) the course of acquisition for the 60 trial groups, and (3) overall terminal acquisition performance. The only evidence for patterning behavior appeared in the SA-60 trial group. The Ss in this group responded nondifferentially on N and R trials for approximately 45 trials at which time they began to anticipate N and R and respond appropriately (see Figure 1).

Insert Figure 1 about here

Correlated t tests on the last five N and last 5 R trials for the SA-60 trials group for start, run, goal, and total speed measures indicated that patterning occurred in start, goal, and total ts, (9) = 8.28, 5.10, 5.85 respectively, all ps < .001, but not in run, t(9) = 1.45, p > .10. The occurrence of patterning in the present experiment is in agreement with a previous study (Capaldi & Lynch, 1966) using a spaced trial appetitive procedure.

The course of acquisition in all alley sections (shown in Figure 2) was examined by analyzing 3 six trial blocks (trials 1-6, 31-36, and 55-60) for the 60 trial groups. A 3(Groups) X 3(Blocks)

Insert Figure 2 about here

analysis of variance revealed significant main effects for Blocks in the run and goal sections, Fs (2,54) = 29.94 and 41.65, ps < .001

respectively, indicating that running speed increased in the goal section across blocks and, as can be seen in Figure 2, that running speed decreased across blocks in the run section. Whether the decrease in speed during acquisition in the run section is due to habituation or some other variable is not clear to the present author. The Groups main effect and Groups X Blocks interaction failed to reach acceptable levels of significance in both the run and goal measures. The analysis on start speeds revealed significant main effects for Blocks, $F(2,54) = 30.20$, $p < .001$, and Groups, $F(2,27) = 8.69$, $p < .01$, and a significant Groups X Blocks interaction, $F(4,54) = 4.97$, $p < .01$. Post hoc analysis of the cell means of the Groups X Blocks interaction indicated that no differences were present between the groups at the beginning of acquisition (block 1) but on blocks 2 and 3 the groups were ordered: $3N > SA > CRF$ (all comparisons reported for the present experiment utilized the Tukey correction procedure for post hoc comparisons at the .05 level of significance). The analysis of total speeds revealed essentially the same information as that for start speeds. The main effects for Groups, $F(2,27) = 6.07$, $p < .01$ and Blocks, $F(2,54) = 28.62$, $p < .001$, were significant as was the Groups X Blocks interaction, $F(4,54) = 3.67$, $p = .01$. The post hoc comparisons again indicated no differences between the groups on block 1 and the following rank ordering of the groups on block 2: $3N = SA > CRF$, and on block 3: $3N > SA > CRF$. Thus the overall acquisition data (for the 60 trial groups) clearly indicate (in the start and total measures) the presence of a partial reinforcement acquisition effect (PRAE), i.e., partially reinforced Ss running faster

than continuously reinforced Ss in the late stages of acquisition.

Overall terminal acquisition performance in all alley sections (seen as point "A" in Figure 3) was examined in a 2(levels of Training)

Insert Figure 3 about here

X 3(Schedules of Reinforcement) factorial analysis of variance performed on a block of the last six acquisition trials. The Levels X Schedules interaction failed to reach significance in any alley section, $F_s(2,54) = .54, 1.65, 2.33, \text{ and } 2.14$, all $p_s > .10$ for start, run, goal, and total measures respectively. The main effect for Level was significant in the run section, $F(1,54) = 5.04, p < .05$, with the 12-trial groups running faster than the 60 trial groups; but not in start, $F < 1$, goal, $F < 1$, or total, $F(1,54) = 2.33, p > .10$. The main effect for Schedules failed to reach an acceptable level of significance in run, $F < 1$, or goal, $F(2,54) = 1.91, p > .10$, but it was significant in start, $F(2,54) = 10.04, p < .001$, and total, $F(2,54) = 5.39, p < .01$. Post hoc analysis of the Schedules main effect led to the same general conclusion as did the analysis of the course of acquisition for the 60 trial groups, i.e., a PRAE occurred (at least for the 3N groups) in both the start and total speed measures; specifically in start $3N > SA = CRF$ and in total $3N = SA, 3N > CRF$, and $SA = CRF$.

Extinction.--A 2(Levels of Training) X 3(Schedules of Reinforcement) X 24(Days) was performed on the extinction data (shown

in Figure 3) for all four speed measures. For the run measure, only the Days effect, $F(23,1242) = 27.41$, $p < .001$, and the Levels X Days interaction, $F(23,1242) = 1.81$, $p = .01$ were significant, while the main effects of Levels and Schedules and all other interactions were nonsignificant (all $F_s < 1$). The results in the goal section were quite similar to those in run: The Days main effect was significant, $F(23,1242) = 64.15$, $p < .01$, while the Levels and Schedules main effects and the interactions of Levels X Schedules, Schedules X Days, and Levels X Schedules X Days were all nonsignificant (all $F_s < 1$). Thus the analysis of the run and goal speed data indicated that the Ss decreased speed over extinction trials and provided some evidence that extended acquisition produced slower extinction across trials than did limited acquisition. The analysis of total speeds revealed a nonsignificant Levels main effect, $F < 1$, and nonsignificant interactions of Levels X Days, $F(23,1242) = 1.18$, $p > .10$, and Levels X Schedules X Days, $F < 1$. The main effects of Trials, $F(23,1242) = 53.24$, $p < .001$ and Schedules, $F(2,54) = 65.58$, $p < .001$ were significant as were the interactions of Levels X Schedules, $F(2,54) = 19.37$, $p < .001$, and Schedules X Days, $F(46,1242) = 3.46$, $p < .001$. The Schedules X Days interaction indicated that the different schedules produced different rates of extinction, specifically the PRF schedules produced slower extinction than CRF. Of major interest, however, was the Levels X Schedules interaction and thus it was examined using post hoc comparisons. The comparisons indicated that the 12 trial groups were ordered $SA > 3N > CRF$ in extinction while the 60 trial groups were ordered $3N > SA > CRF$.

The results of the start speed analysis were similar to the total speed results; the main effects of Levels, $F(1,54) = 5.61, p < .05$; Schedules, $F(2,54) = 190.56, p < .001$; and Days, $F(23,1242) = 49.51, p < .001$ were significant as were the interactions of Levels X Schedules, $F(2,54) = 132.09, p < .001$; Levels X Days, $F(23,1242) = 2.26, p < .001$; Schedules X Days $F(46, 1242) = 3.54, p < .001$; and Levels X Schedules X Days, $F(46,1242) = 2.12, p < .001$. The post hoc analysis of the Levels X Schedules interaction indicated that the 12 trial groups were ordered SA > 3N > CRF during extinction, and the 60 trial groups were ordered 3N > SA > CRF. The significant triple interaction indicated that these differences grew larger over successive days of extinction. Thus the Level of Training X Schedule of Reinforcement interaction which has been reliably observed in both appetitive and escape procedures using massed trials also occurs in spaced trial escape conditioning. It should be noted, however that the differences due to the Schedule main effect in the terminal acquisition data for the start and total analyses may have influenced the Level X Schedule interaction in extinction. However, this effect would have contaminated only the results of the 60 trial groups, since the terminal acquisition and extinction differences were in the same direction for them (3N > SA > CRF), whereas the terminal acquisition and extinction differences (3N > SA > CRF and SA > 3N > CRF respectively) were in opposite directions for the 12 trial groups. Thus, in order to evaluate the extinction performance of the 60 trial groups uncon-

taminated by terminal acquisition differences, the start and total speed extinction data for Groups SA-60, 3N-60, and CRF-60 were transformed using Anderson's (1963) rate transformation procedure and subjected to 3(Groups) X 24(Days) analyses of variance. The analysis of transformed total speeds revealed results identical to the analysis of raw total speeds, i.e., in terms of resistance to extinction: $3N > SA > CRF$. The analysis of transformed start speed yielded results slightly different than those from the analysis of raw start speeds, specifically, $3N > SA = CRF$, whereas in the non-transformed analysis SA was more resistant than CRF. This result is not surprising since the occurrence of patterning during acquisition has been shown to reduce resistance to extinction (e.g., Rudy, 1971), and it also does not attenuate the observed Level X Schedule interaction.

