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THE FUNCTIONAL SIMILARITY OF AVERSIVE EVENTS: TRANSFER OF PERSISTENCE BETWEEN POSITIVE AND NEGATIVE REINFORCEMENT PROCEDURES

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BY

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THE FUNCTIONAL SIMILARITY OF AVERSIVE EVENTS: TRANSFER OF PERSISTENCE BETWEEN POSITIVE AND NEGATIVE REINFORCEMENT EVENTS

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This dissertation is dedicated to my family--my boys, Matt, Marc, and Ryan--and especially my wife Kathy, without whom I would be nowhere and nothing.

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THE FUNCTIONAL SIMILARITY OF AVERSIVE EVENTS: TRANSFER OF PERSISTENCE BETWEEN POSITIVE AND NEGATIVE REINFORCEMENT PROCEDURES

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Abstract

During Phase I of a 3 phase experiment, rats received 48 trials of partial or continuous reinforcement in either reward or escape training. Two control groups received only handling in this phase. During Phase II, the Ss were shifted to 20 trials of continuous reinforcement training of the type not experienced in Phase I (i.e., reward in Phase I, escape in Phase II and vice versa). Subjects were then extinguished in Phase III according to the same reinforcement mode used in Phase II training. Partial reinforcement experience in either reward or escape training transferred to the other reinforcement procedure and resulted in increased responding in either type of extinction. Implications for the generality of laws governing such diverse procedures as punishment, escape, and different nonreinforcement events were discussed.

THE FUNCTIONAL SIMILARITY OF AVERSIVE EVENTS: TRANSFER OF PERSISTENCE BETWEEN POSITIVE AND NEGATIVE REINFORCEMENT PROCEDURES

Daniel MacRae Wrather

University of Oklahoma

A number of studies have indicated the functional similarity of operationally different aversive events as they pertain to response persistence. Several studies have shown that prior experience with an aversive stimulus may serve to increase subsequent resistance to extinction of a food reinforced response. Ratliff and Clayton (1969), Brown and Wagner (1964), German (1969), and Dyck, Mellgren, and Nation (1974) all found that food reinforcement plus partial punishment (punishment on some, but not all trials) resulted in increased resistance to appetitive extinction relative to a food only (no punishment) control group. In addition, the Dyck, et. al. study demonstrated similar results in continuously punished extinction. Wong (1971a) used a slant runway to produce coerced approach to shock and found that prior experience with shock in the goalbox resulted in increased resistance to extinction of a food reinforced running response.

In a slightly different procedure, (Wong, 1971b) rats were coerced to approach shock by more severe shock or were punished for making competing responses. Both these procedures resulted in increased persistence of a hunger motivated running response.

The effect of increased persistence is not limited to shock punishment and the extinction of food reinforced responses, however. Terris and Wechkin (1967), and Terris and Rahhal (1969) demonstrated that subjects trained to approach food in the presence of intense shock were subsequently more resistant to a novel airblast punishing stimulus.

The present study was an attempt to extend findings which indicate that different aversive events may have common psychological properties. It was hypothesized that nonreinforcement was an aversive event with properties analogous to those of other aversive events such as shock or airblast punishment. Prior experience with a nonreinforcement event should therefore increase subsequent resistance to extinction. It would also be reasonable to assume that this nonreinforcement event may be of a different type than the reinforcement used in acquisition and extinction of the response. This view would indicate that prior experience with nonreinforcement in escape conditioning should result in increased resistance to extinction of an appetitively reinforced response relative to a condition where no prior experience with nonreinforcement in escape conditioning is given. Similarly, prior experience with nonreinforcement in reward conditioning should increase resistance to extinction of an escape response relative to a condition where no prior experience with nonreinforcement in reward conditioning is given.

Specifically stated, the hypothesis of the present study was that positive and negative nonreinforcement events share common psychological properties which operate to control response persistence regardless of the reinforcement type (either positive or negative) used in acquisition and extinction of the response. It follows that partially reinforced subjects in a reward conditioning procedure should be more resistant to escape extinction than continuously reinforced subjects, and vice versa.

Method

Subjects

Forty eight experimentally naive male albino rats were used as _S_s. The rats were approximately 80 days old, and were of the Sprague-Dawley strain purchased from the Holtzman Company. The _S_s were randomly assigned to one of 6 groups (_N_ = 8/group).

Apparatus

A commercially made straight alley (Hunter Co.) served as the apparatus for the experiment. Overall runway dimensions were 159.4 cm long, 15.24 cm high, and 10.16 cm wide. The alley was constructed of Plexiglas with a grid floor, and had a startbox 30.48 cm long, a runway section 91.44 cm long, and a goal section 3.48 cm long. Raising the startbox door operated a microswitch which closed a shock circuit to the grid of the start and runway sections of the alley. The start timer began when the startbox door was raised and stopped when the _S_ crossed a photobeam 5.08 cm inside the runway. The same photobeam started the run timer which was stopped by the _S_ crossing a second photobeam 15.24 cm from the end of the runway section. The goal timer was started when the second photobeam was crossed and was stopped when a third photobeam 5.08 cm inside the goalbox was crossed. A Grason Stadler shock scrambler was used to provide shock to all alley sections either simultaneously or independently as needed. A teaspoon mounted in the middle of the far end of the goalbox served as the foodcup. Fractionated and total times were converted to reciprocals and the results are reported in terms of this speed measure.

Procedure

Immediately upon arrival at the laboratory Ss were placed on ad lib. food and water. On the 8th day after arrival Ss were placed on a 10 gm daily food deprivation schedule and remained on the schedule throughout the rest of the experiment. On the 6th and 7th days of food deprivation Ss also received 4 Startina Hog Starter pellets (approx 100 mg. each) in addition to the regular food ration. On the next day Ss received 2 trials of pretraining during which escape groups received two .2mA escape trials and reward groups received 2 rewarded trials (procedures described below).

The actual experiment consisted of 3 phases as described below.

Phase I--Escape Groups. During this phase, 2 groups of Ss received escape training for 12 days (4 trials/day). On each trial the S was placed in the start box and 3 sec later the startbox door was opened and the S was allowed to traverse the alley. On a reinforced trial the S experienced .4mA shock in the start and run sections of the alley and escaped to no shock in the goal section. A nonreinforced trial occurred when .4 mA shock was experienced in all sections of the alley. Subjects were confined for 30 sec in the goal section whether shock was present or not. Group Continuous Escape (CE-R) received only reinforced trials in this phase while Ss in the Partial Escape group (PE-R) received 50% reinforced and 50% nonreinforced escape trials on a repeating 4-day schedule (RNRN, RNNR, NRNR, NRRN).

A third group, the Handle Escape group (HE-R) was handled in the same fashion as the other escape groups but received no training in the alley. Subjects were run in rotation in squads of 6 (1 S from each group) and the intertrial interval was approximately 5 minutes.

Phase I--Reward Groups. Two groups received reward training and were analogous to the previously described escape training groups. Group Continuous Reward (CR-E) received reward training for 12 days (4 trials/day) with two 100 mg pellets of Startina serving as the reward. Group Partial Reward (PR-E) received the same number of trials as the Continous Reward group but experienced 50% nonreinforced trials and 50% reinforced trials on the same schedule used for the Partial Escape group. Another handling group - Handle Reward (HR-E) - received the same handling as the reward groups but was not run in the alley. The reward groups were run in the same fashion as the escape groups with the mode of reinforcement (positive or negative) being the only difference.

Phase II. During this phase subjects were shifted to the type of reinforcement they had not experienced in Phase I. The escape training groups, CE-R and PE-R, and HE-R were shifted to continuous reward training for 5 days (4 trials/day). These groups also received two reward pretraining trials on the first shift day of Phase II making a total of 22 trials of reward training.

The reward groups, CR-E and PR-E, and HR-E were shifted to escape training in Phase II. All of these groups received continuously reinforced escape training (shock termination in the goal box on all trials). This phase also continued for 5 days (4 trials/day) in addition to 2 pretraining escape trials on the first day of Phase II (a total of 22 escape trials).

Phase III (Extinction). During Phase III all groups were extinguished according to the type of continuous reinforcement training experienced in Phase II. Groups which had experienced escape training or handling in Phase I and were then shifted to continuous reward training in Phase II (CE-R, PE-R, and HE-R) received 20 appetitive extinction trials (4 trials/day for 5 days) during which no food was present in the goal box.

Similarly, groups which had received reward training or handling in Phase I and were then shifted to continuous escape training in Phase II received 20 escape extinction trials (4 trials/day for 5 days) during which .4mA shock was present in all alley sections. Subjects were confined to the goalbox for 30 sec in both types of extinction.

It is important to note that all groups had experienced only continuous reinforcement in the mode of reinforcement under which they were extinguished. See Table I for an overall description of the procedure.

Insert Table 1 about here

Results

Since all measures were similar to the Total Speed measure, only analyses of total speed will be reported except for deviations in one of the fractionated measures from the pattern of results found in the total speed measure.

Phase I

The last 4 days of this phase were analyzed using a 2 (Mode of Reinforcement) X 2 (Schedule of Reinforcement) X 4 (Days) Repeated Measures Analysis of Variance. Handling groups (HE-R and HR-E) were not run in Phase I and thus could not be included in the analysis.

Results of the analysis of Total Speeds indicated that the only measure reaching an acceptable level of significance was the main effect of Mode of Reinforcement (F (1,28) = 8.77, $p < .01$) indicating the superior speeds of the reward conditioning groups over the escape conditioning groups. The only measure in which significance was not attained on the Mode of Reinforcement variable was the Run Speed measure (F (1,28) = 2.40, $p > .10$). No other effects reached an acceptable level of significance. The two left panels of Figure 1 show the performance of the 4 groups run in Phase I.

Insert Figure 1 about here

Phase II

Reward-to-Escape. Groups CR-E, PR-E, and HR-E were analyzed using a 3 (Groups) X 5 (Days) repeated measures analysis of variance. Results of the total speed analysis showed a significant Groups effect (F (2,21) = 21.10, $p < .01$) and Days effect (F (4,84) = 6.21, $p < .01$). The groups difference reflected relatively slower speeds by the HR-E group which received only the escape training of Phase II and reached a lower asymptotic speed. The significant Trials effect was due to the re-establishment of the running response under the different reinforcement conditions of Phase II (shifted from reward to escape training). The Groups x Days interaction failed to reach an acceptable level of significance ($\underline{F}$ (8,84) = 1.76, $\underline{p}$ < .01). This pattern of results occurred in the fractionated speeds analyses with the exception of a significant Groups x Days interaction in the goal speed measure ($\underline{F}$ (8,84) = 2.29, $\underline{p}$ < .05). This interaction was due to a relative slowing of the CR-E and PR-E groups in contrast with the slower, but relatively constant speed of the HR-E group. The performance during Phase II of the groups shifted from reward to escape training can be seen in the right panel of Figure 1.

Escape to Reward. Groups CE-R, PE-R, and HE-R were analyzed in the same manner as the reward to escape groups. The Total Speeds analysis revealed a significant Days effect ($\underline{F}$ (4,84) = 93.27, $\underline{p}$ < .01) and Groups X Days interaction ($\underline{F}$ (8,84) = 8.41, $\underline{p}$ < .01). Only the start speed measure was aberrant in that the Groups effect was also significant ($\underline{F}$ (2,21) = 4.41, $\underline{p}$ < .01). The significant Days effect was due to reacquisition of the running response under reward rather than escape conditions. The initial inferiority of the HR-E group which had not received Phase I escape training prior to reward training in Phase II accounted for the significant Groups X Days interaction. The significant Groups effect in the start speed measure was also attributable to the rapid and elevated acquisition of the rewarded reponse by the HE-R group. Comparisons of Total Speeds of the groups on the last day of Phase II demonstrated that the HE-R group was running significantly faster than either the CE-R or PE-R groups. (All comparisons were by the Tukey HSD *post hoc* procedure). The performance during Phase II of the groups shifted from escape to reward training can also be seen in the two right panels of Figure 1.

