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SPECIFIC AND NONSPECIFIC TRANSFER: EFFECTS OF NONREWARD, DELAY OF REWARD AND PUNISHMENT SEQUENCES ON PERSISTENCE

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SHUKRAN JAZILAN.

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Abstract

It was proposed that transfer of persistence effects be divided into two classes to be called specific and nonspecific transfer. The assumptions made were: (a) Specific transfer occurs when the aversive events encountered during the training and testing phases are the same while nonspecific transfer occurs when these events are different. (b) Animals that receive specific transfer suffer less generalization decrement than animals that receive nonspecific transfer. (c) Habit strengths established through associations with different aversive events and undergoing specific and/or nonspecific transfer summate to increase persistence. Two studies were reported in which sequential manipulations of nonreward, delay of reward and punishment were used to test these assumptions. The results provided partial support for the assumptions. It was therefore necessary to modify assumption C to read: Habit strength established through associations with different aversive events and undergoing specific and/or nonspecific transfer will summate to increase the level of persistence, except in the case where the habit strength established through associations with the same aversive event encountered in the second testing phase is at asymptote.

Introduction

The partial reinforcement effect (PRE) is one of the most robust phenomena in instrumental learning. It occurs when subjects that have received partial reinforcement (PRF) in acquisition show greater resistance to extinction than those that have received continuous reinforcement (CRF). This finding has been replicated under a host of conditions (cf. Robbins, 1971) demonstrating the generality of the effect. Although the PRE was once a prime source for theoretical speculation (e.g., Amsel, 1967; Capaldi, 1967; Lawrence & Festinger, 1962; Sheffield, 1949), it has recently been designated as a special case of a more encompassing phenomenon referred to by Amsel (1972a; 1972b) as "persistence."

According to this view persistence develops whenever an animal learns to maintain a response in the face of any kind of stimulus which arouses a competing or disruptive response. Since the main mechanism for the development of persistence is counterconditioning, the basic difference between this position and Amsel's frustration theory (1958, 1962, 1967) is the enlarging of the disruptive stimulus class from nonreinforcement to "any kind of disruptive stimulus" such as punishment. Various forms of Amsel's theory (e.g., D'Amato, 1969; McAllister & McAllister, 1971; Wagner, 1969) have been advanced previously to account for the finding that intermittent punishment training results in increased resistance to continuous punishment relative to CRF control groups. Studies investigating the effects of intermittent punishment (e.g., Banks, 1966a; 1966b; Brown & Wagner, 1964) and the effects of partial delay (e.g., Mellgren, Haddad, Williams & Conkright, 1975) have indeed found a similarity between these effects and the PRE: The results indicate clearly that the intermittent use of any of these events during the acquisition of a response results in increased persistence when that persistence is measured by the same event encountered during acquisition. On the other hand, when the aversive events encountered during the first training phase and the second testing phase are different the resulting increase in persistence is often found to be marginal and sometimes nonexistent. Brown and Wagner (1964) and Dyck, Mellgren, and Nation (1974), for example, have reported that although animals trained with intermittent punishment were always more persistent than CRF control groups, they were more resistant to continuous punishment but less resistant to extinction than animals trained with a partial reinforcement schedule. Banks and Torney (1969), however, have reported that intermittent punishment training failed to result in any increase in resistance to extinction relative to a CRF control group. These conflicting results represent a problem for Amsel's persistence theory. According to Amsel (1972a) persistence is not a unitary nonspecific system. It transfers rather from one aversive event to another only if these events represent "overlapping systems". Unfortunately the nature of these overlapping systems is not defined by Amsel so that conflicting results can be explained with equal vigor by assuming that the aversive events used represent or do not represent, depending on the results, overlapping systems of persistence. This post-hoc explanation clearly is not acceptable.

A second major problem of Amsel's persistence theory is the lack of any assumptions that would account for sequential variables. The overwhelming weight of the evidence indicates that Capaldi's (1967, 1970) sequential theory possesses strong predictive powers not only in the case of the PRE but also in the case of punishment (Capaldi & Levy, 1972; Dyck, Mellgren & Nation, 1974) and in the case of delay of reinforcement (Mellgren, Haddad, Williams & Conkright, 1975). The purpose of the present investigation was to construct an alternative explanatory mechanism to the overlapping systems proposed by Amsel that would make use of the predictive powers of the sequential theory and then test specific predictions derived from the new approach.