Discussion

The spaced trial escape procedure used in the present experiment produced three major findings: (1) a single alternation schedule of N and R trials resulted in patterning behavior. This phenomenon has also been observed in appetitive conditioning at massed (Capaldi, 1967) and spaced trials (Capaldi & Lynch, 1966) and in escape conditioning at massed trials (Seybert, et al., 1974). (2) A PRAE was observed in the start section for the 60 trial groups, i.e., Ss who received PRF were running faster at the end of acquisition than Ss who received CRF. This is a frequent finding in the appetitive conditioning literature (see Robbins, 1971) but has not previously been observed in escape conditioning. Of the escape conditioning studies

comparing CRF and PRF in acquisition some have shown superiority of CRF over PRF at the end of acquisition (e.g., Bower, 1960; Woods, et al., 1972, with large magnitude of reinforcement) while others have found no differences between CRF and PRF in acquisition (Seybert, et al., 1974, experiments I, II, IV, & V). The present results, then, are in clear disagreement with much of the escape literature; it should be noted, however, that the previously cited studies were all conducted at relatively short ITIs, while the present experiment used what must be considered an extremely long ITI (24 hr). Thus, rather than being an anomalous finding, the present results may reflect effects of wide spacing of trials. The fact that the PRAE occurred only in the start section in the present experiment, is in agreement with similar appetitive findings (e.g., Amsel, 1967) and, as such, lends support to the hypothesis that similar processes operate in escape and appetitive conditioning situations. (3) A Level of Training X Schedule of Reinforcement interaction was observed. After limited acquisition (12 trials) a group receiving short N-lengths (SA) was more resistant to extinction than a group receiving long N-lengths (3N), but after extended acquisition (60 trials) the reverse was true ($3N > SA$). This Level X Schedule interaction has also been reported in appetitive conditioning using both massed (Capaldi, 1967) and spaced (Seybert, et al., 1973) trials and in escape conditioning using massed trials (Seybert, et al., 1974). The only theoretical system which can account for this interaction is Capaldi's (1967) sequential hypothesis. According to sequential theory the Level X Schedule interaction occurs because resistance to extinction after limited acquisition is controlled

by the number of occurrences of N-length followed by an R trial (which, when percentage is equated, is greater for a short N-length group), but after extended acquisition extinction performance is a direct function of N-length. The results of the present experiment fit well within a sequential framework and thus are in agreement with a number of other studies (e.g., Capaldi & Levy, 1972, Dyck, et al., 1974; Seybert, et al., 1974; Wroten, et al., 1974) in showing that the boundary conditions of sequential theory may be extended to include certain aversive conditioning situations.

Capaldi (1971) has recently emphasized memory processes in sequential theory, specifically, the important mechanism by which sequential variables operate is long term memory rather than stimulus traces, or aftereffects, which are generally assumed to be short lived. It is apparent that this modification allows wider applicability to sequential theory, specifically to experimental situations involving wide spacing of trials. The present experiment demonstrated that rats in an escape situation could remember what occurred 24 hours previously and use the memory of that prior event to regulate their behavior on subsequent runway trials. Thus, the present experiment, along with a number of others (Capaldi, 1971; Jobe & Mellgren, 1974; Mellgren & Seybert, 1973; Seybert, et al., 1973) provides strong support for the hypothesis that sequential theory can account for spaced trial data and that memory processes play an important role in discrete trial instrumental learning situations.

Finally, it should be noted that the sequential manipulations

in the present experiment had their effects almost exclusively in the start section of the runway. This pattern of results has also been observed in several other aversive conditioning studies (e.g., Capaldi & Levy, 1971; Seybert, et al., 1974) and is thought to occur as a result of a heightened avoidance gradient in the goal area because the goal situation is highly aversive and thus the strong tendency for all Ss to avoid masks any differential performance as a result of experimental manipulations. Portions of the runway farther removed from the goal section are seen as less aversive and thus the avoidance gradient is "shallow" enough to allow the experimental effects to appear. This explanation is, admittedly, post hoc and somewhat speculative and is in need of experimental verification.