Phase III (Extinction)

Since there were differences between the groups at the end of Phase II, the data were subjected to Anderson's Rate Transformation (Anderson, 1963) to assess differences in *rate* of extinction.

Extinction data for Total Speeds were analyzed using two 3 (Groups) X 5 (Days) repeated measures analyses of variance. The performance of the groups under the two different types of extinction may be seen in Figure 2.

Insert Figure 2 about here

Escape Extinction. The results of the escape extinction analysis revealed significant main effects of Groups (F (2,21) = 12.20, p < .01) and Days (F (4,84) = 40.01, p < .01), as well as a significant interaction of Groups X Days (F (8,84) = 3.73, p < .01). The significant Days effect indicated that extinction did occur and the significant Groups effect indicated that the groups were ordered PR-E > CR-E = HR-E in extinction performance. *Post hoc* comparisons on the Groups X Days interaction indicated that there was nondifferential performance by the 3 groups on Days 1 and 2 of extinction followed by superiority of Group PR-E over Groups CR-E and HR-E on Days 3, 4, and 5 of extinction. Comparison of groups CR-E and HR-E indicated that their performance did not differ except on Day 4 of extinction. (All comparisons performed were Tukey's *post hoc* comparisons with a .05 confidence level.). The overall import of these results is that experience with nonreinforcement in reward training in Group PR-E increased resistance to escape extirction when compared with groups having no experience with nonreinforcement (as in Groups CR-E and HR-E).

Appetitive Extinction. The performance in reward extinction of groups CE-R, PE-R, and HE-R was analyzed in a manner analogous to that of escape extinction performance. The analysis revealed significant main effects of Groups (F (2,21) = 35.99, p < 101) and Days (F (4,84) = 68.05, p < .01). The Groups x Days interaction did not reach an acceptable level of significance. The Days effect indicated that extinction did occur, while the Groups effect indicated that the groups were different in terms of extinction performance. Comparisons of group means established that Group PE-R was superior to Group CE-R which was in turn superior to Group HE-R. These results indicate that prior experience with the aversive event of nonreinforcement in escape training (as in Group PE-R) increases resistance to reward extinction as compared with a group which has not experienced nonreinforcement in escape training (Group CE-R). Furthermore, experience with continuously reinforced escape from shock (Group CE-R) also increases resistance to reward extinction as compared to a group which has not had experience with shock in continuously reinforced escape training (Group HE-R).

Discussion

The results of this experiment indicate that experience with a partial reinforcement schedule in reward conditioning results in increased resistance to extinction of an escape response. Similarly, partial reinforcement in escape conditioning results in increased resistance to extinction of a food-rewarded response. Furthermore, continuously reinforced escape training also results in increased resistance to extinction of a food-rewarced response. These data broaden the boundary conditions of the fear-frustration transfer effects found by Brown and Wagner (1964) and others mentioned previously. In the Brown and Wagner type study, increased resistance to extinction of a food reinforced response was found when the Ss had been given prior experience with punishment in the goal box during food-reward acquisition. Similar results were found by Wong (1971b) when the "punishment" experienced was either shock-coerced approach training or punishment of competing responses.

In the present study, "punishment" in the goal box was the same as nonreinforcement for partially reinforced escape Ss and experiencing this "punishment" during negatively reinforced (escape) conditioning resulted in increased resistance to food-reinforced extinction. Similarly, if escape conditioning is conceptualized as a procedure in which responses other than those leading to the safe goal area are punished by increased shock duration (punishment of competing responses), increased persistence of an appetitively motivated response in the continuously reinforced escape group does not seem unexpected. Thus the occurrence of shock in the runway results in increased resistance to extinction of a food reinforced response regardless of the type reinforcement used to maintain responding in the face of aversive stimulation (punishment).

The complementary effect of the escape-to-reward transfer of persistence also occurs. Experience with nonreward in the goal box during reward conditioning results in greater resistance to extinction of an escape response. Such a finding is not unexpected. If approach training to punishment increases persistence to nonreward, it would appear that approach training to nonreward would increase persistence to punishment (nonreinforced escape responding) as was found.

Amsel's (1972) theory of persistence seems best able to handle the data of the present study. According to this view, continued responding in the presence of a disruptive stimulus (i.e., nonreinforcement of an escape response) results in the counterconditiong of the effects of the disrupting stimulation to the approach response. Later, when other disruption occurs (i.e., nonreinforcement in extinction of an appetitively motivated response), resistance to the later disruption is increased due to the apparent psychological similarity of the disrupting events. The mediation of extinction responding by different nonreinforcement events can clearly be interpreted as supporting this persistence viewpoint. Additionally, increased persistence in reward extinction following a prior phase of continuously reinforced escape training might be predicted using a similar analysis. Continued responding in the presence of shock in reinforced escape training results in counterconditioning of the disruptive shock to the approach response and culminates in increased persistence in the extinction of a food rewarded response.

It seems apparent that increased persistence may result from previous experience with events not traditionally viewed as important in the determination of later responding. Many different procedures (escape, punishment, nonreinforcement in the same or different reinforcement dimensions) seem to result in similar behavior (increased persistence in later responding). The findings of the present study seem to indicate even more strongly the possibility that many of the same psychological laws govern apparently diverse procedures. This view is a delimiting one in that the range of psychological laws needed for the understanding of different procedures may be less than that traditionally thought necessary.

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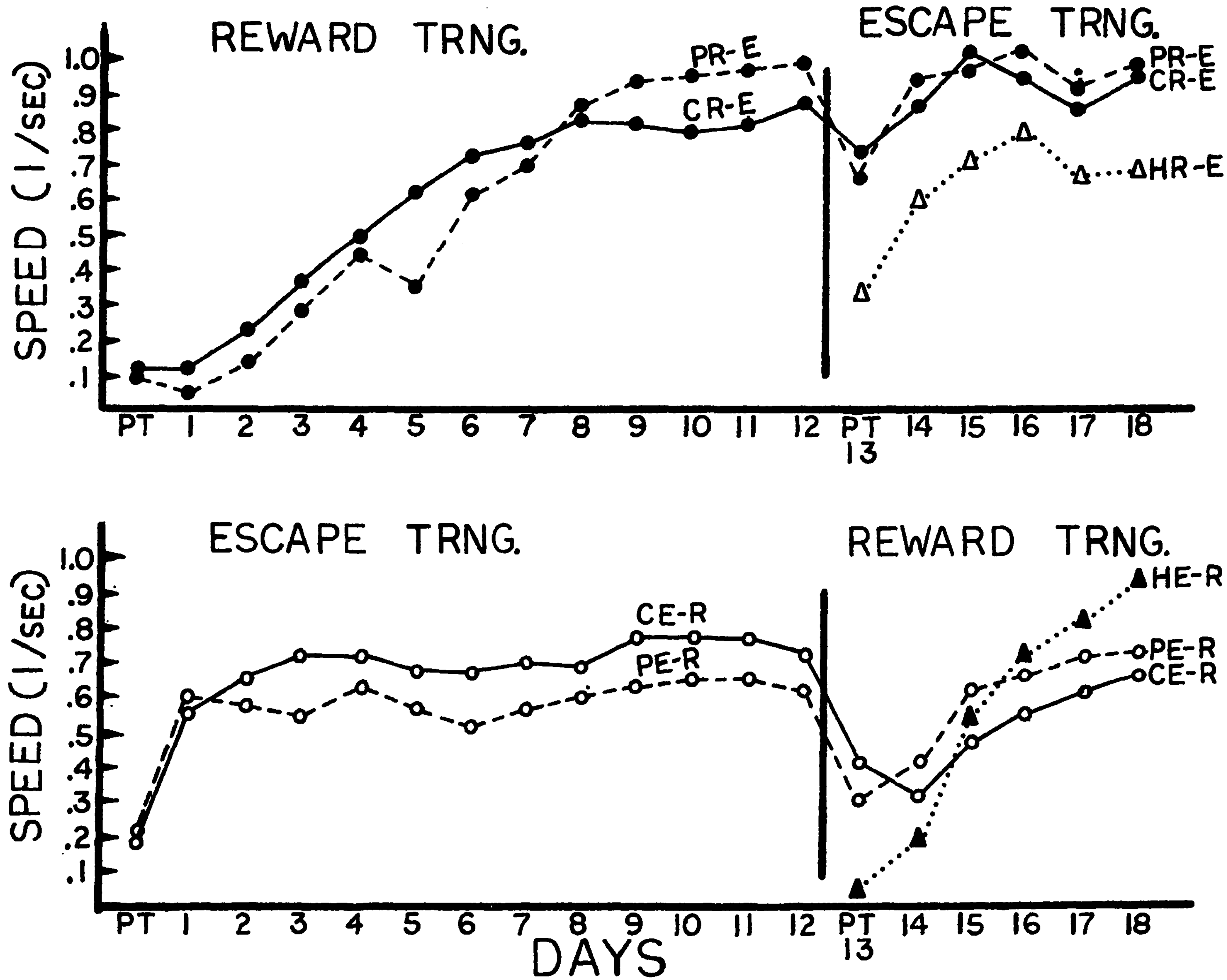
Figure Captions

Figure 1 Summary of Procedures used in successive phases broken down by Groups.

Figure 2 Mean running speeds over Pretraining (PT) and 12 days of Phase I training along with Phase II Pretraining (PT 13) and 5 days of Phase II training. The heavy black line represents the shift from Phase I to Phase II. Two trials of training were given on the pretraining days and 4 trials/day on other days.

Figure 3 Extinction Rate over the last day of acquisition and 5 days of extinction (4 trials/day).

GROUPS	PHASE I (12 Days)	PHASE II (5 Days)	PHASE III EXTINCTION (5 Days)
	PRF-Reward (PR-E) →	CRF-Escape →	ESCAPE EXTINCTION
	CRF-Reward (CR-E) →	" " →	" "
	HANDLE (HR-E) →	" " →	" "
	PRF-Escape (PE-R) →	CRF-Reward →	REWARD EXTINCTION
	CRF-Escape (CE-R) →	" " →	" "
	HANDLE (HE-R) →	" " →	" "