It is assumed here that an increase in the habit strength of a response occurs when the memory of an aversive event such as nonreward or punishment is associated with subsequent reward of that response. Various levels of this habit strength may then generalize to the testing period, depending on the particular aversive events encountered during the first, training, phase and those encountered during the second, testing, phase. In addition the new theoretical approach proposed here consists of three basic assumptions: (a) Transfer of persistence effects are divided into two classes to be called specific and nonspecific transfer. Specific transfer occurs when the aversive events encountered in the training and the testing phases are the same while nonspecific transfer occurs when these aversive events are different. (b) Animals that receive specific transfer suffer less generalization decrement than animals that receive nonspecific transfer (e.g., Brown & Wagner, 1964; Dyck et. al., 1974; Mellgren et. al., 1975). (c) Habit strengths established through associations with different aversive events and undergoing specific and/or nonspecific transfer summate to increase the level of persistence.

Experiment 1

To provide an adequate test of the assumptions outlined above, a 3(types of training) x 2(levels of training) factorial design was employed in the first, training, phase and resistance to extinction was measured in the second, testing, phase. An extended (E) and a limited (L) level of training were used in order to provide a test of the summation assumption for both asymptotic and sub-asymptotic levels of habit strength. The three types of training constituted a CRF schedule (Groups L-CRF and E-CRF), a PRF schedule (Groups L-N and E-N) and an NPD schedule which employed the aversive events of nonreward, punishment and delay of reward (Groups L-NPD and E-NPD). Thus Group L-N received 18 N-R transitions while Group L-NPD received 6 N-R, 6 P-R and 6 D-R transitions. Similarly Group E-N received 54 N-R transitions while Group E-NPD received 18 N-R, 18 P-R and 18 D-R transitions.

Since 18 N-R transitions are sufficient to produce asymptotic habit strength (Mellgren et. al., 1975) it was hypothesized that Groups E-N and L-N would not differ in their resistance to extinction. Following limited training however, Group L-N should show greater resistance to extinction than Group L-NPD because the accrued habit strength of Group L-NPD would suffer more generalization decrement due to its nonspecific transfer. On the other hand, following extended training Group E-NPD should show greater resistance to extinction than Group E-N. Since the 18 N-R transitions received by Group E-NPD are sufficient for establishing asymptotic habit strength, any nonspecific transfer of the habit strength established by the 18 P-R and 18 D-R transitions should further increase this group's persistence. In terms of resistance to extinction, the four experimental groups should therefore be ordered E-NPD > E-N = L-N > L-NPD and all four groups should show greater resistance to extinction than the two CRF control groups.

Method

Subjects. The subjects were 48 naive male albino rats, 80 days old, of the Sprague Dawley strain, purchased from the Holtzman Company, Madison, WI. The animals were randomly assigned to one of six groups (*n*=8/ group). During the course of the experiment one subject died leaving five groups with 8 subjects per group and one with 7 subjects.

Apparatus. The apparatus consisted of a modified straight alley runway manufactured by the Hunter Corporation. The runway was constructed of clear Plexiglas with a grid floor and measured 161 x 15 x 10 cm. It was divided into a 33-cm. long start box, a 95cm. long run section and a 33-cm. long goal box. The modifications consisted of a teaspoon, mounted at the far end of the goal box, which served as a foodcup. In addition a manually retractable guillotine door, immediately preceding the food cup, was constructed. It served as a delay door and was used only on delay of reinforcement trials. Start, run and goal times were measured to the nearest .01 sec. by means of three Standard timers controlled by a microswitch, located at the door of the start section, and a series of three photoelectric cells. Upon opening the start-box door, the microswitch activated the start timer. The first photocell, located 12 cm. beyond the start-box door, stopped the start timer when interrupted and started the run timer. The second photocell, located 13 cm. in front of the goal-box door, stopped the run timer when interrupted and started the goal timer. The latter was stopped when the third photocell, located 9 cm. inside the goal box was interrupted. The sum of these three measures for each trial yielded total time, and reciprocals of all four measures were then calculated to yield start, run, goal and total speeds. On punished trials a Model 700 Grayson-Stadler shock generator delivered ½ sec. of either .1, .2 or .3 mA. scrambled shock to the grid of the goal box upon the interruption of the third photocell by the animal.