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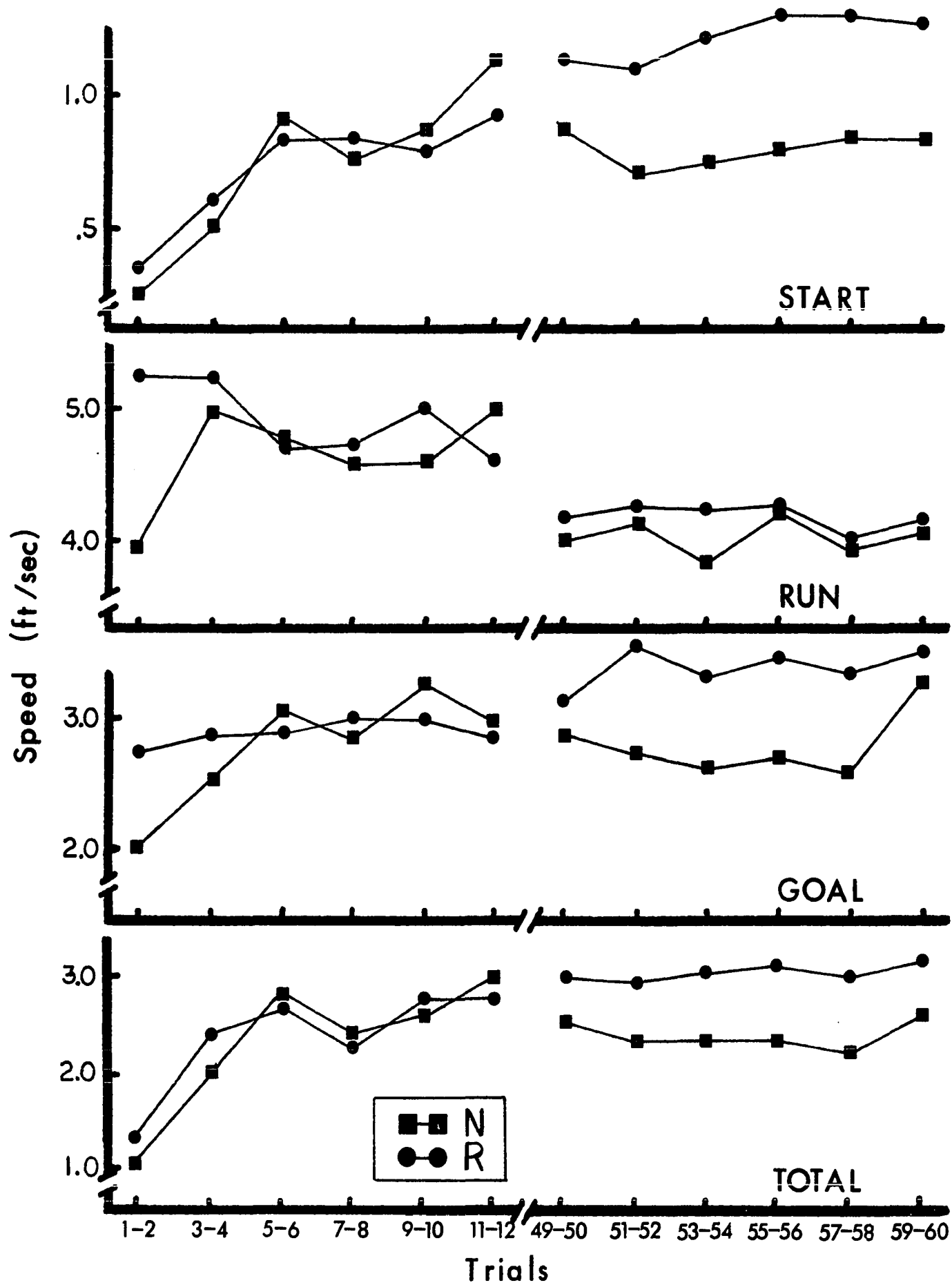
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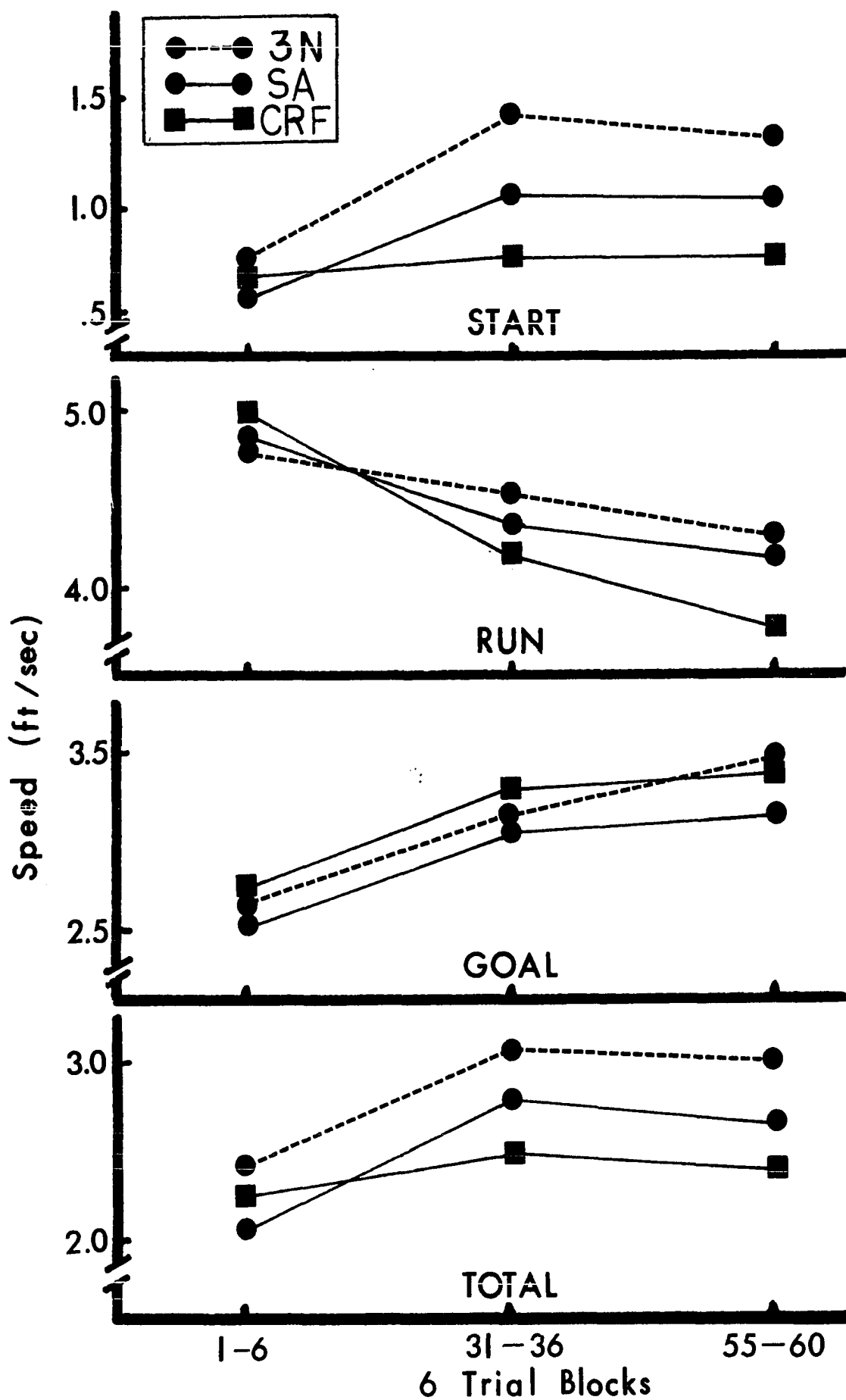
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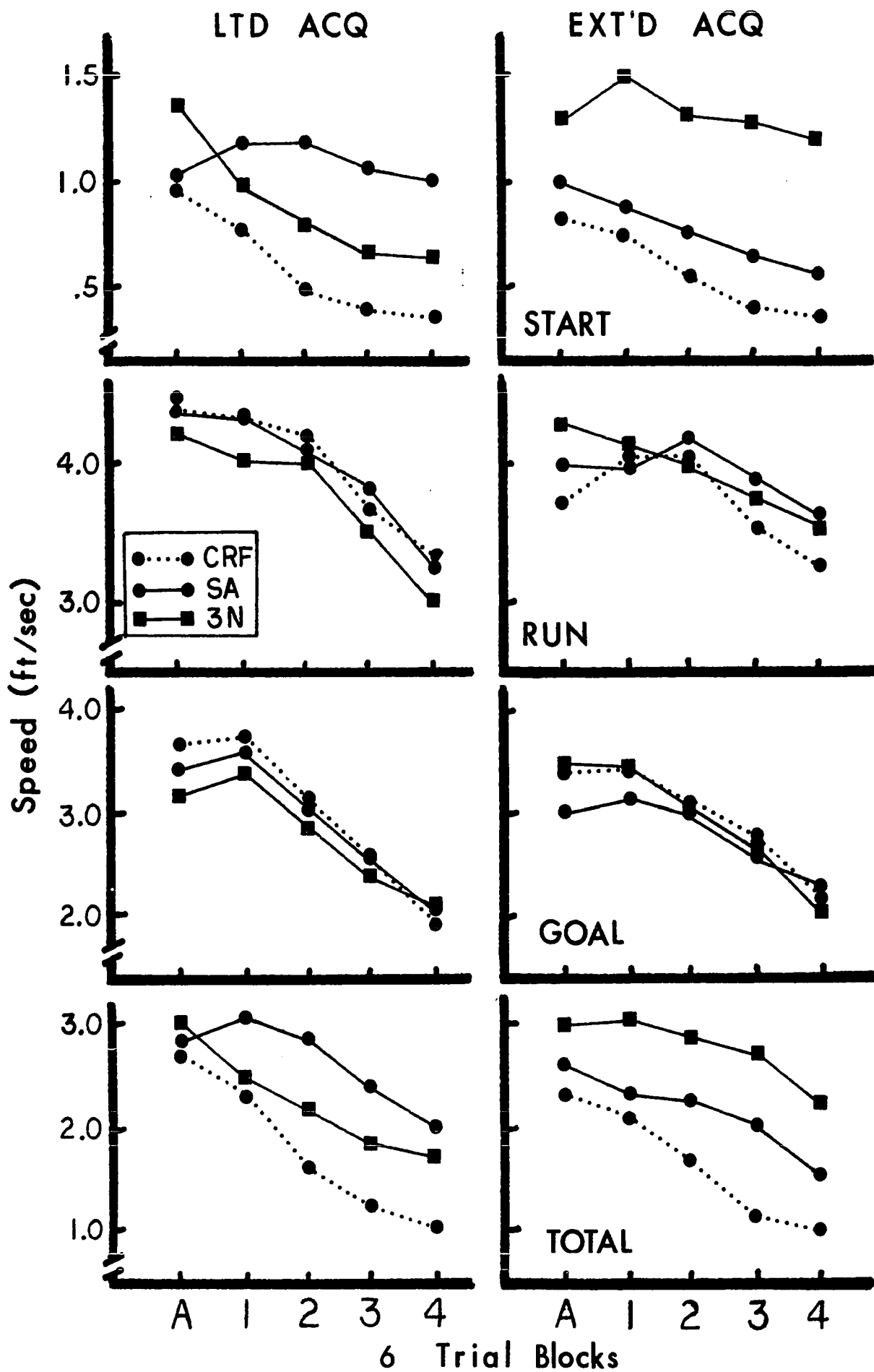
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Figure Captions

- Fig. 1 Mean speeds on reinforced (R) and nonreinforced (N) trials for the SA-60 trial group on trials 1-12 and 49-60 of acquisition (N occurred on odd numbered days and R on even numbered days).
- Fig. 2 Mean speeds in six trial blocks, for three stages of acquisition: Early (trials 1-6), middle (trials 31-36), and late (trials 55-60).
- Fig. 3 Mean speeds for the last six trials of acquisition and 24 trials of extinction, in six trial blocks, for Ss receiving limited acquisition training (left panels - ltd. acq.) and extended acquisition training (right panels ext'd. acq.).







APPENDIX A

PROSPECTUS

Variables Which Affect Response Acquisition and
Extinction in Instrumental Escape Conditioning:
A Review of the Literature

Escape conditioning procedures have been widely used in instrumental learning situations, both for the study of escape learning as a phenomenon and as a technique for investigating other learning processes. It is the purpose of the present paper to examine the variables which influence both the acquisition and extinction of escape responses. This will involve examination of several escape paradigms as well as a number of experimental variables which have been shown to be important in escape conditioning. Experiments which have used escape procedures to investigate other processes (e.g., development) will not be considered except where they specifically add important information about escape conditioning as a phenomenon. Following a review of the available literature, several experiments will be proposed to further examine some of the variables which affect escape responding as well as test a number of predictions derived from Capaldi's (1967; 1970; 1971) sequential theory of instrumental learning.