REWARD TRNG.
ESCAPE TRNG.
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.2
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PR-E
CR-E
HR-E
PT
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4
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8
9
10
11
12
PT
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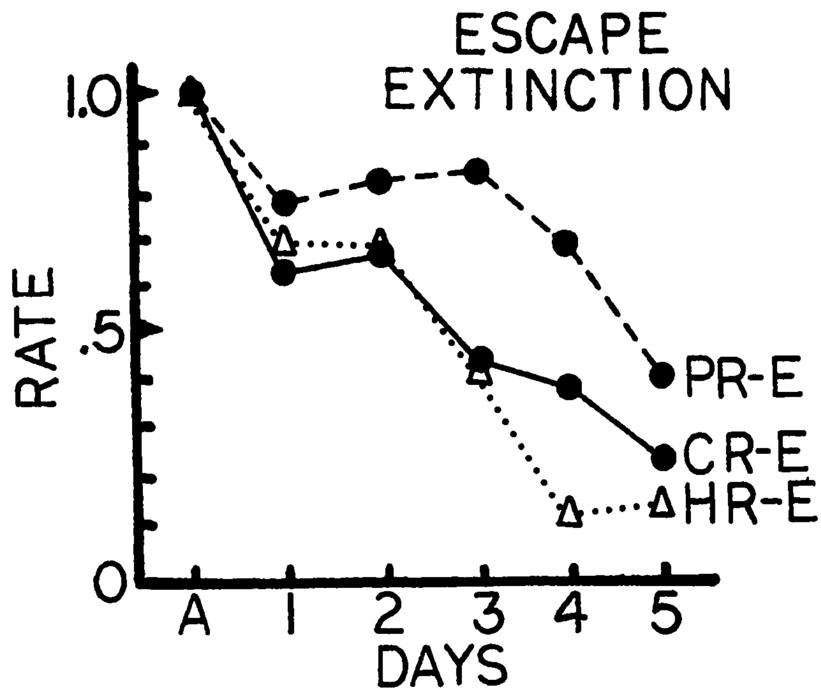
ESCAPE TRNG.
REWARD TRNG.
SPEED (1/SEC)
CE-R
PE-R
HE-R
DAYS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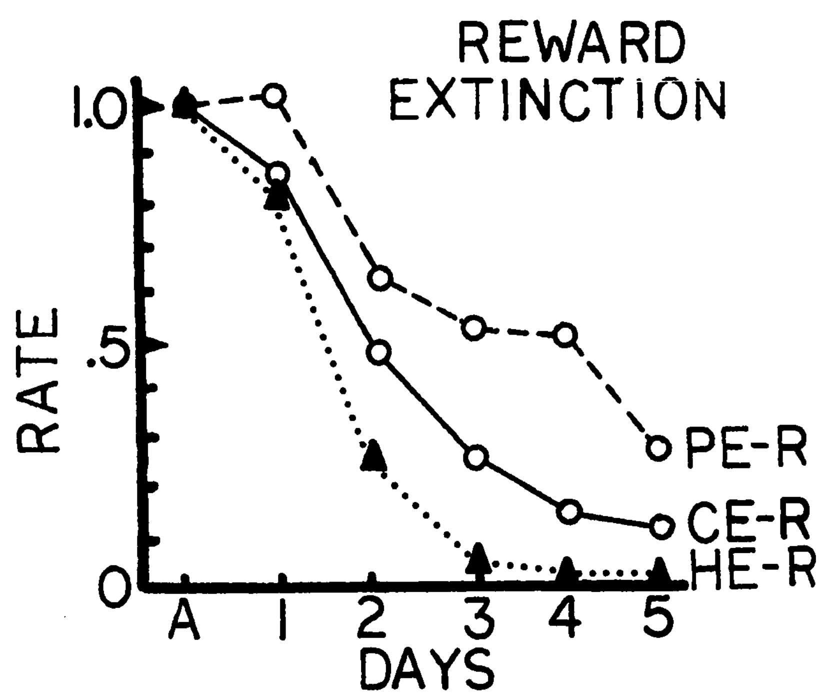
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APPENDIX A

PROSPECTUS

THE FUNCTIONAL SIMILARITY OF AVERSIVE EVENTS:

EFFECTS OF RESPONSE PERSISTENCE

Aversive events have traditionally been defined in terms of their suppressive effects on responding (Church, 1963). More recently, however, a number of researchers have found that experience with an aversive stimulus during the acquisition of a response may result in increased persistence of that response. Probably the most widely known finding of this type is the partial reinforcement extinction effect (PREE) in which experience with nonreinforcement in a partial reinforcement group produces greater persistence to continuous nonreinforcement relative to a group having experienced only continuous reinforcement (c.f. Robbins, 1971). The widespread impact of this literature on the psychology of learning has led numerous researchers to attempt to extend the boundary conditions of the effect. Recent research has indicated that experience in acquisition with aversive stimuli different from that used in persistence tests also increases response persistence.

The present paper will attempt to draw together evidence from a number of procedures and variables analogous to those used in investigating the PREE to determine the conditions which result in increased persistence to different aversive events. This analysis will not be concerned with PREE investigations themselves except as they apply to the general persistence literature. The review will also be limited in several other ways. Interpretation of studies which investigate the effects of aversive stimulation on selective learning or discrimination learning variables will not be included due to the complexity of such variables and the relative lack of knowledge about the effects of different aversive stimuli on response persistence in those procedures. A restricted approach which can be later extended to more complex situations is seen to have more utility in the present examination. Investigations which examine the effects of delay of reinforcement or omission training will also be deleted unless directly relevant. While considerable merit may be given to an analysis of delay or omission of reinforcement as aversive events with many similarities to the properties of nonreward, the present analysis will not include delay of reinforcement or omission training procedures within its scope.

The paper will be generally divided into an examination of the available data in positive and negative reinforcement procedures which directly examine the effects of changed motivation procedures and different reinforcement modalities on response persistence. Following examination of the data, two theoretical explanations will be described. Finally, a proposal to extend the boundary conditions of the persistence effects delineated in the review will be presented.

Due to the complex terminology used in many of the studies to be examined, a number of terms will defined here in the introduction. These terms will be used throughout the paper and will be further explained if variations are noted in particular studies.

Several terms will be used in relation to the first large division of the review--Responses Acquired Under Positive Reinforcement. Regular Training or Reward Training will refer to a procedure in which only positive reinforcement is given contingent upon a response. Punishment Training refers to a procedure involving reward training but in which an aversive stimulus is delivered contingent upon the reinforced response. Reward training on which some responses are nonreinforced will be referred to as Partial Reinforcement (PRF) while delivery of punishment contingent only on some trials will be referred to as Intermittent Punishment (IP). Turning to persistence testing procedures, Regular Extinction or Extinction involves a procedure whereby a positive reinforcer is not administered. (The term can also refer to a procedure used in the testing of persistence of escape of avoidance responding in which aversive stimulation-usually shock- is not present in any part of the apparatus.) Punished Extinction refers to a situation in which each response is punished but is not positively reinforced. (Again, some researchers use extinction procedures in escape and avoidance which involve punishment along with the above mentioned regular extinction procedure.)

Procedures which fall under the rubric of negatively reinforced responses include Escape Training, which refers to a procedure in which removal of an aversive stimulus is contingent upon a response. Avoidance Training denotes a situation in which a response within a designated period of time results in the nonocurrence of an aversive stimulus (alternatively, one could use Pavlovian terms and describe the procedure as when a conditioned stimulus (CS) is followed by an unconditioned stimulus (UCS) such as shock whenever the subject fails to make some designated response to the CS within a certain time period). There are also a number of procedures used in response decrement testing under negatively reinforced conditions. Escape extinction is a procedure in which a response does not remove the aversive stimulus which motivated the original acquisition of the escape response. (As previously noted, some researchers use a procedure in which no aversive stimulus is present in the apparatus as an excape extinction procedure. This is not analogous to the regular extinction procedures used in positively reinforced situations in that not only is reinforcement not present, but neither is the primary motivation for responding.) Avoidance Extinction refers to a procedure in which responding during the CS does not result in avoidance of an aversive stimulus. (Again, some researchers use the absence of aversive stimulation in the apparatus as a persistence testing procedure.) Other unusual avoidance response persistence tests will be discussed as encountered.

RESPONSES ACQUISITION UNDER POSITIVE REINFORCEMENT

This section will review situations in which the response is originally based on positive reinforcement. Studies mentioned in this section will involve the introduction of an aversive stimulus prior to training,in acquisition,or as a response decrement procedure to test for persistence of responding following acquisition. Almost all the literature associated with these procedures is concerned with the effects of punishment (usually shock) and nonreward introduced during the acquisition of a response and subsequent persistence testing in the presence of continuous shock (punished extinction) or continuous nonreward (regular extinction). This section will review these procedures and related procedures along with several miscellaneous studies.

<u>Performance During Punished Extinction</u>

<u>Punishment Training</u> -- Miller (1960) investigated the effects of punishment training with positive reinforcement during the acquisition of a running response. He found that gradual increments in shock intensity (125 v. to 335 v.) superimposed on the continuous food schedule resulted in faster running speeds to the final level of punishment relative to a control group which had not experienced the lower levels of punishment during acquisition. Subjects exposed to gradual increase in shock intensity in a distinctively different shock box did not demonstrate increased resistance to the highest level of punishment in extinction. Additionally, sudden introduction to the highest level of shock rather than gradual introduction served to decrease the relative superiority of a punishment training group. A conceptually similar study by Kurtz and Walters (1962) involved prior shock experience followed by approach training and then punishment training as a response decrement test. Results indicated decreased persistence to the punishment training session for preshocked subject relative to no-shock controls. While appearing to be in clear contract to the Miller (1960) results, several procedural differences may account for the differences found by Kurtz and Walters. Most obvious is the difference in administration of shock intensity to the subjects. The Miller study involved gradual introduction of increased intensities while Kurtz and Walters used sudden introduction of the final shock level at the start of the punishment training phase. Perhaps more important, however, may be the locus of the punishment in the response

chain. The onset of punishment was coincident with the initiation of eating in the Kurtz study, but shock followed the completion of eating in the Miller study. Additionally, subject were allowed only a bite of food in the Kurtz study during the punishment training phase, a relatively small reward magnitude compared to the bean sized pellet of wet mash used as reward by Miller. Subsequent re-lications of the Miller (1960) study by Martin (1963) and Martin and Ross (1964) as well as conceptually similar experiments in discrete trials bar pressing situations (Karsh, 1964a; 1966) tend to support the conclusion that procedural differences may account for the differences between the Miller and Kurtz studies.

Several investigations involving reward magnitude manipulations should be mentioned in this area. Ferraro (1966) manipulated magnitude of water reinforcement prior to punishment training. His results indicated that resistance to punishment training was inversely related to the magnitude of reinforcement in acquisition. Ratliff, Koplin, and Clayton (1968) trained rats with small and large reward (1 or 8 pellets) in a runway and found that large reward resulted in decreased persistence in punished extinction relative to small reward. Similar reward magnitude results are reported by Hulse (1958) and Wagner (1961) in regular extinction following reward training. Wagner (1966) and Capaldi (1967) have hypothesized that goal events are distributed along a continuum of aversiveness. Following their reasoning, it could be hypothesized that various stimuli may possess more or less functional similarity according to proximity on the continuum (i.e. nonreward similar in function to punishment). This view could be extended such that experience with an event (small reward) more similar to the aversive event experienced in persistence testing (nonreward or punishment) might result in greater persistence than experience with a less aversive event (large reward). By this analysis, then, the previous continuous punishment results may be conceived as similar to the small magnitude results found by Hulse and Wagner.

Partial Punishment -- Intermittent punishment (IP) of an instrumental response increases its persistence to continous punishment relative to a non-punished control group -- a phenomenon called the Intermittent Punishment Effect (IPE) by Banks (1966a). The Banks (1966a) study used shock on 3 of 10 CRF trials for an experimental group and found that those subjects were significantly more persistent to punishment training than no-shock control subjects. Banks (1966b) extended the generality of the effect by giving an experimental group shock trials coupled with nonreward in a 30% schedule (shock and nonreward occurred together). A second group received the same training except that shock was given in a different apparatus to control for adaptation to shock. A third group received PRF training with no shock. The results of punished extinction analyses indicated that IP-nonreward subjects were more persistent than noncontingent shock-nonreward subjects, who were superior to the PRF only group. The study was replicated by Kinler and Banks (1969) with the addition of a control group which received partial punishment placements in the same apparatus as the experimental group. The added control group was inferior to the IP-nonreward group when tested in punished extinction as were the control groups also used in the Banks (1966a) study (no differences between the controls). Banks and Torney (1969) employed a similar procedure but used qualitatively or quantitatively different punishers during the response decrement testing phase (punished extinction). In experiment I, intermittent shocks of a .3 mA intensity were administered on 15% of the trials during acquisition of a running response which was reinforced with a .90 mg food pellet. Subsequent persistence testing demonstrated increased resistance to .6 mA punished extinction in the IP group relative to a no punishment control group which received only shocked placements along with acquisition training. Experiment II demonstrated a similar effect with a different punisher. The same treatment was given control and experimental subjects during acquisition. Punished extinction, however, consisted of dropping the guillotine door of the goal box on the subject's tail. These results indicate not only that the IPE is a reliable phenomenon but that there is a presumed similarity between the anticipatory states elicited by an electric shock and a tail pinch. Experiment III involved an investigation of IP to determine if it would increase resistence to regular extinction. This investigation was prompted by the findings of Banks (1966a) which indicated that PRF also resulted in decreased persistence to punished extinction compared to CRF subjects and the contrasting findings by Brown and Wagner (1964) who reported increased persistence to punished extinction following PRF (again compared to a CRF group). Banks and Torney found that under conditions of IP in acquisition (0.3 mA on 15% of the trials) resistance to extinction was not increased relative to control subjects receiving shocks on placement trials during acquisition. While the data for Brown and Wagner (1964) have not been discussed, there are several plausible explanations for the differing results in the two experiments. Magnitude of reward was three times as high (.13 gm vs. .45 gm) and punishment two times as high (approx .6 mA vs. .3 mA) in the Brown and Wagner study. If these differences were not enough to cause the difference in results, the fact that punished placements were used by Banks and Torney in their control group while Brown and Wagner used a CRF control group might also have had an effect. Placement procedures have been shown to have effects beyond those of simple habituation control operations (c.f. Capaldi, 1967) and so the punished placement would not be equivalent to a CRF group. This being the case, a direct comparison of the results of the two studies is difficult.