Procedure. Upon arrival in the laboratory, the subjects were individually housed and allowed free access to food and water for 10 days. The subjects were then placed on a 12 gm daily food-deprivation schedule with continuous free access to water. In addition to their daily ration of 12 gm of Purina Lab Chow, the animals received approximately 10 pellets of Purina Hog Starter per day for 10 days to familiarize them with the reward. During these 10 days the animals were individually taken out of their cages and handled for 2-3 min. daily. Prior to the start of the first experimental manipulation subjects in all six groups received 2 rewarded pretraining trials per day for 2 days. A rewarded (R) trial during pretraining and throughout the experiment consisted of 2 cm. of Purina Hog Starter placed in the food cup. On a delayed (D) trial, the delay door prevented the animal's immediate access to the baited goal box. Thirty seconds after the animal's entry to the goal box the delay door was lifted and the animal was allowed to consume the reward which also consisted of 2 cm. of Purina Hog Starter. On a punished (P) trial the animal received the appropriate amount of shock immediately upon interrupting the third goal-box photocell, and was allowed immediate access to the same magnitude of reward as on an R trial. The combination of shock and reward was used on P trials to avoid confounding the effects of punishment and nonreward. The first two P trials received by each subject consisted of ½ sec. of .1 mA shock, the second two consisted of ½ sec. of .2 mA shock and the remainder were ½ sec. of .3 mA shock each. Nonrewarded (N) trials presented during the first and the second phases of the experiment consisted of a 30 sec. nonreinforcement confinement duration during which the delay door was not in use. The training phase consisted of 36 days while the testing phase consisted of 8 days. All groups received 5 trials per day throughout the experiment and the intertrial interval was approximately 5 min. The initiation of the training phase of the experiment was staggered so that both the extended (E) training groups and the limited (L) training groups ended the first phase and started the second phase on the same days. Thus the training phase of the experiment lasted for 36 days (180 trials) for the E groups and 12 days (60 trials) for the L groups. Groups E-N and E-NPD received a schedule of reward consisting of 45% immediate reward trials and 55% aversive event trials. The aversive event used for Group E-N was N only while those used for Group E-NPD were N, P and D trials. Group E-N received a total of 54 N-R transitions. In order to avoid any possible patterning however, the schedules were constructed so that half the transitions contained an N-length of 1 and the other half contained N-lengths of 2. In addition the locus of the N trials was varied from day to day. Group E-NPD received 18 N-R transitions, 18 P-R transitions and 18 D-R transitions (54 "X"-R transitions in all). Again half the N-R transitions, half the P-R transitions and half the D-R transitions consisted of a length of 1 while the other half consisted of a length of 2. The locus of these aversive events was also changed from day to day. It should be noted that two different aversive events occurred on each day. However these events were always separated by one or two R trial before a different aversive event was presented. Finally Group E-CRF received 5 R trials per day for 36 days. The schedules, which were repeated every four days, are provided in Table 1.

Insert Table 1 about here

During the first 22 days of the training phase the subjects in the L groups were treated exactly like those in the E groups with the exception that they received a 10 sec. handling period on each of their trials instead of a running trial in the runway. On the 23rd and 24th days of the first phase, subjects in the L groups received 2 pretraining trials per day in the runway. The L groups received the same percentage of reward and the same schedules as their respective E groups except that their training was limited to one third that received by the E groups. Thus Group L-N received 18 N-R transitions, Group L-NPD received 18 total transitions consisting of 6 N-R, 6 P-R and 6 D-R transitions while Group L-CRF received 5 R trials per day for 12 days only. During the testing phase all six groups received an extinction schedule that consisted of 5 N trials per day for 8 days.

Results and Discussion

At the end of the training phase the groups were not performing at the same asymptotic levels. The extended training groups were generally running faster than the limited training groups with Group E-NPD performing at the highest asymptotic level. Nevertheless, all groups were performing at asymptote. These terminal acquisition differences were assessed via 2(level-of-training) x 3(type-of-training) analyses of variance performed on the means of the last two days of acquisition in all four measures. The analyses revealed a significant training-level effect in the start, goal and total measures [$Fs\ (1,41) = 9.10, 5.22$ and 4.06 respectively, $ps < .05$] indicating a superior terminal acquisition performance for the extended training groups. The only other statistically significant finding was the type-of-training main effect obtained in the run measure, $F\ (2,41) = 3.63$, $p < .05$, which was due to the superior performance of Group E-NPD. Figure 1 shows the total speeds of the six groups for the entire training phase.