Paradigmatic Studies

Although many of the studies involving escape procedures use an escape-from shock technique in a straight runway, several

other experimental paradigms have been investigated and utilized to examine factors which influence escape learning. Several studies have been reported using shock as the aversive motivational stimulus in an operant procedure. Dinsmoor & Hughes (1956) and Dinsmoor, Hughes, & Matsuoka (1958) demonstrated that rats would learn to press a bar to escape from footshock. Similarly Rachlin & Hineline (1967) demonstrated that pigeons would learn a keypeck response, the reinforcement for which was escape from shock delivered through gold wires imbedded under the pigeons' pubis bones, although the level of shock had to be gradually increased throughout the duration of training in order to maintain responding. A number of studies have utilized the fact that certain species have strong aversions to light. Keller (1941) using rats as subjects and 101 foot candles illumination as the aversive stimulus, obtained acquisition and extinction performance using a lever press response reinforced by one minute of darkness. Lee (1963) used the termination of intense light to reinforce passage through a narrow beam of light by planaria. He found that experimental Ss (i.e., those for whom the response resulted in a 15 minute period of darkness) evidenced more responses and a higher rate of responding than did yoked control Ss which received the same amount of light and darkness as did the experimental Ss but in the absence of any reinforcement contingency. These results were replicated by Crawford & Skeen (1967) using a similar procedure with 60 sec light termination as reinforcement.

A number of investigators have shown that Ss will learn to escape from intense noise. Barnes & Kish (1957) used white noise of 98 db as the aversive stimulus. A group of mice which turned the white noise off by depressing a platform acquired the response, while control groups which had no noise, noise all the time, or for whom the platform depression turned the noise on failed to acquire the response. Two studies (Harrison & Abelson, 1959; Harrison & Tracy, 1955) have demonstrated that rats will learn a lever press response to escape from intense noise. Myers (1965) has shown that rats would learn a wheel turn response which resulted in the termination of a 70 db buzzer for 15 sec, and also (1967) that rats would learn a similar response to terminate intense white noise or a combination of white noise and a 4,000 cps pure tone.

A paradigm in which Ss must escape by swimming from an alley containing one temperature of water to a goal box containing water of a different temperature has been employed in a number of experiments. Woods (1963) for example, found that rats would acquire the swimming response when the alley temperature was 20°C. with a 20°C. reinforcement, i.e., goal temperature was 40°C. He also found that when half of the Ss were shifted to extinction conditions (20°C. in both alley and goal sections) a concomitant decrease in response speed occurred. Using Ss much lower on the phylogenetic scale, French (1940) found that paramecia pulled by capillary action from a test drop on a microscope slide into a tiny glass tube, and allowed to escape by swimming back into a drop of their own culture medium, escaped more

rapidly over successive trials. This result has been replicated by Hanzel & Rucker (1971; 1972).

Two rather unique escape procedures have been used by van Sommers (1963a; 1963b). He found (1963a) that rats exposed to various concentrations of carbon dioxide (CO_2) would learn to escape the CO_2 for 30 sec periods by touching a metal tube. Van Sommers (1963b) was able to demonstrate that immature turtles could be trained to depress a lever to secure air while submerged in water. Periodic extinction was shown to produce a decline in response rate and compensatory increases were observed during periods of reacquisition using continuous reinforcement (CRF). Finally, Martin, Richardson, & Martin (1966) demonstrated that squirrel monkeys would learn a lever press response to escape from centrifugally produced accelerations of twice normal gravity.

Motivational Effects

Numerous studies have been reported investigating effects of level or intensity of drive¹ in escape conditioning. A number of these studies, particularly those employing shock-escape procedures, have used complete reduction of the aversive stimulus as reinforcement. This technique does not allow for the separation of effects of intensity and reinforcement magnitude since those Ss with high intensity receive large magnitude of reinforcement while Ss with low intensities receive small magnitude of reinforcement. The effects of reinforcement magnitude may be separated from intensity effects, however, when only partial reduction of

aversive stimulus intensity occurs and, in fact, this technique has been used in a number of situations. Thus, the present section will review experiments involving complete reduction in drive intensity, and the succeeding section on reinforcement magnitude effects will review those experiments which have used a partial reduction in intensity to investigate effects of magnitude apart from those of aversive stimulus intensity.

Several studies of drive intensity have been reported in which operant shock-escape procedures were employed. Dinsmoor & Hughes (1956) using rats in a bar press situation, reported that .4 ma shock produced more rapid approach to asymptote than did .2 ma although both intensities resulted in approximately the same asymptote. These results were replicated by Dinsmoor, et al. (1958) using a similar procedure. This finding was also confirmed by Campbell & Kraeling (1953) in a runway situation. They used three levels of shock: 200,300, and 400 v. in the start and run sections of a straight alley reduced to zero in the goal box and found that the rate of acquisition was a function of intensity while the final asymptote was not (all three intensities yielded essentially the same asymptote). Substantially similar results were obtained by Seward, Shea, Uyeda, & Raskin (1960) using 315, 255, & 190 v. shock in the start and run sections of a straight runway and zero shock in the goal box. Dinsmoor & Winograd (1958) used a wider range of shock intensities (0, .05, 1.0, 2.0, & 4.0 ma) in a lever press situation and found that rate of responding was, for the most part, a function of intensity, i.e., the higher the level

of shock the greater the response rate. Stavely (1966), again using a lever press situation and shock levels of .25, .40, .64, 1.05, & 1.65 ma found that acquisition performance was an increasing function of intensity. He also demonstrated that resistance to extinction in terms of number of responses during a 15 min period of continuous shock was greater as shock level increased although no provisions were made for terminal acquisition differences. Boren, Sidman, & Herrnstein (1959) demonstrated that latency of responding in an operant lever press procedure was also an increasing function of shock level (they used intensities of .1, .5, 1.2, 1.7, 2.15, 2.6, 3.2, & 3.7 ma) but that the largest differences in latency occurred at lower levels of shock, suggesting a Weber-Fechner type analogy. These authors, like Stavely, also demonstrated that resistance to extinction was an increasing function of shock level.

A number of other escape paradigms have also been used to investigate intensity effects. Franchina (1969b), using a hurdle box apparatus and the intermittent shock procedure developed by Jones (1953), compared 20, 50, & 80 v. shock on both a between-groups and a within-subjects basis in both acquisition and extinction. He found that acquisition of the hurdle jumping response was a direct function of shock intensity for both between-groups and within-subjects conditions, although performance was higher at each shock level for within-subject Ss than for between-group Ss. Similarly, trials to extinction increased with increased shock intensities but was greatest for the Ss that received all shock intensities (i.e., the

within-subject Ss). Masterson (1969) measured escape from several intensities of loud noise using a key peck response. Pigeons could silence one of five noise levels (0, 77, 87, 97, & 107 db) for one minute by pressing the key. The results generally indicated a positive relationship between noise intensity and escape performance, i.e., in terms of percentage of time the noise was off during experimental sessions: $107 > 97 = 87 > 77 = 0$. Employing the water runway procedure and removal from the runway as the reinforcement, Hack (1933) compared the efficacy of three water temperatures as motivators: 15°, 37.5°, & 45°C. He found that rats swimming speeds were generally an inverse function of water temperature (i.e., as temperature increased, swimming speed decreased), although the 45° Ss swam slightly faster than the 37.5° Ss during the latter stages of acquisition. Van Sommers (1963a) in the CO₂ escape experiment found, using three concentrations of CO₂ (8%, 10%, & 15%) that response speed was a direct function of percentage of CO₂. Thus, these studies seem, for the most part, to indicate that escape responding is a direct function of intensity of the aversive motivational stimulus, i.e., the stronger the stimulus intensity, the faster Ss respond in order to escape from that stimulus. However, a number of studies, using relatively wide ranges of stimulus intensity, have shown that response strength may not be a simple increasing monotonic function of intensity but rather, the intensity-response strength relationship may be represented by a somewhat more complex nonmonotonic function. Kaplan (1952), for example, employed an operant bar press procedure with the following values