The data presented in the preceding paragraph indicate several relationships involving similar effects using different aversive stimuli. It seems clear that partial punishment produces persistence effects to punished extinction over that obtained with PRF alone. Additionally, under certain conditions, experience with nonreward may increase resistance to punished extinction. Factors affecting the transfer of persistence across different aversive stimulus conditions will be discussed later.

Performance During Regular Extinction

Intermittent Punishment — Martin and Ross (1964) trained subjects to run in a straight alley for water reinforcement (20 licks per trial from a drinkometer tube). On half the trials gradually increasing shock was introduced up to a maximum of 30 v. for subjects in the experimental group. A control group received only water reinforcement and did not receive punishment. A total of 224 acquisition trials were given followed by 112 regular extinction trials. Resistance to extinction was shown to be greatest for IP subjects in both start and combined sectional running speed measures relative to the performance of the nonshock control group. Fallon (1971) used a double runway to investigate the effects of various reward conditions in the first goal box on subsequent performance in the second runway portion of the apparatus. In a 2 X 2 factorial design, Fallon crossed large and small reward (three 45 mg pellets vs. one 45 mg pellet) with 50 and 100 % reward. In addition, the 100% reward group received 50% punished trials (450 v.). These conditions were in effect in the first runway. In the second runway all subjects received continuous reinforcement. It was hypothesized that punishment which occurred on reinforced trials would reduce the effects of large reward magnitude. Presumably this effect would result in similar performance by the 100% large - 50% punishment group and the 100% small group. Results demonstrated the hypothesized relation to be a correct one in that performance in the second runway and during extinction in the first runway were not different between the small reward and punished-large groups. Recall now the results obtained by Ferraro (1966) and Ratliff and Clayton (1969) in which small reward in acquisition resulted in greater persistence in punished extinction relative to large reward.

Their results supply an analogy for the Fallon (1971) results under the different conditions, that is, small reward (made functionally small by punishment) to regular extinction.

Linden (1974) has investigated the effects of different punishment intensities during intermittent punishment of an appetitively reinforced running response. Linden used 5 groups which received 6 T/day; Group C received 84 trials of CRF, Group N received 3 nonrewarded and 3 rewarded trials (total of 84 T), and the remaining 3 groups received 3 trials of shock of 125, 150, or 175 v. respectively on 3 of the 6 CRF trials they received each day. Following the completion of acquisition training, 60 extinction trials were administered (6 T/day). Results indicated that the 125 v. IP group did not differ from the CRF control while the remaining 3 groups were significantly different. The PRF group was most resistant, followed by the 175 v. IP group and then the 150 v. IP group. Again, these data are consistent with the findings of Fallon (1971), and those of Ferraro and Ratliff and Clayton in showing a functional similarity between shock and nonreward.

Interactions Between Nonreinforcement and Punishment

Training with shock and nonreinforcement -- The previously mentioned results of Miller (1960) in which prior punishment training resulted in increased resistance to punished extinction relative to a non-punished control led Brown and Wagner (1964) to test the possibility of transfer of persistence between nonreward and punishment training. They trained 3 groups of rats in a straight alley. Group C received a CRF schedule with .135 g wet mash delivered contingent upon the running response. Group N experienced nonreward on 50% of the trials during acquisition. Group P received punishment training during which shock was gradually increased from 75 to 235 v. Only 50% of the trials were shock trials for Group P. Acquisition consisted of 112 trials (6 T/day). There were no significant differences between the groups (F (2, 85) = 2.96, p = .06) in acquisition, although the punishment group was slightly inferior to the C and N groups. In extinction testing, each of the three groups were divided into 2 subgroups, with one subgroup receiving extinction, and the other receiving punished extinction. Clear results of transfer of persistence between punishment and nonreward were apparent in both response decrement procedures. Exposure to either nonreinforcement or punishment during acquisition produced increased persistence to both extinction and punished extinction. In fact, running speed for Group P subjects given punished extinction and Group N subjects given regular extinction showed very little decrement over a 6 day test period (8 T/day). Of more interest, Group P was more resistant to extinction and Group N was more resistant to punished extinction than Group C in extinction and punished extinction, respectively. Thus, in punished extinction the groups were ordered P> N>C, and during extinction testing, N >P>C. This was a landmark study in kindling interest in the cross-paradigm transfer of persistence. It was clear evidence that theories would have to be able to handle situations involving the transfer of persistence between different aversive events.

Uhl (1967) utilized a fixed-ratio procedure which was conceptually similar to the runway procedure used by Brown and Wagner (1964). Church and Raymond (1967) failed to find increased resistance to punished extinction foblowing punishment training during one phase of acquisition and so Uhl attempted to determine the generality of persistence transfer in operant analogs of the discrete trial paradigm. Uhl used a 3 X 2 X 2 factorial design incorporating 0%, 50%, and 100% punished trials; 50% and 100% reinforcement with a 30% sucrose solution, and punished versus unpunished extinction. Uhl found that increased levels of punishment during acquisition varied inversely with running speed and resulted in a decrease in running speed for all groups relative to continuous reinforcement and partial reinforcement groups. Extinction testing confirmed and extended the results reported by Brown and Wagner in that resistance to extinction, with or without punishment, was increased by punishment experience in training relative to a CRF control group with no shock experience in acquisition. In addition, the absence of an interaction between the experimental variables indicated transfer between the aversive events and confirmed Brown and Wagner's results demonstrating that punished subjects were more resistant to the effects of nonreinforcement, and partially reinforced subjects were more resistant to punishment (relative to CRF control groups).

Ratliff and Clayton (1969) replicated Brown and Wagner (1964) with the addition of shock combined with nonreward on acquisition trials and a wide range of reinforcement percentage schedules and shock intensities. A 4 X 3 X 2 factorial design was used which incorporated four percentages of reward (25%, 50%, 75%, and 100%), three extinction punishment intensities (0, .8, and 1.6 mA), and two experimenters. As mentioned previously, shock was given on nonreward trials in acquisition and consisted of .8 mA for Lo shock groups and 1.6 mA for Hi shock groups. Examination of extinction rate analyses indicated that resistance to extinction was greater for partial reinforcement groups as compared to the CRF control group (reflecting the typical PREE, Robbins, 1971). In terms of resistance to punishment extinction, subjects trained and extinguished under the .8 mA punishment condition reflected an Intermittent Punishment Effect (IPE). The 50% and 75% punishment groups did not differ and demonstrated greater resistance to punished extinction relative to the 25% and 100% reinforcement groups which did not differ. In the 1.6 mA condition, however, no differences in persistence to punished extinction were shown. While somewhat troubling, the fact that intense punishment extinction suppresses responding may only reflect the difficulty in detecting acquisition differences due to the very rapid extinction caused by the strong punishment. Consistent with this interpretation is the fact that the 1.6 mA groups extinguished within 6 trials while .8 mA groups took 12-15 trials to extinguish. The addition of a boundary condition such as limited intensity of shock in no way affects the theoretical treatment of the results. The decreased persistence of the 25% punishment group in .8 mA extinction may indicate that substantial experience with punishment during acquisition is necessary to increase response persistence to subsequent continous punishment. Overall, the results of Ratliff and Clayton (1969) extend the findings of Brown and Wagner (1964) while also suggesting limits within which response persistence transfer may operate. The results provide further support for a view emphasizing the similarities of nonreward and punishment.

Torney (1973) investigated persistence to punishment training (reward and punishment both present) in groups receiving: (a) CRF in acquisition (b) PRF in acquisition (c) IP in acquisition, and (d) IP and PRF (50%) with two aversive events occuring on the same trial. Shock for the IP groups during acquisition training consisted of .32 mA applied to the food cup and grid floor of the goal box. Reward on all trials was three 45 mg pellets. Following 160 acquisition trials (20 T/day, 13 min intertrial interval), subjects received 20 punishment trials on which all subjects received a 3.0 mA shock for 1 sec and reward upon arrival in the goal section. Subsequent analysis of the punishment training data indicated that IP-PRF subjects were more resistant than IP-CRF subjects who were in turn more resistant than the PRF and CRF groups (which did not differ). These data are consistent with previous data (Ratliff and Clayton, 1969) which indicate that experience with PRF and IP together increases persistence relative to CRF groups. They also might be taken as support for the previously cited data of Fallon (1971) indicating that punishment may functionally reduce reward magnitude in a CRF group (IP-CRF) and cause it to demonstrate increased persistence to later aversive events. It should be noted that the results indicating equivalent performance in the CRF and

PRF groups reported by Torney may be a function of the high punishment intensity used in punishment training relative to that experienced by PRF subjects in acquisition training. Ratliff and Clayton (1969) reported no differences in punished extinction with a 1.6 mA shock intensity. If there is indeed a boundary condition limiting shock intensity then the 3.0 mA intensity used by Torney may very well have exceeded it. Perhaps the effects of experience with IP and PRF were strong enough to overcome the stimulus generalization decrement involving approaching a punishment of 3.0 mA, resulting in the increased persistence of the IP-PRF group. Torney notes that subsequent work in his laboratory has demonstrated increased resistance of PRF relative to CRF training groups with subsequent 1.5 mA punishment training.

Subsequent research by Linden and Hallgren (1973) and Linden (1974a; b) has extended the hypothesized similarity of nonreward and punishment. Linden and Hallgren trained groups with either PRF or IP and tested subsequent persistence of responding to either extinction or punishment training. Additionally, a block of continuously reinforced trials was interpolated between acquisition and subsequent response suppression testing. Acquisition groups were the same as those employed by Brown and Wagner (1964). Group C received 6 CRF trials per day with a 1 min ITI. Group N also received 6 trials per day but 50% of the trials were nonreinforced. Group P was given 6 CRF trials per day with punishment administered on 50% of the trials (administered .5 sec after the subject picked up the reinforcement pellet). The intensity of the punishing shock was gradually increased over the course of the 18 days of acquisition from 75 to 235 v. (as in Brown & Wagner, 1964). Following acquisition training 30 continuously reinforced trials were given over 5 days. Extinction testing then was begun with one half of the subject from each group assigned to receive either extinction or punishment training (punishment on CRF trials). Acquisition data for the last day of training and the 5 days of CRF training showed no significant differences between groups. This observation was of interest because of the observation by D'Amato (1969) that the increased resistance shown by Brown and Wagner (1964) in partially punished subjects might be due to the removal of punishment during extinction - a sort of positive contrast effect due to the shift from punishment conditions to nonreward similar to that reported in an operant study by Azrin (1960) following removal of punishment in an operant chamber. No such increases were noted in the CRF interpolated block of trials used by Linden and Hallgren. Recent research by Nation, Mellgren, and Wrather (1975) involving an examination of contrast effects with shifts in punishment level also seems to refute the D'Amato hypothesis. Shifts from small to large magnitude of punishment resulted in negative contrast but corresponding shifts from large to small magnitude of punishment failed to result in positive contrast (an increase in speed relative to a non-shifted control group). The Linden and Hallgren analysis of response decrement procedures indicated that Group N was superior to Group P which was superior to Group C in extinction, while Group P was equal to Group N and both were superior to Group C in punishment training (punishment plus continuous reinforcement). These results may be taken as further confirmation of the functional commonality of nonreward and punishment during persistence testing. These finding replicate those of Brown and Wagner (1964) and extend the effect to show that the effects are sustained through a block of continuously reinforced trials. If anything, the persistence shown to punishment training is enhanced relative to that shown by Brown and Wagner as evidenced by the nondifferential speeds of Group N and Group P in the present study.