Insert Figure 1 about here

The extinction data provided partial confirmation for the predictions stated earlier. The two CRF control groups were indeed inferior to the four experimental groups in terms of resistance to extinction. As can be seen in Figure 2 however Group L-NPD was less resistant to extinction than Groups L-N and E-N, which did not differ from each other, but Group E-NPD did not show greater resistance to extinction than Group E-N.

Insert Figure 2 about here

The 2(level-of-training) x 3(type-of-training) x 8(days) repeated measures analyses of variance performed on the four measures of extinction revealed significant type-of-training main effects [F's (2,41) = 42.42, 74.93, 56.81, and 79.24 for the start, run, goal and total measures respectively, p's < .05]. In addition, these main effects interacted significantly with the repeated measure of days [F's (14,287) = 7.13, 9.55, 8.57 and 11.25 for the start, run, goal and total measures respectively, p's < .05]. These analyses, together with Figure 2, illustrate clearly the inferior resistance to extinction of the two CRF control groups and the faster rate of extinction which these groups exhibited. In order to obtain a clearer understanding of the differences between the four experimental groups the extinction data of the two CRF groups was withheld and 2 x 2 x 8 repeated measures analyses of variance were performed on the extinction data of the four experimental groups in all four measures. Marginally significant main effects of level-of-training were obtained in the start measure, F (1,27) = 3.92, p < .10, and the total measure, F (1,27) = 4.71, p < .05, reflecting some increased persistence of the extended-training groups. This was primarily due to the consistent superiority of Group E-N over Group L-NPD and also the overall superiority of Group E-NPD during the first three days of extinction which was apparently a carry-over effect from acquisition. No significant main effects due to type-of-training were obtained. The analyses revealed, however, significant type-of-training x days interactions [F's (7,189) = 2.57, 5.00, 3.45 and 4.35 for the start, run, goal and total measures, respectively, p's < .05]. These interactions illustrate a reliable difference between the extinction performances of Groups L-N and E-N and those of Groups L-NPD and E-NPD. The NPD groups extinguished at a faster rate than the N groups so that despite the absence of any terminal acquisition differences between Groups L-N and L-NPD, the latter exhibited a higher rate of extinction and showed less resistance to extinction in the final six days than Group L-N. Similarly, despite the superior terminal acquisition performance of Group E-NPD relative to Group E-N, the two groups exhibited approximately the same level of resistance to extinction during the final five days.

In summary, the results show that: (a) The two CRF groups, which did not differ from each other, were less resistant to extinction than the four experimental groups; (b) Groups L-N and E-N did not differ from each other in extinction; (c) Group L-N was more resistant to extinction than Group L-NPD. (d) Group E-NPD was more resistant to extinction than Group E-N during the first three extinction days only and thereafter was equally as resistant as Group E-N.

The failure of Group E-NPD to show increased resistance to extinction relative to Group E-N beyond the third day of extinction does not undermine the assumptions presented earlier regarding the nature of specific and nonspecific transfer. This finding necessitates the inclusion of a boundary condition that would define a limit to assumption C. This boundary condition would state that at asymptotic levels the habit strength established through associations with the same aversive event encountered in the second testing phase (i.e., specific transfer) will not summate with habit strengths established through associations with other aversive events even if the latter were at asymptote. Alternatively the failure of Group E-NPD to show a higher level of persistence may have been an artifact of the schedules or the procedures used in Experiment 1, in which case the boundary condition stated here may neither be necessary nor valid. Experiment 2 was designed to test this possibility in order to provide further evidence regarding the possible need for the inclusion of this boundary condition in assumption C.

Experiment 2

According to the sequential theory (Capaldi, 1967) the memory of nonreward is completely replaced by the following rewarded trial of an N-R transition. There is no evidence however to indicate that this memory replacement mechanism occurs in situations employing more than one aversive event during training. If the memory of an aversive event encountered in a complex schedule, like that used for Group E-NPD in Experiment 1, is not completely replaced by an ensuing R trial then the use of more than one aversive event per day would preclude the proper testing of the assumption regarding the summation of specific and nonspecific transfer. In the case of the schedules used for Group E-NPD for example, the memories of the two aversive events encountered on each day may have interferred with each other so that the accrued transitions were not distinct N-R, P-R and D-R transitions but rather "functionally combined" transitions in the form of ND-R, NP-R or DP-R. Because these functionally combined or compound aversive events encountered in the training phase (i.e., NP, DP, ND) would always differ from the nonreward encountered during the testing phase only nonspecific transfer would have occurred thus precluding the summation of specific and nonspecific transfer. Therefore the failure of Group E-NPD to exhibit increased persistence may have been due to the increased generalization decrement suffered through nonspecific transfer.