of intense light as aversive stimuli: 27, 111, 183, 530, 960, & 2312 mL. He found that response rate increased up to approximately 183 mL and decreased thereafter. Similarly, Kaplan, Jackson, & Sparer (1965) used five intensities of aversive light (2.5, 18, 105, 190, & 386 foot candles) in an operant lever press situation with rats. They found that responding increased as a function of intensity up to 105 foot candles and then decreased, again indicating that responding was an inverted U-shaped function of intensity. A similar function was observed in the water runway paradigm by Wever (1932). He used eight water temperatures ranging from 10° to 45°C. in increments of 5°C., again with removal from the apparatus serving as the reinforcement, and found that swimming speed decreased with increasing temperature up to 40°C. at which point it increased. Barry & Harrison (1957) investigated the relationship between response strength and intensity in both CRF and PRF reinforcement schedules. They used a lever pressing procedure with cats and termination of intense noise (3.1, 12.5, 25.0, 56.0, 106.0, 410.0, 1480.0, & 3750.0 mV.) as the reinforcement. They found that responding was a direct function of intensity with a CRF schedule but when a PRF schedule was used responding increased up to approximately 1480.0 mV. and then decreased, in a manner similar to the Kaplan, et al., and Wever, studies. Trapold & Fowler (1960) used a wide range of shock intensities (120, 160, 240, 320, & 400 V.) in the start and run sections of a straight alley with zero shock in the goal box. They found that although run speeds were a direct function of shock intensity, start speeds increased as a function of intensity up to 240 V. and then decreased, again yielding an inverted U-shaped

function. Finally, Winograd (1965, Experiment II) varied shock intensity (0, .25, .50, 1.0, 2.0, 4.0 ma) in a lever press escape situation with rats. The results, both in terms of escape rate and latency of the first escape response, indicated that responding increased up to an intensity of about 1.0 ma and then leveled off and decreased. Thus, the data of several experiments indicates that when a greater range of stimulus intensities are utilized, response strength initially increases with increasing intensity but at higher intensities the level of responding tends to decrease, leading to the conclusion that response strength is a nonmonotonic (possibly inverted U-shaped) function of aversive stimulus intensity.

Effects of Reinforcement Magnitude

In a study discussed previously in relation to motivational effects, Seward, et al. (1960) also investigated partial shock reduction in a straight runway shock-escape procedure. They used the following partial-reduction combinations of shock intensities in the runway and goal sections respectively (in volts): 315-125, 315-190, 255-125, 255-190, 190-125. The results generally indicated that running speeds were faster with greater amounts of shock reduction. A study by Campbell & Kraeling (1953, previously discussed in relation to effects of level of motivation) served to specify more precisely the relationship between reinforcement magnitude and response strength suggested by the data of Seward, et al. In addition to the three groups discussed previously, seven partial shock reduction conditions were employed: 400-300, 400-200, 400-100,

300-200, 300-100, 200-100, in terms of volts in alley and goal box respectively. Two major results were observed: (1) Ss ran faster with increasing shock reduction (similar to Seward, et al.), specifically, in terms of acquisition asymptote: 400-100 > 400-200 400-300 and 300-100 > 300-200. (2) A constant reduction in shock was more effective at a low alley shock level than at a high alley shock level, i.e., in terms of asymptotic acquisition running speed: 200-100 > 300-200 > 400-300. Thus, these data indicate that a Weber-Fechner analogy exists for reward magnitude in escape conditioning similar to that observed for aversive stimulus intensity (e.g., Boren, et al., 1959). Further support for this finding was provided in a study by Campbell (1955). He used white noise ranging from 90 to 115 db as the aversive stimulus and learning consisted of acquisition of a preference for the side of a tilting cage receiving the lower of two intensities. "Just noticeable" learning was defined as the point at which the curves relating proportions of noise reduction to preference percentage crossed the 75% level. A number of levels of noise and percentages of noise reduction were combined. In general, larger reductions of noise produced stronger preferences, and the results also indicated that, above a lower limit where no learning occurred, as intensity increased, the amount of noise reduction needed to produce just noticeable learning increased, leading Campbell to conclude that a Weber-Fechner type relationship exists for reward magnitude in escape conditioning. This latter result was replicated using shock in a similar procedure by Campbell (1956).

However, two studies (Woods, Davidson, & Peters, 1964; Woods & Holland, 1966) using the water runway procedure have yielded results which are somewhat contradictory of the runway escape data. Woods, et al. used the following groups in their first experiment (in terms of water temperature in runway and goal sections respectively): 15°-20°, 15°-30°, 15°-40°, 25°-30°, 25°-40°, 35°-40°C. The only significant effects were due to reinforcement magnitude, there were no differences among groups with the same amount of reinforcement but different drive levels. Experiment II was very similar to Experiment I except that slightly different drive and reinforcement values were employed and again no differences as a result of different drive levels with the same amounts of reinforcement were observed. Woods & Holland performed two experiments to once again investigate effects of constant magnitude of reinforcement at different levels of aversive stimulus intensity. In Experiment I alley-goal differentials were varied 0-10°C. in steps of 2° for two different alley conditions: 15° & 30°C. In Experiment II alley conditions of 15° & 25°C. were used with alley-goal differentials of 4°, 8°, & 16°C. In both experiments, similar to Woods, et al., it was demonstrated that the reinforcement magnitudes had the same effects at both drive levels. Thus the four experiments reported in Woods, et al. and Woods & Holland are not in agreement with the Weber-Fechner analogy findings of Campbell (1955); and Campbell & Kraeling (1953). It is difficult to evaluate this discrepancy, however, since the data were collected in markedly different aversive stimulus situations. Clearly, more research is

needed on the effects of reinforcement magnitude in the several escape conditioning paradigms.

Effects of Shifts in Drive and Reinforcement

Several escape conditioning studies have examined the effects of shifts in drive level and/or reward magnitude on instrumental behavior. Bower, Fowler, & Trapold (1959) used a runway shock-escape procedure to investigate whether or not shifts in amount of shock reduction would produce concomitant changes in behavior similar to those observed in appetitive reward shift studies. They ran 15 preshift and 15 postshift trials and employed seven groups (in terms of volts of shock in the goal box in preshift and postshift phases, respectively): 50-50, 50-150, 50-200, 150-150, 200-50, 200-150, 200-200. The shock level in the start and run sections was 250 V. throughout the experiment. The three preshift goal box shock levels (50, 150, & 200 V.) produced different asymptotes during preshift ($200 > 150 > 50$). In the postshift phase the shifted groups showed rapid changes in speed to the level of the unshifted controls, but not beyond. Thus neither positive or negative contrast was observed. Howe (1961), again in a runway escape situation, replicated these results for a downshifted group but obtained no performance change for an upshifted group. Woods (1967) used the water runway procedure to investigate reinforcement magnitude shifts. The alley temperature was 25°C. throughout the experiment and two reinforcement magnitudes were employed in the goal section: small (a 2° increase) and large (a 16° increase). Two control groups got small and large reinforcement

respectively throughout the experiment while an upshifted experimental group got small reward in the preshift phase and large reward in postshift phase, and a downshifted experimental received the opposite (large reward in preshift and small reward in postshift - this is a successive nondifferential contrast procedure). The different reward magnitudes produced reliable differences in the preshift phase (large > small) and in postshift the shifted Ss gradually approached the response levels of the unshifted controls, with the upshifted group attaining the level of the large reward control group but not surpassing it (no positive contrast), while the downshifted group did eventually swim slower than the small reward control group (thus negative contrast was observed). The negative contrast portion of this experiment was replicated, again by Woods (1973), using 15°C. as the alley temperature, and 4° and 24°C. increases as small and large reward respectively. Similarly, Cicala & Corey (1965), using a successive differential contrast type procedure in a shock runway, i.e., one group received 60 V. in the start and run sections, one group received 90 V. in the start and run sections, and a third group received 60 V. and 90V. on alternate trials in the start and run sections (all Ss received no shock in the goal box) demonstrated negative contrast (alternating group running slower on 60 V. trials than 60 V. group) but not positive contrast (alternating group ran as fast, but no faster on 90 V. trials than 90 V. group).