Linden (1974b) trained rats to make an approach response with either partial reward, intermittent punishment, or a combination of IP and PRF. Subjects were subsequently tested for persistence to extinction, punishment training, or punished extinction. Acquisition training involved rewarded trials with a 45 mg. food pellet, punished trials involving shock increased over trials from 125 volts to 175 volts, nonreward trials, or combinations of the three given in the following manner: a) Group C received 6 CRF trials each day, b) Group N received 6 trials of 50% PRF each day, c) Group P received 6 trials of punishment training (reward and shock) each day, and d) Group PN received 3 trials like Group N and 3 trials like Group P each day (occurance of P and N randomly assigned). Acquisition training continued for 10 days with 10 minute intertrial intervals. Following acquisition, all subject received 6 days (6 T/day) of CRF trials. During persistence testing, the four acquisition groups were randomly divided among the three procedures of a) extinction b) punishment training, and c) punished extinction. Extinction shock intensity was 175 volts, the same intensity as experienced during the late stages of acquisition. Analysis of extinction indicated that Groups P and PN were superior to Group N which was in turn superior to Group C. The same relationships were found to hold during punishment training. Under punished extinction conditions, however, Groups PN and P were not different with respect to persistence, but were superior to Groups N and C, which also did not differ significantly. These results agree with the prevously reported investigations of increased persistence and transfer of persistence produced by partial reward and intermittent punishment during approach training (esp. Brown and Wagner, 1964; Linden and Hallgren, 1973). The present study indicates that the combination of these training procedures produced resistance to extinction and to punishment training that was equal to exposure to only nonreward or punishment during acquisition. A somewhat troubling finding, however, is the failure to find evidence for increased persistence to punished extinction following PRF training (relative to a CRF control group). One possible explanation of the failure may be due to the smaller number of nonreward occurances (30) which occured in this study compared to the 54 nonreward occurances in Brown and Wagner (1964) and Linden and Hallgren (1973). Certainly this finding does not fit well with the previous results indicating increased persistence to punished extinction following partial reward training (Brown and Wagner, 1964; Linden and Hallgren, 1973) and may be an anomalous finding.

The Effects of Locus of Aversive Stimulation During Training

Muenzinger (1934) devised a selective learning experiment in which he found that punishment of the "right" response served to increase the rate of learning and mastery of the task. While the

Muenzinger study is not of direct interest in the present paper it is of importance because of the number of studies it engendered to investigate the problem of the effects of locus of punishment. While the "jury is still out" involving selective learning and locus of aversive stimulation, perhaps examination of a number of persistence transfer studies may serve to illustrate principles involved and variables affecting locus of aversive stimulation and persistence transfer.

Holz and Azrin (1961) manipulated punishment administration so that it occured on either nonreinforced or reinforced responses. Under these conditions punishment came to be a discriminative stimulus. The 60 volt shock which occured on reinforced trials alone was shown to increase subsequent responding while the shock which was given only on nonreinforced responses resulted in a decrease in response rate. These data demonstrate that punishment can serve other functions than simply to suppress responding when contingent upon a response.

The investigation of discrete trial analogs to the Holz and Azrin finding proceeded with a study by Scull and Vechseler (1972). These researchers gave three groups of rats PRF (50%) training in a straight runway. Two groups also experienced gradually increasing shock (.1 to .25 mA) over the 160 trials of acquisition. One of the punished groups received punishment on reinforced trials while the other received shocks on nonreinforced trials. Both punished groups were shown to be inferior to the PRF group. Additionally, the group punished on rewarded trials was superior in terms of running speed and evinced fewer retraces during the acquisition of the response. Unfortunately extinction data were not obtained in this study. The results are consistent with the hypothesis that punishment can serve as a discriminative stimulus using a discrete trial procedure as in operant studies.

Fallon (1968; 1969) has reported data indicating that performance during unpunished and punished extinction is increased when, during training, punishment is administered on nonreinforced rather than on reinforced trials. Fallon (1968) trained four groups of rats to press a lever for a dilute saccharin solution on a 50% PRF schedule. Group R was shocked (.25mA) after licking each presentation of a wet cup (reinforced occasion), Group N was shocked after licking each presentation of a dry cup (nonreinforced occasion), and Group H was punished after half the reinforced occasions and half the nonreinforced occasions. The fourth group, Group C, was never shocked. To test for persistence, half of each group was shifted to unpunished extinction while the other half was shifted to 50% punished extinction (punishment on half of the nonreinforced occasions). Analysis of the acquisition data indicated that all punished groups were inferior to the control group. Unpunished extinction data indicated that Group H was superior to all other groups, which did not differ from one another. Punished extinction data, on the other hand, indicated that Groups R and H did not differ and were superior to groups N and C, which also did not differ. Fallon (1969) subsequently replicated his previous (1968) study with the addition of groups receiving 50% punishment on N trials (IP_N) or

R trials (IPR). The results indicated that subjects receiving intermittent punishment on N trials show more persistence to extinction than do those groups receiving intermittent punishment on R trials. While these results and those of Scull and Vechsler (1972) seem contradictory, the fact that subjects punished on nonreinforced trials demonstrated a nonsignificant trend to be inferior to subjects punished on reinforced trials may indicate that slight procedural variables may be responsible for differences observed. Additionally, the added aversiveness of partial punishment in addition to PRF may account for the superiority of the IPN group in extinction.

In a double runway study already discussed, Fallon (1971) hypothesized that punishment occuring on reinforced trials would functionally reduce the effects of large reward magnitude. His results indicated that a punished large reward group was superior to a large CRF group but did not differ from a small reward CRF group in alley 2 speeds. This analysis indicates that punishment of nonreinforced trials does not result in a functional decrement of reward magnitude while punishment of reinforced trials does have such an effect. This could very easily be interpreted to be consistent with the Hulse (1958), and Wagner (1961) findings that large reward on a PRF schedule results in greater persistence relative to small magnitude of reward on a PRF schedule. This interpretation would not imply superior performance by subjects punished on N trials in acquisition, as was found by Scull and Vechsler (1972), however.

A pair of studies by Campbell and his associates (Campbell, _et al_, 1972a,b) have indicated that rats can discriminate regular patterns of reinforcement (1972a) and are able to utilize shock on N trials as an additional source of information about the response contingencies existant in runway training. Subjects who received shock contingent on N trials showed a greater decrement than subjects without the additional source of stimulation. In the (1972b) investigation, rats learned an alternating schedule and achieved a pattern discrimination involving N and R trials. These studies indicate that attending to the sequence of occurences in acquisition of a response is a potentially important variable.

Several recent investigations have taken the empirical finding that punishment on N trials increases response persistence and incorporated it within the Sequential Theory framework elucidated by E. J. Capaldi (Capaldi, 1966; 1967; 1970).

Dyck, Mellgren, and Nation (1974) trained rats to traverse a runway to obtain food according to the following groups. A CRF group obtained food contingent upon every running response in the runway. A PRF group was employed such that reinforced trials followed nonreinforced trials (N-R transitions). An intermittent punishment group received punishment imposed on nonreinforced trials such that punished trials occured prior to reinforced trials. Sequence of N and R trials and P and R trials was the same for the PRF and IP group respectively. Persistence testing involved splitting of the groups such that half of each group received regular extinction training and the other half of each group received punished extinction. Results indicated that the PRF group was more resistant to regular extinction than the IP group while in punished extinction the IP group was more resistant than the PRF group. The CRF group was inferior to the other two groups in both persistence testing procedures.

These results indicate again that similarity of function seems to operate between different types of aversive stimulation. In addition, the results of the experiment are clearly predicted by Capaldi's theory. The similarity between the aversive stimulus experienced during acquisition and associated with the instrumental response and the related stimulus experience during extinction or other type of persistence test is crucial. This similarity is assumed to contribute to increased resistance to subsequent aversive stimulation because of the capacity of the aversive event in persistence testing to produce the instrumental response. It seems then to be a rather straightforward prediction to postulate that experience with PRF leads to greater persistence in regular extinction and that IP leads to greater persistence in punished extinction.

Wroten, Campbell, and Cleveland (1974) employed 36 rats in a study involving 16 days of PRF training. During the final 12 days each animal received one punished trial per day. One group received punishment on an N trial preceding an R trial (P-R). A second group received punished trials following reinforced trials (R-P transitions) but no P-R transitions. An additional control group received punishment after completing all daily trials. To test persistence, the groups were split with half of each group receiving extinction and the other half receiving partial reward with continuous punishment. During extinction, the P-R and control animals were equal in persistence but both were superior to the R-P subjects. During punished extinction, P-R animals were more persistent than either the R-P or control animals which did not differ. These findings indicate that when the aftereffects of punishment are conditioned to the approach response, facilitated responding may often occur to another aversive situation (i.e. extinction). The authors note that a low number of training trials may have attenuated the results somewhat in this investigation.

Capaldi and Levy (1972) in the first of two experiments replicated the findings of Wroten, et al (1974) and found that a group receiving P-R transitions was superior in resistance to continuous punishment relative to both the R-P and control groups. In the second experiment it was found that increased persistence could be obtained by an increase in magnitude of reinforcement of trials following punishment (with nonreward). Conversely, increasing magnitude of reinforcement on trials preceding punishment resulted in decreased persistence to punished extinction. These results indicate that increasing reinforcement magnitude on trials preceding punishment decreased persistence to punished extinction, but increasing reward magnitude on trials following punishment increased persistence. These findings are consistent with a number of studies involving nonreinforcement rather than punishment (Eckert and Mellgren, 1973; Leonard, 1969; Mellgren, Dyck, Seybert, and Wrather, 1973).

Miscellaneous Procedures Utilized in Persistence Transfer

Following the findings that experience with one class of aversive event (such as punishment) may increase persistence to another class of aversive event (such as nonreinforcement) a number of investigators have attempted to broaden the generality of persistence transfer manipulations. Studies mentioned in this section are illustrative of the attempts to explore the boundary conditions and to extend the understanding of the persistence transfer effect.

Changes in Type of Aversive Stimulus -- A number of studies have either utilized different types of punishment or tested for persistence with different aversive stimuli than that used earlier in training. Terris and Wechkin (1967) trained rats to approach and consume food for 14 trials (1 T/day) and subsequently divided the subjects into groups which received punishment training with either mild shock (.25 mA for 1 sec), mild airblast (.5 sec at 28 psi, 12 inches from the nose), or no aversive stimulus. Subsequent persistence was tested to either strong shock (.5mA for 1 sec) or strong airblast (1 sec at 28 psi, 3 inches from the nose) for 6 days at 1 trial per day. Evaluation of the persistence data indicated that subjects trained with shock or airblast in acquisition were more resistant to subsequent greater intensity shock or airblast relative to a no-punishment control group.

Terris and Rahhal (1969) trained subjects to approach and consume food while being subjected to shock punishment. Subsequent persistence testing to the effects of airblast punishment demonstrated that the shocked subjects were more resistent to the effects of the airblast punishment than a nonshock control group.