The purpose of this second experiment was to prevent these hypothesized compounds of aversive events in an attempt to maintain the integrity of N-R, P-R and D-R transitions and thus to provide an uncontaminated test of the summation assumption to determine whether the boundary condition discussed earlier is indeed necessary. If the distribution of the aversive events used in an NPD schedule were altered so that different aversive events occurred on different days, the chances for these events to become compund stimuli should be minimal. Therefore an NPD-2 group, introduced in this experiment, received a schedule that separated N, P and D events into 2-day blocks. For example the first two days included N-R transitions only, the third and fourth days included P-R transitions only, the fifth and sixth days included D-R transitions only and so on for the entire training phase. In addition three control groups that received N, NPD and CRF schedules similar to those of Experiment 1 were used.

Method

Subjects. The subjects were 40 naive male albino rats like those used in Experiment 1. The animals were randomly assigned to one of four groups (n=10/group). During the course of the experiment one subject died leaving three groups with 10 subjects per group and one with 9 subjects.

Apparatus. The apparatus was the same runway used in Experiment 1. During the course of the first experiment, it was noted that a few subjects in the NPD groups had learned to stop short of the goal box, break the third photocell beam with their nose and proceed to enter the goal box after the delivery of the shock. The apparatus was therefore modified slightly to prevent the occurrence of this behavior. The third photocell was moved further towards the food cup so that it was located 17 cm inside the goal box.

Procedure. The subjects were housed, handled, pre-fed and deprived like those in Experiment 1. The ITI's and the parameters for R, N, D and P trials were also the same as those used in Experiment 1. After the two pre-training days all four groups received 5 training trials per day for 36 days. Groups CRF, N and NPD received the same schedules used for the extended training groups of Experiment 1. Group NPD-2 received the same percentage of reward and the same number of N-R, P-R and D-R transitions as Group NPD. The only difference was the redistribution of the aversive events received by Group NPD-2 so that N-R, P-R and D-R transitions were separated into 2-day blocks and only one type of aversive event occurred on any one day. To control for the order of aversive event presentations however Group NPD-2 was divided into three sub-groups with each receiving a different aversive event on any one day. The schedules used for Groups N, NPD and NPD-2, which were repeated once every twelve days, are presented in Table 2. During the testing phase, all groups received five N trials per day for 8 days.

Insert Table 2 about here

Results and Discussion

There were no terminal acquisition differences between the four groups. The 4(groups) x 6(days) repeated measures analyses of variance performed on the data of the last six training days revealed significant main effects for the repeated measure of days in the run, goal and total measures only [F's $(5,175) = 4.20, 6.74, 2.92$ respectively, p's $< .05$]. This indicates that the run, goal and total speeds of the four groups were still showing a consistent increase over the last six days of training. The absence of any significant differences between the groups may have been due to the modification of the goal box photocell: Figure 3 shows the total

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Insert Figure 3 about here

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speeds of the four groups during the entire training phase.

Groups N, NPD and NPD-2 exhibited greater resistance to extinction and slower rates of extinction than the CRF control group. The 4(groups) x 8(days) repeated measures analyses of variance performed on the extinction data revealed highly significant groups main effects, days main effects and groups x days interactions in all four measures. The smallest F ratio for the groups main effect, $F\ (3,35) = 21.35$, $p < .001$, and the smallest F ratio for the days main effect, $F\ (7,245) = 67.80$, $p < .001$, were in the start measure while the smallest F ratio for the interaction, $F\ (21,245) = 4.94$, $p < .001$), was in the run measure. Figure 4, which shows the total speeds of the four groups during extinction, illustrates clearly the inferior

Insert Figure 4 about here

performance of Group CRF and the equivalent levels of persistence exhibited by Groups N, NPD and NPD-2. These observations were confirmed by a series of Tukey's pairwise comparisons conducted on the daily extinction means of the four groups in all four measures. Other than the comparisons involving the CRF group, the only significant ($p < .05$) pairwise comparison revealed that Group N was more persistent than Group NPD-2 only on the total speed measure of the last day of extinction.