Finally, there have been two reports of experiments demonstrating both positive and negative contrast (Nation, Wrather, &

Mellgren, 1974; Woods & Schutz, 1965). Woods & Schutz used the water runway and two drive levels in the alley: 12°C. (high drive) and 30°C. (low drive) with the goal box always being 10° warmer than the alley. Two control groups received high and low drive respectively throughout the experiment while an upshifted experimental group received low drive in the preshift phase and high drive in the postshift phase, and a downshifted experimental group received the opposite (high drive in preshift and low drive in postshift). The high drive groups were swimming faster at the end of preshift; in the postshift phase the downshifted group swam slower than the low drive control (negative contrast) and the upshifted group swam faster than the high drive control (positive contrast). Nation, et al. reported two experiments, both using the shock-escape procedure in a straight runway. Experiment I employed a successive nondifferential procedure with three groups (in terms of shock in ma in the start and run sections of the runway for the preshift and postshift phases respectively): .2-.4, .4-.4, .8-.4. The goal box was uncharged throughout the experiment. Reliable preshift differences, as a function of shock level, were observed; and the .2-.4 group ran faster in postshift than did the .4-.4 group (positive contrast) while the .8-.4 group ran slower than the .4-.4 group (negative contrast). The performance shifts in the experimental groups occurred very rapidly and very early in the postshift phase. Experiment II employed a successive differential procedure, similar to Cicala & Corey (1965), with one

group receiving .2 ma on all trials, another group receiving .4 ma on all trials, and a third group receiving .2 and .4 ma on alternating trials. Again all groups received zero shock in the goal box. After approximately twelve trials the alternated group was running slower on .2 ma trials than the .2 ma control group (negative contrast) and faster on .4 ma trials than the .4 ma control group (positive contrast).

There would thus seem to be a substantial amount of disagreement in the available literature concerning the effects of reward and drive shifts. While some authors observe shifts in performance only to the levels of control groups (Bower, et al., 1959; Howe, 1961), others observe negative but not positive contrast effects (Cicala & Corey, 1965; Woods, 1967; 1973), and still others observe both positive and negative contrast effects (Nation, et al., 1974; Woods & Schutz, 1965). In one procedure (shock runway) performance shifts as a result of reward or drive shifts are relatively rapid, while corresponding performance shifts in another procedure (water runway) are relatively gradual. Finally the mode in which the shift occurs (i.e., drive intensity or reward magnitude) seems to have no consistent effect on performance. Drive shifts sometimes produce positive and negative contrast (Nation, et al.; Woods & Schutz) and sometimes only negative contrast (Cicala & Corey). Likewise, shifts in reward magnitude sometimes produce negative contrast (Woods, 1967; 1973) and sometimes no contrast effects at all (Bower, et al.; Howe). That this confusing state of affairs is badly in

need of further empirical investigation and clarification goes without saying.

Delay Effects

The results of experiments involving delay of reinforcement in escape conditioning are considerably more straightforward than those from the shift procedures. Hughes (1959) investigated the effects of various delays of reinforcement in a bar press shock-escape procedure. He used a .4 ma shock and 0, 2, 5, & 10 sec delays and observed that response latency was shorter for lesser values of delay, i.e., latency was a direct function of length of delay. Fowler & Trapold (1962) used an analogous procedure in a discrete trials runway shock-escape paradigm. The shock in the runway was 240 V. and delays of 0, 1, 2, 4, 8, & 16 sec were examined. The results indicated that asymptotic running speed was an inverse function of the length of the delay interval. Similar results were reported for response latencies by Keller (1966) in an operant bar press experiment with light as the aversive stimulus and delays of 1, 2, 5, & 10 sec. Hammond & Lambert (1970) performed an experiment which was quite similar to Fowler & Trapold except that larger delay values were utilized, specifically 0, 15, 30, & 45 sec. The results indicated that a slight amount of acquisition occurred in the 0 sec group, no change in speed was observed for the 15 sec group and the 30 and 45 sec groups experienced a decrease in speed across the 14 acquisition trials, leading the authors to conclude that long delays of reinforcement in an escape situation are actually punishing. The relative failure, however, of the 0 sec group to acquire

the escape response, compared, for example, with the 0 sec group of Fowler & Trapold, raises a serious question about the validity of these results and thus it is possible that they should be considered anomalous. Leeming & Robinson (1973) investigated effects of delay in a shuttle box shock-escape procedure. Six levels of delay were used: 0, 1, 2, 4, 8, & 16 sec. At the termination of training the groups were ordered (in terms of response latency): $16 > 8 > 4 = 2 > 1 > 0$, however the only statistically reliable differences were as follows: 16 sec was greater than 1 sec and 0 sec which did not differ. These results do not agree with those of Fowler & Trapold (1962) but since these two studies were conducted in different apparatuses (runway and shuttlebox) it is difficult to evaluate the empirical differences between the two experiments.

Two studies (Bell, Noah, & Davis, 1965; Woods & Feldman, 1966) have investigated the effects of delay as they interact with other variables to determine escape performance. Bell, et al. examined the combined effects of delay and shock intensity by factorially combining 3 levels of shock (.25, .50, & 1.0 ma) with 4 levels of delay (0, 1.25, 2.50, & 5.00 sec). The experiment was conducted in a shuttle box apparatus and consisted of both acquisition and extinction training. The acquisition data indicated that asymptotic speed was an inverse function of the length of delay and was also a direct function of shock intensity. The main result in extinction was an Intensity X Delay interaction, i.e., intensity had its greatest differential effect at 0 sec delay and these

effects decreased as the delay interval increased. In other words, as shock level increases, the delay gradient shifts from a shallow linear function to a steep quadratic function. Woods & Feldman examined the combined effects of delay and reward magnitude in a water runway procedure by factorially combining 3 levels of delay (0, 3, & 10 sec) and 3 reward magnitudes (the goal box being either 0°, 5°, or 25° C. warmer than the alley). The results indicated that running speed was an inverse function of the length of delay and a direct function of reward magnitude. A Delay X Magnitude interaction was also observed which resulted from the fact the differential effects of reward magnitude were much more pronounced at 0 sec delay than at either 3 sec or 10 sec delay.

Effects of Schedule and Number of Reinforcements

Three studies (Campbell, 1959; Martin, 1966; Santos, 1960) have dealt directly with the effects of number of reinforcements on escape performance. Santos, using a shuttle box shock-escape procedure found no differences in acquisition or extinction between a group receiving 10 CRF acquisition trials and a group receiving 40 CRF trials. Martin looked at resistance to extinction as a function of the number of reinforcements using the runway shock-escape paradigm. Four groups differed in the number of escape training trials received before extinction: 4, 8, 16 & 32 trials. The results, in terms of responses to an extinction criterion, indicated that greater numbers of responses were required to reach the

extinction criterion for Ss having greater numbers of training trials, specifically $32 = 16 > 8 > 4$. This relationship was not observed in a speed measure, however and, in fact, there were no differences in speeds for any of the groups. Campbell performed a lever press shock-escape experiment using a procedure analogous to that of Martin. He compared resistance to extinction of groups which received 0, 5, 25, 100, 300 & 500 shock termination reinforcements. The results showed that resistance to extinction, in terms of the number of responses during a fifteen minute extinction period increased consistently as the number of reinforcements increased but that its magnitude decreased, i.e., resistance to extinction was a negatively accelerated increasing function of the number of reinforcements.

Several studies have examined certain schedules of reinforcement in a number of operant escape paradigms. Hendry & Hendry (1963), using a within-subject bar press escape procedure, were able to demonstrate acquisition of the response with CRF and FR-2 schedules but not with FR-4 or FR-8. Winograd (1965), on the other hand, again with a lever press shock-escape procedure and FR-1 (CRF), FR-5, FR-10, and FR-20 schedules obtained escape performance for all schedules similar to that observed under similar appetitive schedules. Similarly, Azrin, Holz, Hake, & Ayllon (1963) using monkeys in a lever press shock-escape procedure produced escape responding with schedules up to FR-25 much like that observed in similar appetitive procedures. Martin & Heckel (1965) used a wheel bar shock-escape

procedure and observed appropriate responding on FR-2, FR-4, and FR-10 schedules. Kaplan (1956) used an operant pedal press procedure and a light of 183 m μ L as the aversive stimulus. With schedules ranging from FR-1 to FR-16 he found that the temporal properties of the escape response are similar to those elicited using FR schedules under positive reinforcement. Hineline & Rachlin (1969), using pigeons in a key peck shock-escape procedure, were able to demonstrate appropriate responding on schedules from CRF to FR-21 and FI-300 sec. Thus, Hendry & Hendry's inability to obtain responding on FR-4 and FR-8 schedules, in light of the data just discussed, must be considered an anomalous finding.