Shock during acquisition was gradully increased from .15 mA to .35 mA over 8 days of training for mild punishment and from .03 mA to .5mA for strong punishment training. Airblast used in punishment training was a 20 psi blast delivered 2 inches from the animal's nose. Subjects which received strong punishment training showed greater resistence to subsequent intense airblast punishment relative to mild punishment training or no punishment training groups which did not differ. These data indicate that intensity of the aversive stimulus experience in a prior phase affects subsequent persistence testing with different aversive stimuli. The lack of difference between the mild punishment and control groups is not consistent with the findings of Terris and Wechkin (1967) but the gradual introduction of the punishment in the present study may have operated to decrease the aversiveness of the mild shock group.

Terris and Barnes (1969) used a procedure similar to that just discussed in which they gradually increased intensity of: (a) shock punishment in one group, (b) airblast punishment in another group, or (c) gave no punishment to a control group. Subjects were tested for persistence to either shock punishment training or airblast punishment training. Results of persistence testing indicated that the shock subjects were superior in resistance to shock punishment testing relative to the airblast and control subjects which did not differ. In airblast punishment training, airblast punishment subjects were most resistant and were significantly different from shock subjects which were superior to control animals. These results are somewhat puzzling in that the airblast subjects were not different from no punishment controls in persistence to shock punishment training while mild shock subjects were superior to controls in persistence to airblast punishment -- results contrary to those found by Terris and Rahhal (1969). Closer examination, however, indicates that the introduction of mild punishment began at a higher intensity (.1 mA vs. .03 mA) and reached a higher maximum (.4 mA vs. .35 mA) in the present study. Additionally, gradual introduction of airblast punishment may be affected as with mild punishment, thereby resulting in reduced performance relative to a no shock control group.

Terris, German, and Enzie (1969) trained a group of rats to approach food under gradually increasing punishment or no punishment and tested disruption of home cage eating behavior with either shock or air blast. Shock subjects in acquisition were exposed to shock in the goal box on rewarded trials (gradually increased from .1 to .5 mA). Subjects in the no shock group were given no punishment training in acquisition. Subjects were subsequently trained to consume food in their home cage (which was inverted over a grid floor) and "disruption testing" took place with either electric shock or airblast following 2 days of the home cage consummatory training. The measure of disruptive effects was the time elapsed until the subject returned to finish consuming the food in the home cage. The results of the investigation indicated that shock and airblast trained subjects were faster to resume consummatory behavior than control subjects who had not experienced punishment training.

Transituational Effects and Persistence Transfer -- The reference study by Ross (1964) serves as a good introduction to this topic. Ross trained 6 groups of rats under hunger motivation to make either a jumping, climbing, or running response under CRF or 50% PRF conditions. Following acquisition of the responses, subjects acquired a running response in a straight alley for water reinforcement on a CRF schedule. Following 32 trials of acquisition, the water reinforced response was extinguished under continuous nonreward (extinction) conditions. Extinction results indicated that PRF running and jumping subjects in Phase I were most resistant to extinction and the climbing PRF group was least resistant to extinction while the other groups were intermediate and did not differ from each other. The results demonstrate that persistence can be transferred across different apparatuses. In addition, the finding that the partial food reward training resulted in increased resistance to extinction of a response trained under water CRF conditions demonstrated persistence transfer across motivational conditions.

Banks (1967) trained subjects to approach food in the presence of IP in a short, wide apparatus. Control subjects received a like amount of shock experience in a separate apparatus. All subjects were then continuously reinforced with water for running in a long narrow runway. Finally, all subjects were tested for persistence to punishment and phase one IP subjects were found to be more persistent to punishment training relative to no punishment controls.

Increased persistence was shown to transfer from shock punishment in acquisition through CRF water conditions in a different apparatus and manifest itself in increased responding to punishment training. The previously mentioned Terris, German, and Enzie, (1969) study also demonstrated persistence transfer from training in a runway to testing in the home cage of the subject. Banks (1973) trained subjects under IP in one runway and subsequently tested the subjects for persistence to continuous punishment in a different runway. The runways were made as different as possible to facilitate discrimination between them. The persistence transfer results replicated the findings of Banks (1967) in that if the instrumental response and the punishing stimulus remain constant from training to testing, IP training in one situation results in an IPE in a different situation. Additionally, the data show that although the situations were sufficiently different such that there was no evidence of fear generalization between them, there was apparently complete generalization of persistence. Experiment II demonstrated that IP training of a climbing response produced an increase in persistence to punishment training. Previous experiments which failed to show increased persistence in transfer from presumably incompatible responses (Ross, 1964) did not use a large amount of acquisition training as in the present study which may account for the successful cross-response persistence transfer shown.

<u>Transfer from Operant to Discrete Trials</u> -- German (1969) trained subjects to approach and consume food in a modified operant chamber under conditions of PRF, IP, or CRF . Subjects were then

tested in extinction or punished extinction in a long straight alley. In punished extinction, IP subjects were superior to either PRF or CRF subjects. In regular extinction, no differences were observed in any of the groups. A relatively small amount of training was used which may account for the lack of persistence transfer to extinction.

Amsel (1972) reports data from subjects trained on an FR schedule during operant conditioning and later extinguished in a runway. He reports that prior training with higher FR requirements results in greater persistence during extinction for subjects who have experienced only prior CRF training in the runway.

Transfer from an Aversive Stimulus Unrelated to Training -- A series of studies involving the administration of aversive stimulation in the absence of reinforcement have shown persistence transfer to later aversive experiences. Amsel, Wong, and Scull (1971) gave two groups of newly hatched chicks imprinting experience with or without shock punishment and gave two control groups either punishment or no punishment without imprinting experience. The groups were then split such that half received CRF and half received 50% PRF for running in a straight alley. The running response was extinguished and all groups trained under the PRF schedule showed increased resistance to extinction. Additionally, it was shown that subjects that had experienced imprinting in the presence of shock punishment were superior to all other subjects in resistance to extinction. It would seem that aversive experience associated with a response compatible to running (following a stimulus object during imprinting) may result in later persistence of a running response.

Wong (1971a) forced rats to approach and enter a shock box without accompanying reward by utilizing a slanted tube to coerce the approach response. Group shock-slant, shock-no slant, and no shock-no slant were formed according to degree of coerced approach training. Following the coerced approach training, all subjects were trained to run down a wooden alley for CRF food reward. Finally, the food rewarded response was extinguished. The slant-shock coerced approach manipulation was shown to increase resistance to extinction. This transfer was across different experimental situations, different motivational systems, and different responses. It was also sustained through an approach to goal test, choice test, and continuous reinforcement training blocks. Wong (1971b) again utilized a coerced approach group (Group CA) which was coerced to approach a goal by more severe shock. In addition, Group PC was punished for making competing responses, Group FS was given free shock, Group NS was given no shock, and Group CR received only continuous reinforcement. All groups were then trained to run for CRF food reward in a wooden alley. Extinction for all groups produced the following results: Groups CA and PC were superior to Groups FS and NS which were in turn superior to the CRF group. These data extend the generality of persistence of escape from a more aversive stimulus or because of punishment of competing responses.

RESPONSES ACQUIRED UNDER NEGATIVE REINFORCEMENT

There is meager evidence indeed concerning the effects of added aversive stimulation on responses which are primarily motivated by the removal of or postponement of other aversive stimulation. As in the case of positive reinforcement, the principal instance of added aversive stimulation on negatively reinforced responses is shock punishment delivered contingent upon the response. Since most escape and avoidance procedures use electric shock as the motivating stimulus, the punishment procedure typically involves an increase in intensity of shock or the introduction of shock into a nonshocked extinction situation. As noted by Marx (1969), forms of extinction of an escape response may involve either (a) no possibility of escape from the aversive stimulus which is motivating the response (escape extinction) or (b) complete removal of the aversive stimulus from the situation (regular extinction as in a positive reinforcement extinction). While the removal of aversive stimulation has been the most often used procedure, perhaps a more analogous procedure to appetitively reinforced responses and their extinction procedures would be the inescapable extinction procedure in which motivating conditions remain the same while reinforcement is not present.

Procedures for avoidance extinction also may be either the unavoidable shock procedure (completion of the response does not result in avoidance the punishing stimulus) or removal of aversive stimulation entirely from the avoidance situation. The use of these various procedures make extrapolation within paradigms and between negative and positive reinforcement situations somewhat difficult.

Punishment of Escape Responses -- Gwinn (1949) trained rats to traverse an 8 foot circular runway to escape a 60 volt shock. Escape from the runway was possible by jumping out of the end section to a containing cage. Acquisition took place gradually as length requirements for running were successively increased until the full runway was traversed. Extinction consisted of removal of shock from the runway situation for half the subjects while the other half were subjected to either 60 volts (same as in acquisition training) or 120 volts of shock occuring in the 6th and 7th foot of the runway. Shocked groups were also divided into continuous (100%) and partial (33%) groups which received shock on the designated percentage of total trials. Results indicated that subjects punished in the latter stages of the runway ran faster than subjects who did not receive punishment training. In addition, the subjects receiving 120 volts punishment (higher than acquisition levels of shock) ran faster than those that received 60 volts shock during extinction. It should be noted that Gwinn used a rather lenient extinction criterion (stopping for 10 sec. at any point in the runway) which may have affected his results. It was also noted that subjects shocked on 33% of the extinction trials ran slower following shock trials than following no-shock trials. These results indicate that the shock inhibited running on some trials, but overall speeds were still superior to no shock extinction groups while inferior to the continuous shock extinction group. These results seem to indicate that punishment experienced in regular extinction enhances resistance to extinction of an escape response.

Seward and Raskin (1960) have reported results contrary to those of Gwinn (1949) in that shock present in an intermediate portion of the runway did not lead to increased speeds in extinction. In the same study, extinction following avoidance training was compared with escape training in terms of resistance to extinction. Again using shock in an intermediate portion of the runway, avoidance subjects ran faster than escape subjects in extinction, but no facilitory effects were found with shock present in the extinction condition relative to nonshocked extinction. It should be noted that shock intensities were lower in the Gwinn experiment indicating that shock intensity is an important aspect of facilitation of shocked extinction following escape training. Additionally, subjects could not jump into a safe box as in the Gwinn (1949) study.

A number of studies involving procedures similar to Gwinn (1949) and Seward and Raskin (1960) have demonstrated that subjects would expose themselves to aversive stimulation when not responding would result in no aversive stimulation. These instances have been termed "self punitive" or "viscious circle" behavior. A typical procedure may be noted in a study by Brown, Martin, and Morrow (1964) in which rats were trained to escape a 70 volt shock in a straight alley. Three subgroups were then subjected to extinction with (a) addition of shock over the entire 6 foot run section but not in start or goal sections (long shock), (b) shock in the last 2 feet only (short shock), or (c) no shock at all. Results indicated that there was no facilitation in response persistence in the shocked group. A second experiment was run with lower shock intensity (45V) which was gradually introduced during acquisition of the escape response. Additionally, half as many escape training trials were run (200 trials in experiment 2). Results indicated that facilitation of running speed occurred such that the long shock and short shock groups were superior to the no shock control group and did not differ with one another. The facilitative effects have been shown to occur in a number of similar studies extensively reviewed by Brown (1969). It should be noted that the self punitive effect always seems to occur under low shock intensity and is more pronounced following relatively limited acquisition training. These results demonstrate that the effect of aversive stimulation is very dependent upon shock intensity in terms of subsequent persistence transfer. If the studies mentioned here and by Brown (1969) involving escape paradigms can be taken as indicative of punishment effects as they operate on aversively motivated responding, then somewhat analogous results might occur in the manipulation of several punishment variables as indicated in positively reinforced situations.

An interesting transfer between the effects of shock and noise punishment as used in the self punitive paradigm was developed by Melvin and Martin (1966) who used loud buzzer (100db) or 60 v. shock as the aversive stimulus during the training of an escape response. Subsequent testing with regular extinction and either noise, shock, or nothing indicated that subjects shocked during extinction (Sk-Sk, Bz-Sk) were superior to a group receiving transition from shock training to buzzer extinction training. Bz-Bz subjects were equal to those receiving no aversive stimulation during extinction and were inferior to the first three groups. These results gave evidence of persistence transfer across differenct aversive stimulus conditions under negative reinforcement as was demonstrated under positive reinforcement operations (Terris and Wechkin, 1967; Terris and Rahhal, 1969).