A number of studies have been reported which examined effects of various manipulations of schedules of reinforcement. Bower (1960) performed two experiments with a runway shock-escape procedure. In experiment I four percentages of reinforcement were used during acquisition (100%, 75%, 50%, & 25%). The shock level in the start and run sections was 250 V. throughout the experiment and was 250 v. in the goal section on nonreinforced (N) and extinction trials and zero on reinforced (R) trials. The data indicated that acquisition performance was a direct function of percentage (specifically: 100% = 75% > 50% > 25%). This result is the opposite of the usual occurrence in appetitive conditioning where partially reinforced (PRF) groups are often superior to continuously reinforced (CRF) groups at the end of acquisition - an effect called the partial reinforcement acquisition effect (PRAE - cf. Robbins, 1971). The extinction data showed

that the 50% group was more resistant to extinction than the 100% group. This effect, i.e., PRF Ss showing greater resistance to extinction than CRF Ss, is called the partial reinforcement extinction effect (PREE), and is a reliable finding in appetitive experiments involving PRF schedules (Robbins, 1971). Experiment II, also conducted in a shock runway, was performed to see if rats could run slower than a given speed (called a cutoff) if they were reinforced for so doing and nonreinforced for running faster than the cutoff. This procedure is sometimes called differential reinforcement of low rates (DRL) and has been shown to effectively control appetitively motivated behavior. In this experiment the Ss were reinforced if they took 2.5 sec or more to traverse the runway appropriately in approximately 10 trials. Cohen (1970) also used the DRL technique and an operant escape procedure which required dogs to endure a minimum duration of electric shock without responding in order for the response (a panel press with the head) to terminate the shock. He employed three cutoff criteria: 0, 2.25, & 7.00 sec and observed appropriate DRL performance for all three values and also that increasing the shock level didn't disrupt or interfere with DRL behavior.

In another study, Woods, Markman, Lynch, & Stokely (1972) investigated the effects of CRF versus PRF schedules as a function of different reinforcement magnitudes using the water runway procedure. In Experiment I two schedules (CRF & PRF) were factorially combined with two reward magnitudes (small - a 2° C. increase in the goal box,

and large - a 16° C. increase in the goal box). The acquisition data showed that the CRF Ss responded faster than the PRF Ss when a large reward magnitude was involved (similar to Bower, 1960) but no difference was observed for the Ss receiving small reward magnitude. A typical reward magnitude effect was observed, i.e., large reward produced faster asymptotic responding than did small reward. In extinction a PREE was observed for the large reward Ss but not for the small reward Ss. Experiment II investigated effects of CRF and PRF schedules after small, medium, and large amounts of reinforcement reduction (drops in goal temperature of 6°, 12°, & 22° C. respectively). During preshift (using an alley-goal differential of 26° C. - a large reward magnitude) the CRF groups performed faster than did the PRF groups (similar to Experiment I). In the postshift phase speeds for the large reduction Ss decreased with CRF Ss swimming slower (an effect similar to a PREE), for the medium reduction condition speeds for both CRF and PRF Ss decreased at approximately the same rate, and for the small reduction condition the CRF Ss showed no drop in speed while the PRF speeds dropped slightly and then returned to their preshift level. The authors concluded that a PREE-like effect can be produced when reward magnitude conditions approach those of extinction.

In a review of the appetitive partial reinforcement literature, Robbins (1971) concluded that Capaldi's (e.g., 1967) sequential theory was the most viable approach to the understanding

of partial reinforcement phenomena. Therefore, Seybert, Mellgren, Jobe, & Eckert (1974) performed five experiments to investigate the effects of a number of sequential variables in escape conditioning. Using the runway, shock-escape paradigm they examined the effects of N-length (number of consecutive N trials followed by an R trial), N-R transitions (an N trial followed by an R trial), pattern of N and R trials, in both single and double alternating sequences, and extended versus limited acquisition training. In the four experiments where CRF and PRF were compared, a PREE was observed, and it was also shown that resistance to extinction after limited acquisition was controlled by the number of N-R transitions, while after extended acquisition resistance to extinction was demonstrated to be a function of N-length (the Schedule of Reward X Level of Acquisition Training interaction commonly observed in appetitive situations). They also demonstrated that patterning behavior (slow speeds on N trials and fast speeds on R trials) would occur given sufficient massing of trials and relatively short inter-trial intervals. The authors interpreted their results as supporting the notion that the boundary conditions of Capaldi's sequential theory can be extended to include escape conditioning data. Thus, although there is a large quantity of published research dealing with the effects of manipulations of reinforcement schedules in the appetitive literature, relatively few studies using escape procedures to investigate schedule effects have been reported. The need for further

research in this area is readily apparent.

Several studies have been reported using a technique, known as the intermittent shock (IS) procedure, which involves manipulation of shock and non-shock trials rather than N and R trials. Although the IS procedure has produced data similar to that from experiments involving schedules of reinforcement, it is not analogous to the actual manipulation N and R trials since no primary motivation is present on the nonshock trials; and thus the generality of the results from the IS procedure may be limited. Jones (1953) found that rats given IS training in a runway during acquisition, ran faster during a period of "extinction" consisting of no shock anywhere in the apparatus than did rats given continuous escape training during acquisition, a result analogous to the PREE. Franchina and his coworkers have reported a number of studies utilizing the IS procedure in a two compartment shuttle-box apparatus, wherein a shock trial consists of shock in one side of the apparatus, a nonshock trial consists of the complete absence of shock, and extinction is a series of nonshock trials. Franchina (1966a) found that acquisition was a direct function of the percentage of shock trials (100% > 66% > 33%), similar to Bower (1960), and that extinction performance was an inverse function of the percentage of shock trials during acquisition (33% > 66% > 100%). Franchina & Snyder (1970) demonstrated patterning behavior in a single alternation (shock-nonshock) group, similar to Seybert, et al. (1974) but found relatively

little difference in extinction between the alternation group, a 100% (CRF) group and two other 50% IS groups, a result that agrees with neither the previous IS data (Franchina, 1966a), nor the actual escape-schedule data (Bower, 1960; Seybert, et al. 1974). In another study investigating extinction as a function of percentage of shock trials, Franchina (1971) again observed slower (although not significantly so) running on nonshock trials than on shock trials for single alternation Ss and greater resistance to extinction for 2 of 3 50% groups over a 100% group. This result together with those of Bower; Seybert, et al.; and Franchina (1966a) indicate that the lack of extinction differences observed by Franchina & Snyder (1970) is probably an anomalous finding.

In a study of transfer of escape training, Franchina (1968a) factorially combined 33%, 67%, & 100% preshift and postshift shock schedules. He found that both pre- and postshift performance was a direct function of percentage. A switch from 100% to 33% or 67% produced an immediate decrease in speed to the postshift level. A switch from 33% or 67% to 100% initially produced responding that was a direct function of preshift percentage but gradually increased to the level of the 100% group. A switch from 33% to 67% and vice versa produced performance which immediately attained the preshift level of the new percentage. In a similar study, Franchina (1968b) found that between day downshifts in percentage (e.g., 100%-33%) produced immediate performance drops while some between day upshifts

produced immediate increases in speed and some upshifts produced gradual increases in responding.

In a factorial design, Franchina examined the combined effects of schedule (50% & 100%) and ITI (1 min., 5 min., 1 hr., & 24 hr.). The results indicated that the 100% Ss responded faster than the 50% Ss at ITIs of 1 min., 5 min., and 1 hr., but no differences at 24 hr. Escape performance was inversely related to ITI under both schedules but the differences were more pronounced under 100% shock. In another study using percentage (50% & 100%) Franchina (1966b) also varied the schedule of discrete CS presentations (100%, 50%, and 0%). In acquisition, performance again was a direct function of shock percentage and the presence or absence of a CS had no differential effect. In extinction, with the CS present, resistance to extinction was an inverse function of percentage and again the CS variations produced no differential effects. Franchina & Snyder (1969) studied repeated acquisitions and extinctions of escape behavior and found that acquisition occurred more rapidly and extinction more slowly over successive phases.

The IS procedure has generated a quantity of interesting data; however, because of the lack of correspondence between the shock-nonshock procedure and the actual manipulation of N and R trials in a partial reinforcement situation, the results of IS experiments probably hold little immediate theoretical value.

Proposal

Capaldi's (1967) sequential hypothesis has received considerable support when appetitive instrumental conditioning procedures are used (e.g., Robbins, 1971). Recently, a number of studies have also demonstrated the importance of sequential variables in the punishment paradigm (Capaldi & Levy, 1972; Dyck, Mellgren, & Nation, 1974; Wroten, Campbell, & Cleveland, 1974). Only one published report (Seybert, et al., 1974), however, has indicated that sequential variables operate in escape conditioning. Thus, the proposed experiment, using a spaced trial instrumental escape procedure, will attempt to provide further evidence that the boundary conditions of sequential theory can be extended to include escape conditioning phenomena. Also, while some authors (e.g., Amsel, 1967) have concluded that sequential theory is applicable only for data collected at massed trials, others (e.g., Mellgren & Seybert, 1973; Seybert, Mellgren, & Jobe, 1973) have presented data indicating that sequential theory can explain both massed and spaced trial results. The results of the proposed experiment, to be conducted at widely spaced trials (ITI - 24 hrs), should provide further clarification for this question.

The proposed experiment will employ a factorial design to investigate two reliable sequential phenomena: patterned running and the Level of Training X Schedule of Reinforcement interaction (Capaldi, 1967). Two levels of training: 12 and 60 acquisition trials, will be factorially combined with three schedules of reinforce-

ment: continuous reinforcement (CRF); 50% PRF with N-lengths of 1 (i.e., single alternation-SA); and 50% PRF with N-lengths of 3 (3N). If sequential variables effect spaced trial escape performance in a manner similar to the way they effect performance in massed trial situations, it would be predicted that Ss in the SA-60 trial condition would learn to run slow on N trials and fast on R trials, i.e., they would pattern respond, while Ss in the SA-12 trial condition would not, since patterning usually takes 35-50 trials to develop. It would also be predicted that Group SA-12 would be more resistant to extinction than Group 3N-12, while Group 3N-60 would show greater resistance to extinction than Group SA-60 (a Level of Training X Schedule of Reinforcement interaction).

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Footnotes

1. For simplicity the term "drive" will be used in present review to describe the motivation, i.e., escapable aversive stimulation, utilized in the various experiments discussed. Thus the term, as used here, carries none of the theoretical connotations or implications of Hull-Spence theory, or for that matter, any theory of motivation, but rather is employed simply for its descriptive value.

APPENDIX B

STATISTICAL TESTS

SUMMARY TABLE FOR 3(SCHEDULES) X 3(TRIAL BLOCKS)
ANALYSIS OF VARIANCE ON START SPEEDS FOR GROUPS
RECEIVING EXTENDED ACQUISITION TRAINING

Source	MS	df	F
Total	.969	89	
Between	1.499	29	
A (Groups)	8.513	2	8.69**
Error	.980	27	
Within	.713	60	
B (Trial Blocks)	9.623	2	30.20**
AB	1.584	4	4.97**
Error	.319	54	

**p < .01

SUMMARY TABLE FOR 3(SCHEDULES) X 3(TRIAL BLOCKS)

ANALYSIS OF VARIANCE ON RUN SPEEDS FOR GROUPS

RECEIVING EXTENDED ACQUISITION TRAINING

Source	MS	df	F
Total	.059	89	
Between	.075	29	
A (Groups)	.048	2	.63
Error	.077	27	
Within	.051	60	
B (Trial Blocks)	.757	2	29.94**
AB	.048	4	1.91
Error	.025	54	

**p < .01

SUMMARY TABLE FOR 3(SCHEDULES) X 3(TRIAL BLOCKS)
ANALYSIS OF VARIANCE ON GOAL SPEEDS FOR GROUPS
RECEIVING EXTENDED ACQUISITION TRAINING

Source	MS	df	F
Total	.483	89	
Between	.525	29	
A (Groups)	.750	2	1.48
Error	.508	27	
Within	.463	60	
B (Trial Blocks)	.297	2	41.65**
AB	.114	4	.57
Error	.199	54	

**p < .01

SUMMARY TABLE FOR 3(SCHEDULES) X 3(TRIAL BLOCKS)
ANALYSIS OF VARIANCE ON TOTAL SPEEDS FOR GROUPS
RECEIVING EXTENDED ACQUISITION TRAINING

Source	MS	df	F
Total	.023	89	
Between	.032	29	
A (Groups)	.143	2	6.07**
Error	.024	27	
Within	.019	60	
B (Trial Blocks)	.262	2	28.62**
AB	.034	4	3.67*
Error	.009	54	

* $p < .05$

** $p < .01$

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
ANALYSIS OF VARIANCE ON TERMINAL ACQUISITION START SPEEDS

Source	MS	df	F
Total	.858	59	
Between	2.904	5	
A (Levels)	.370	1	.55
B (Schedules)	6.711	2	10.04**
AB	.365	2	.55
Error	.668	54	

** $p < .01$

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
ANALYSIS OF VARIANCE ON TERMINAL ACQUISITION RUN SPEEDS

Source	MS	df	F
Total	.059	59	
Between	.105	5	
A (Levels)	.274	1	5.05*
B (Schedules)	.036	2	.66
AB	.090	2	1.65
Error	.054	54	

* $p < .05$

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
ANALYSIS OF VARIANCE ON TERMINAL ACQUISITION GOAL SPEEDS

Source	MS	df	F
Total	.416	59	
Between	.697	5	
A (Levels)	.167	1	.43
B (Schedules)	.747	2	1.91
AB	.911	2	2.34
Error	.390	54	

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
ANALYSIS OF VARIANCE ON TERMINAL ACQUISITION TOTAL SPEEDS

Source	MS	df	F
Total	.016	59	
Between	.047	5	
A (Levels)	.031	1	2.33
B (Schedules)	.073	2	5.39**
AB	.029	2	2.14
Error	.013	54	

**p < .01

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
X 24(TRIALS) ANALYSIS OF VARIANCE ON EXTINCTION START SPEEDS

Source	MS	df	F
Total	1.108	1439	
Between	18.887	59	
A (Levels)	8.862	1	5.61*
B (Schedules)	301.234	2	190.56**
AB	208.814	2	132.09**
Error	1.581	54	
Within	.347	1380	
C (Trials)	8.807	23	49.51**
AC	.403	23	2.26**
BC	.629	46	3.54**
ABC	.378	46	2.12**
Error	.178	1242	

* $p < .05$

** $p < .01$

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
X 24(TRIALS) ANALYSIS OF VARIANCE ON EXTINCTION RUN SPEEDS

Source	MS	df	F
Total	.092	1439	
Between	.588	59	
A (Levels)	.090	1	.15
B (Schedules)	.193	2	.31
AB	.403	2	.65
Error	.619	54	
Within	.071	1380	
C (Trials)	1.349	23	27.41**
AC	.089	23	1.81*
BC	.044	46	.88
ABC	.040	46	.82
Error	.049	1242	

* $p < .05$

** $p < .01$

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
X 24(TRIALS) ANALYSIS OF VARIANCE ON EXTINCTION GOAL SPEEDS

Source	MS	df	F
Total	1.524	1439	
Between	4.855	59	
A (Levels)	3.494	1	.68
B (Schedules)	2.360	2	.46
AB	.295	2	.06
Error	5.141	54	
Within	1.382	1380	
C (Trials)	43.319	23	64.15**
AC	1.293	23	1.91**
BC	.484	46	.72
ABC	.496	46	.73
Error	.675	1242	

** $p < .01$

SUMMARY TABLE FOR 2(LEVELS OF TRAINING) X 3(SCHEDULES)
X 24(TRIALS) ANALYSIS OF VARIANCE ON EXTINCTION TOTAL SPEEDS

Source	MS	df	F
Total	.053	1439	
Between	.586	59	
A (Levels)	.071	1	.46
B (Schedules)	10.106	2	65.58**
AB	2.985	2	19.37**
Error	.154	54	
Within	.031	1380	
C (Trials)	.841	23	53.24**
AC	.019	23	1.18
BC	.055	46	3.46**
ABC	.012	46	.74
Error	.016	1242	

** $p < .01$

SUMMARY TABLE FOR 3(SCHEDULES) X 24(TRIALS) ANALYSIS OF
VARIANCE ON TRANSFORMED START SPEEDS IN EXTINCTION FOR GROUPS RECEIVING
EXTENDED ACQUISITION TRAINING

Source	MS	df	F
Total	.138	719	
Between	2.028	29	
A (Schedules)	15.650	2	15.36**
Error	1.019	27	
Within	.058	690	
B (Trials)	.915	23	46.08**
AB	.149	46	7.52**
Error	.020	621	

**p < .01

SUMMARY TABLE FOR 3(SCHEDULES) X 24(TRIALS) ANALYSIS OF
VARIANCE ON TRANSFORMED TOTAL SPEEDS IN EXTINCTION FOR GROUPS RECEIVING
EXTENDED ACQUISITION TRAINING

Source	MS	df	F
Total	.064	719	
Between	.446	29	
A (Schedules)	2.951	2	11.31**
Error	.261	27	
Within	.048	690	
B (Trials)	.598	23	22.88**
AB	.064	46	2.44**
Error	.026	621	

** $p < .01$