Punishment of Avoidance Responses -- Jones (1953) investigated relative resistance to regular extinction in groups trained with escape and avoidance procedures. Jones found that avoidance (2 sec CS-UCS interval), limited avoidance (.8 sec CS-UCS interval), and intermittent escape subjects (no shock present in the runway on some trials) were superior in persistence to a regular escape training group. In each of the procedures resulting in increased persistence, subjects received (a) some trials in acquisition entirely free from shock (as in extinction), or (b) shock experience on a grid that was initially uncharged when the response began. Each of these procedures can be contrasted with a procedure of partial reinforcement (as in a.) or intermittent punishment (as in b.). Since both these intermittent aversive stimulation procedures have been shown to increase persistence, Jones' results are not surprising. Jones was also able to show that limited avoidance was superior to regular avoidance training during regular extinction, a finding which could be conceptualized as analogous to findings demonstrating that intermittent punishment-partial reinforcement training was superior in resistance to groups experiencing a lower level of intermittent aversive events (See Ratliff and Clayton, 1969; Linden and Hallgren, 1973; and Linden, 1974). While Jones characterized his results as being a function of similarity of acquisition and extinction conditions, they could also be profitably explained in transfer of persistence terms.

A number of studies involving the self punitive behavior procedure have been done with avoidance training. Seward and Raskin (1960) did not demonstrate self punitive behavior in their study described earlier. They did find that escape was inferior to avoidance in persistence, a relationship which could also be handled by the alternative explanation for Jones' (1953) findings. More evidence for the low shock intensity, limited acquisition boundary condition for self punitive behavior facilitation was shown by Moyer (1955), Seligman and Campbell (1965), Smith, Misanin, and Campbell (1961), and Melvin and Smith (1967). All these studies have been reviewed by Brown (1969) and further demonstrate that persistence transfer may occur in negatively reinforced responses. Studies by Beecroft and Brown (1967), Eison and Sawrey (1967), and Bender and Melvin (1967) demonstrated the established pattern of superiority of avoidance procedures over escape responses during persistence testing. Bender and Melvin also were able to show that CS-UCS intervals longer than 5 sec during avoidance training may decrease or reverse the superiority of avoidance groups relative to escape groups in persistence tests. This result would be expected if it is noted that longer intervals between signal and shock during avoidance would decrease the numbers of punishment experiences that occurred between the initiation of the response and successful avoidance.

Sandler, Davidson, Greene, and Holzschuh (1966) have shown that the punishment of an avoidance response and subsequent facilitation are related to punishment intensity, further delimiting the boundary condition hypothesis advanced about previous self punitive studies. In addition, they demonstrate that intensity of punishment during avoidance training and response facilitation during extinction vary together within the confines of the boundary condition (Melvin and Martin, 1966; Terris and Wechkin, 1967). These results have also been observed in operant procedures in which responding increased as a function of punishment (Appel, 1960; Sidman, 1958; Sidman, Herrnstein, and Conrad, 1957).

Marx and Hellwig (1964) and a conceptually related study by Coulter, Riccio and Page (1969) investigated procedures in which rats were trained in avoidance paradigm but were not allowed to make the usual escape responses in acquisition. Experimental subjects received 15 sec of unavoidable shock if they did not make an avoidance response within 3 sec after onset of the CS, while controls were allowed to escape or avoid during acquisition of the response. Experimental subjects demonstrated more than twice as many responses in extinction. These results seem to indicate that prior inescapable shock associated with the acquisition of an avoidance response will increase resistance to extinction. The inescapable shock can be conceived as punishment associated with non-responding resulting in later facilitation in extinction. These results bring to mind the "learned helplessness" situation in which prior inescapable shock experience results in poorer acquisition of an escape or avoidance response relative to subjects who have not experienced inescapable shock. This procedure has been reviewed by Maier, Seligman, and Solomon (1969). Learned helplessness was shown to be attenuated, however, in situations where the escape or avoidance response was well learned prior to the delivery of inescapable shock (Baum, 1965; Sidman, Herrnstein, and Conrad, 1957; for example). This procedure is analogous to one in which prior experience with an aversive stimulus (i.e. punishment) results in persistence to a later aversive situation (i.e. extinction). Additionally, the subsequent learning of an escape response or avoidance response will result in more shock being experienced in association with acquisition such that conditioned fear or other associative mechanisms related to the stimulus should be more intense and facilitate subsequent escape and avoidance persistence. It would seem that some association of the aversive stimulus with continued responding during training would be necessary to clarify the relationship of inescapable shock experience to subsequent response persistence. Testa, Juraska, and Maier (1974) addressed this question directly in a study which investigated the effects of prior exposure to inescapable shock on extinction after the successful acquisition of an escape response. They employed a group which was exposed to prior escapable shock, a group which was exposed to prior inescapable shock, and a group which was yoked to the prior escapable subjects. Results in escape extinction (shocked) indicated that only preshock which was inescapable produced lower extinction performances following escape training. Prior exposure to escapable shock did not have a decremental effect and to the extent that it had any influence at all, the effect was an elevated level of extinction responding. These results seem on the surface to be in contrast with those of Seligman and Maier (1967) who demonstrated that dogs first exposed to escapable shock in a shuttlebox and then given inescapable shock in a harness showed no detectable effect of the inescapable shock when returned to the avoidance schedule in the shuttle box. It should be noted that the Testa, et al. experiment involved extinction while Seligman and Maier utilized continued acquisition training as their method of measuring the effects of prior exposure to shock procedures. While differing measures of persistence such as the two mentioned are possibly compatible in terms of results, there may be limits to this generality. Additionally, in the Seligman and Maier study the subjects were exposed to training in the order escape-no escape-escape, while Testa, et al. (1974) exposed their subjects to training in the order no escape-escape-extinction (no escape). Sequential or temporal variables may be implicated by these differences in procedure.

THEORETICAL EXPLANATIONS

The transfer of persistence between functionally similar aversive events has typically been approached with theoretical views originally formulated to explain the partial reinforcement effect. More general theories of persistence which subsume the partial reinforcement effect as a special case of persistence phenomena developed through investigation of the PRE and incorporated procedures modeled after typical partial reinforcement investigations in arriving at the general persistence viewpoints. In particular, two theorétical positions have been substantially modified to the extend of handling most persistence phenomena; Amsel's general theory of persistence (1972) which developed from his earlier frustration account of the partial reinforcement effect (1962; 1967), and the sequential theory of E. J. Capaldi (1966; 1967; 1970; and 1974).

Amsel's General Persistence Theory

A number of studies have shown that frustrative nonreward influences behavior in a number of ways. It may evoke nonspecific emotional-motivational effects resulting in sharp increases in response vigor. It may control the direction of behavior through the association of primary frustration feedback stimuli and the behavior. Finally, it may influence behavior through the directive properties of stimulus feedback from anticipatory frustration. (Amsel, 1972). Amsel (1962; 1967) postulated that the occurance of nonreinforcement in the presence of the anticipation of reinforcement would result in primary frustration (R_F) which is eventually anticipated (r_F) by the organism. The occurance of reinforcement in the presence of this anticipated frustration results in the counter conditioning of the stimulus feedback from r_F (s_F) to the response of approaching the goal. It is through the counterconditioning of cues associated with the anticipation of frustration that partial reward training stimuli become associated with goal approach behavior and prolong that behavior in the face of later experiences with nonreward in extinction.

The analysis on an intermittent punishment effect was the first extension of the theory to a more general form. Brown and Wagner (1964) demonstrated that exposure to either nonreinforcement or intertermittent punishment during acquisition produced resistance to the decremental effects of either aversive event relative to continously reinforced control groups. Wagner (1966; 1969) and D'Amato (1969) proposed that anticipatory frustration and anticipatory punishment existed along a hypothesized continuum of aversive stimuli when experienced in the context of reinforcement.

Amsel (1972) proposed a more general theory to include other stimuli besides nonreward which produce disruption of behavior amenable to subsequent counterconditioning. According to this view, persistence develops when an organism exhibits approach behavior in association with an aversive event. It is not necessary that the approach be motivated by reinforcement, only that the stimulus properties of the aversive event be presented in contiguity with the approach behavior.

Evidence for this more general premise is most evident in studies which utilized coerced approach or punishment of competing responses to insure approach to a goal (Wong, 1971a;b). Reinforcement was not present during the forced approach training. These studies demonstrated increased persistence which could only be due to the previous coerced approach training.

Problems for this view of persistence are most evident in situations where locus of aversive events and reinforcement seems to be critical in determining response persistence. Recent studies by Capaldi and Levy (1972); Wroten, Campbell, and Cleveland (1972); and Dyck, Mellgren, and Nation (1974) illustrate these problems.

<u>Sequential Theory</u>

The sequential theory espoused by Capaldi (1966) suggests that the capacity of nonreward related stimuli to elicit instrumental behavior depends upon the sequence of occurance of nonreinforced and reinforced trials. Response persistence is increased when the stimuli present during persistence testing (i.e. nonreward) have been present during training and the strength of conditioning of the stimulus after effects of nonreward (S^N) to the instrumental response (R_I) are high. Sequence is important because S^N is conditioned to R_I when reinforced trials follow nonreinforced trials (N-R) but not when reinforced trials precede nonreinforced trials (R-N). These represent well established findings in the literature (Capaldi, 1967; 1970).

The sequential analysis has been extended to include punishment effects by Capaldi and Levy (1972), Wroten, Campbell, and Cleveland (1972) and Dyck, Mellgren, and Nation (1974). It is postulated that punishment after effects (S^P) like those of nonreward, are conditioned to approach responses (R_I) on reinforced trials preceding punished trials (P-R transitions) but not on reinforced trials preceding punished trials (R-P transitions), even though number of punished and reinforced trials were held constant.

While extension of the sequential hypothesis to include other aversive events has not been done, the possibility of including other aversive stimuli among the set of stimuli whose aftereffects may be conditioned to the approach response is certainly inviting. The work of Dyck, et al (1974) especially indicates that generalization between aversive aftereffects contributing to increases persistence may be possible between various other functionally similar aversive stimuli. Attempts to demonstrate common sequential findings with a wide range of aversive stimuli would appear to be needed to extend the scope of the theory.

The transituational transfer studies involving coerced approach to a goal and subsequent enhanced persistence in approaching that goal during response decrement testing reported by Wong (1971a; b) and Amsel, Wong, and Scull (1971) do not appear to be reconcilable with Sequential Theory as originally formulated. Capaldi (1972) has postulated that nonreward or smaller reward procedures produce memory aftereffects which consist of 2 components: a component that corresponds to perceptual or cognitive characteristics, and an aversive or emotional component. If aversive events somehow share stimulus aspects then the basis of transfer of response persistence may be due to the similarity of aversive components within S^N which are present within both persistence training and acquisition training. This view may encompass the transituational studies mentioned in that the similar components of S^N which are conditioned to R_I in different procedures still serve to prolong responding in a situation which involves a distinctively aversive stimulus but similar S^N components in persistence testing.

SUMMARY

This review has been primarily concerned with the delineation of variables affecting the facilitation of persistence following experience with aversive stimuli other than those used in persistence testing. The general conclusion following examination of the data is that this facilitation occurs in responses trained under either positive or negative reinforcement, in changed situations, across stimulus modalities, and is a relatively robuse phenonmenon. One is struck by the high degree of similarity involved in positive and negative reinforcement situations with regard to the understanding of enchanced persistence. Additionally, the generality of the findings reviewed are stiking as they apply to the amenability of related procedures to explanation by ideas stemming from the transfer of persistence view.

The two theories discussed seem to handle most of the data although lack of information about sequential variables and their manipulation in most studies limits the applicability of Sequential Theory. Were it is possible to examine sequential variables, the sequential view seems most capable of handling the available data.

Overall, the persistence transfer viewpoint seems a useful idea to pursue in extending the analysis of learning variables. It may also provide a method of extending the generality of the laws of learning to apparently diverse procedures, thereby delimiting the range of psychological laws necessary to predict behavior

PROPOSAL

A number of studies have indicated the functional similarity of operationally different aversive events with respect to response persistence. Prior experience with aversive stimuli has been shown to increase resistance to extinction of a food reinforced response. It has been shown that punishment of some food reinforced trials results in greater resistence to regular extinction (Brown and Wagner, 1964; Ratliff and Clayton, 1969; and Linden, 1974), that partial reward in greater persistence to punished extinction (Dyck, Mellgren, and Nation, 1974), and that coerced approach to a goal increases later resistance to extinction (Wong, 1971a;b).

While the efficacy of nonreinforcement in positive reinforcement situations in increasing persistence has been contrasted with persistence increasing stimuli of other types, the relationship of negatively reinforced responses and aversive stimulation is less well known. Additionally, the possibility of investigating the relative transfer of persistence between positive and negative nonreinforcement events is an intriguing one.

In the proposed experiment, rats will receive 48 trials of partial or continuous reinforcement in either reward (positive reinforcement) or escape (negative reinforcement) conditioning. Two control groups will receive only handling in phase I. In a second phase, the subjects will be shifted to 20 trials of CRF training of the type reinforcement not received in phase I (i.e., reward in phase I, escape in phase II and vice versa). Subjects will then be extinguished in phase III according to the same reinforcement mode used in phase II . It would be expected that persistence would transfer from the PRF training mode in phase I to the opposite mode extinction operation and result in increased persistence to a CRF control group. More specifically, it is hypothesized that experience with nonreward will increase the persistence in escape extinction of a CRF escape group relative to a group that has received CRF reward and CRF escape. Alternatively, a group with PRF escape training in phase I and which is shifted to CRF reward in phase II should be more resistant to extinction than a group with CRF training in both reward and escape. This experiment is intended also to examine the effect of shock experience in escape training upon subsequent resistance to regular extinction. This experience might be hypothesized to increase persistence because the aversive properties of the shock in escape may be conditioned to the approach response and transfer to the aversive experience of nonreward in extinction, thereby increasing persistence. The experiment should extend the hypothesis that functional similarity exists between various aversive events to transfer of persistence between positive and negative reinforcement events.

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APPENDIX B

STATISTICAL TESTS

SUMMARY TABLE FOR 2 (REINFORCEMENT MODE) X 2 (REINFORCEMENT SCHEDULE) X 4 (DAYS) ANALYSIS OF VARIANCE ON PHASE I TOTAL SPEEDS

Source	MS	df	F
Total	0.064	127	
Between	0.229	31	
A (Mode)	1.578	1	8.77**
B (Schedule)	0.015	1	0.08
AB	0.462	1	2.57
Error	0.180	28	
Within	0.010	96	
C (Days)	0.001	3	0.12
AC	0.017	3	1.57
BC	0.008	3	0.80
ABC	0.003	3	0.31
Error	0.011	84	

$^{**}p<.01$

SUMMARY TABLE FOR 2 X (REINFORCEMENT MODE X 2 (REINFORCEMENT SCHEDULE) X 4 (DAYS) ANALYSIS OF VARIANCE ON PHASE I START SPEEDS

Source	MS	df	F
Total	17.551	127	
Between	59.089	31	
A (Mode)	876.271	1	29.81**
B (Schedule)	41.195	1	1.40
AB	91.264	1	3.10
Error	29.394	28	
Within	4.139	96	
C (Days)	3.207	3	0.73
AC	3.076	3	0.70
BC	2.012	3	0.46
ABC	0.234	3	0.05
Error	4.424	84	

**p <.01

SUMMARY TABLE FOR 2 (REINFORCEMENT MODE) X 2 (REINFORCEMENT SCHEDULE)

X 4 (DAYS) ANALYSIS OF VARIANCE ON PHASE I RUN SPEEDS

Source	MS	df	F
Total	0.109	127	
Between	0.369	31	
A (Mode)	0.868	1	2.40
B (Schedule)	0.227	1	0.63
AB	0.238	1	0.66
Error	0.361	28	
Within	0.026	96	
C (Days)	0.019	3	0.72
AC	0.009	3	0.35
BC	0.048	3	1.84
ABC	0.009	3	0.34
Error	0.026	84	

SUMMARY TABLE FOR 2 (REINFORCEMENT MODE) X 2 (REINFORCEMENT SCHEDULE) X 4 (DAYS) ANALYSIS OF VARIANCE ON PHASE I GOAL SPEEDS

Source	MS	df	F
Total	1.340	127	
Between	4.001	31	
A (Mode)	16.359	1	4.65*
B (Schedule)	5.857	1	1.66
AB	3.277	1	0.93
Error	3.519	28	
Within	0.486	96	
C (Days)	0.193	3	0.40
AC	1.175	3	2.41
BC	0.135	3	0.28
ABC	0.199	3	0.41
Error	0.489	84	

*$p < .05$

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE

ON TOTAL SPEEDS FOR GROUPS SHIFTED FROM REWARD TO ESCAPE (PHASE II)

Source	MS	df	F
Total	0.034	119	
Between	0.119	23	
A (Groups)	0.911	2	21.10**
Error	0.043	21	
Within	0.013	96	
B (Days)	0.064	4	6.22**
AB	0.018	8	1.76
Error	0.010	84	

**$p < .01$

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE ON START SPEEDS FOR GROUPS SHIFTED FROM REWARD TO ESCAPE (PHASE II)

Source	MS	df	F
Total	2.108	119	
Between	4.220	23	
A (Groups)	25.091	2	11.24**
Error	2.232	21	
Within	1.602	96	
B (Days)	5.927	4	4.47**
AB	2.531	8	1.77
Error	1.325	84	

**p < .01

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE ON RUN SPEEDS FOR GROUPS SHIFTED FROM REWARD TO ESCAPE (PHASE II)

Source	MS	df	F
Total	0.086	119	
Between	0.297	23	
A (Groups)	2.017	2	15.19**
Error	0.133	21	
Within	0.036	96	
B (Days)	0.340	4	15.23**
AB	0.028	8	1.26
Error	0.022	84	

**p <.01

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE ON GOAL SPEEDS FOR GROUPS SHIFTED FROM REWARD TO ESCAPE (PHASE II)

Source	MS	df	F
Total	1.103	119	
Between	2.838	23	
A (Groups)	25.710	2	38.94**
Error	0.660	21	
Within	0.687	96	
B (Days)	3.215	4	6.18**
AB	1.189	8	2.29*
Error	0.520	84	

**p <.01

*p <.05

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE ON TOTAL SPEEDS FOR GROUPS SHIFTED FROM ESCAPE TO REWARD (PHASE II)

Source	MS	df	F
Total	0.064	119	
Between	0.126	23	
A (Groups)	0.184	2	1.52
Error	0.121	21	
Within	0.049	96	
B (Days)	0.841	4	93.27**
AB	0.076	8	8.41**
Error	0.009	84	

**p <.01

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE ON START SPEEDS FOR GROUPS SHIFTED FROM ESCAPE TO REWARD (PHASE II)

Source	MS	df	F
Total	9.041	119	
Between	22.825	23	
A (Groups)	77.614	2	4.41*
Error	17.607	21	
Within	5.738	96	
B (Days)	45.568	4	14.22**
AB	12.432	8	3.88**
Error	3.204	84	

**p <.01

*p <.05

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE ON RUN SPEEDS FOR GROUPS SHIFTED FROM ESCAPE TO REWARD (PHASE II)

Source	MS	df	F
Total	0.128	119	
Between	0.183	23	
A (Groups)	0.028	2	0.14
Error	0.198	21	
Within	0.114	96	
B (Days)	2.168	4	126.07**
AB	0.109	8	6.33**
Error	0.017	84	

**p <.01

SUMMARY TABLE FOR 3 (SCHEDULES) X 5 (DAYS) ANALYSIS OF VARIANCE ON GOAL SPEEDS FOR GROUPS SHIFTED FROM ESCAPE TO REWARD (PHASE II)

Source	MS	df	F
Total	0.821	119	
Between	1.110	23	
A (Groups)	0.311	2	0.26
Error	1.186	21	
Within	0.752	96	
B (Days)	10.875	4	45.84**
AB	1.094	8	4.61**
Error	0.237	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED TOTAL SPEEDS IN ESCAPE EXTINCTION

(Groups shifted from Reward in Phase I to Escape in Phase II)

Source	MS	df	F
Total	0.085	119	
Between	0.153	23	
A (Groups)	0.943	2	12.20**
Error	0.077	21	
Within	0.068	96	
B (Days)	0.960	4	40.01**
AB	0.090	8	3.73**
Error	0.024	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED START SPEEDS IN ESCAPE EXTINCTION

(Groups shifted from Reward in Phase I to Escape in Phase II)

Source	MS	df	F
Total	0.098	119	
Between	0.125	23	
A (Groups)	0.194	2	1.64
Error	0.118	21	
Within	0.092	96	
B (Days)	0.898	4	19.11**
AB	0.158	8	3.37**
Error	0.047	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED RUN SPEEDS IN ESCAPE EXTINCTION

(Groups shifted from Reward in Phase I to Escape in Phase II)

Source	MS	df	F
Total	0.113	119	
Between	0.191	23	
A (Groups)	0.863	2	6.80**
Error	0.127	21	
Within	0.094	96	
B (Days)	0.878	4	15.17**
AB	0.086	8	1.49
Error	0.058	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED GOAL SPEEDS IN ESCAPE EXTINCTION

(Groups shifted from Reward in Phase I to Escape in Phase II)

Source	MS	df	F
Total	0.125	119	
Between	0.193	23	
A (Groups)	1.021	2	8.91**
Error	0.115	21	
Within	0.108	96	
B (Days)	1.493	4	32.25**
AB	0.067	8	1.46
Error	0.046	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED TOTAL SPEEDS IN REWARD EXTINCTION

(Groups shifted from Escape in Phase I to Reward in Phase II)

Source	MS	df	F
Total	0.128	119	
Between	0.169	23	
A (Groups)	1.506	2	35.99**
Error	0.042	21	
Within	0.118	96	
B (Days)	2.106	4	68.05**
AB	0.043	8	1.39
Error	0.031	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED START SPEEDS IN REWARD EXTINCTION

(Groups shifted from Escape in Phase I to Reward in Phase II)

Source	MS	df	F
Total	0.220	119	
Between	0.391	23	
A (Groups)	3.046	2	22.03**
Error	0.138	21	
Within	0.179	96	
B (Days)	2.362	4	28.45**
AB	0.092	8	1.11
Error	0.083	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED RUN SPEEDS IN REWARD EXTINCTION

(Groups shifted from Escape in Phase I to Reward in Phase II)

Source	MS	df	F
Total	0.199	119	
Between	0.262	23	
A (Groups)	1.899	2	17.97**
Error	0.106	21	
Within	0.184	96	
B (Days)	2.804	4	39.07**
AB	0.051	8	0.72
Error	0.072	84	

**p <.01

SUMMARY TABLE FOR 3 (GROUPS) X 5 (DAYS) ANALYSIS OF VARIANCE

OF TRANSFORMED GOAL SPEEDS IN REWARD EXTINCTION

(Groups shifted from Escape in Phase I to Reward in Phase II)

Source	MS	df	F
Total	0.143	119	
Between	0.207	23	
A (Groups)	1.676	2	24.99**
Error	0.067	21	
Within	0.128	96	
B (Days)	2.050	4	44.43**
AB	0.028	8	0.61
Error	0.046	84	

**p <.01