It was hypothesized that the schedules used in Experiment 1 for the NPD groups might have resulted in compound rather than independent aversive events. The schedules used for Group NPD-2 in the second experiment were therefore designed specifically to maintain the integrity of N-R, P-R and D-R transitions and thus minimize the likelihood of compounding these events. It was predicted that Group NPD-2 would receive specific transfer of the habit strength established through its N-R transitions and nonspecific transfer of the habit strength established through its independent P-R and D-R transitions. It was predicted further that these transfer effects would summate thereby resulting in increased resistance to extinction relative to the NPD, N and CRF groups. The failute of Group NPD-2 to exhibit such an increase in resistance to extinction indicates that the schedules used for Group E-NPD in Experiment 1 and those used for Group NPD in Experiment 2 did not appear to have resulted in compound aversive events. If the memory replacement mechanism advanced by Capaldi was not disrupted in those groups the summation assumption proposed here may need some modification. Assumption C must therefore be modified to read: Habit strengths established through associations with different aversive events and undergoing specific and/or nonspecific transfer will summate to increase the level of persistence except in the case where the habit strength established through associations with the same aversive event encountered in the second testing phase is at assymptote. Alternatively,the summation assumption may be discarded altogether. Such a severe step however should await further research.

The experiments reported here represent the initial test of the present theoretical approach to the problem of persistence. They demonstrate clearly that the assumptions advanced here can generate testable predictions for novel manipulations that go beyond the explanatory and predictive powers of the existing persistence theories. Because the results of the experiments reported here provided partial confirmation for the predictions made, an important boundary condition for one of the assumptions was defined. Further testing of other predictions that can be generated from the assumptions presented here will help in defining further the predictive and explanatory powers and limitations of the present approach thereby increasing our understanding of the problem of persistence.

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TABLE 1

Sample Schedules Used in the Training Phase

Experiment 1

Days	Groups E-N and L-N	Groups E-NPD and L-NPD
1	N N R N R	N N R D R
2	R N R R N	R P R R D
3	N R N N R	N R P P R
4	R N N R N	R D D R P

TABLE 2

Sample Schedules Used in the Training Phase

Experiment 2

Days	Group N					Group NPD					Group NPD-2				
1	N	N	R	N	R	N	N	R	D	R	N	N	R	N	R
2	R	N	R	R	N	R	P	R	R	D	R	N	R	R	N
3	N	R	N	N	R	N	R	P	P	R	P	R	P	P	R
4	R	N	N	R	N	R	D	D	R	P	R	P	P	R	P
5	R	N	R	R	N	R	D	R	R	N	R	D	R	R	D
6	N	N	R	N	R	P	P	R	N	R	D	D	R	D	R
7	N	R	N	N	R	P	R	D	D	R	N	R	N	N	R
8	R	N	N	R	N	R	N	N	R	D	R	N	N	R	N
9	R	N	N	R	N	R	P	P	R	N	R	D	D	R	D
10	N	R	N	N	R	D	R	N	N	R	D	R	D	D	R
11	N	N	R	N	R	D	D	R	P	R	P	P	R	P	R
12	R	N	R	R	N	R	N	R	R	P	R	P	R	R	P

TABLE 3

Analyses of Variance on Terminal Acquisition Data for the

Four Speed Measures: Experiment 1

START

Source	df	MS	F
Between	5	3.73	
A(Level of Training)	1	12.75	9.10**
B(Type of Training)	2	2.05	1.46
AB	2	0.89	0.64
SS/AB	41	1.41	

RUN

Source	df	MS	F
Between	5	0.27	
A(Level of Training)	1	0.07	0.51
B(Type of Training)	2	0.51	3.63*
AB	2	0.12	0.89
SS/AB	41	0.14	

GOAL

Source	df	MS	F
Between	5	3.51	
A(Level of Training)	1	9.90	5.22*
B(Type of Training)	2	1.01	0.53
AB	2	2.83	1.49
SS/AB	41	1.89	

TOTAL

Source	df	MS	F
Between	5	0.07	
A(Level of Training)	1	0.14	4.06*
B(Type of Training)	2	0.09	2.63
AB	2	0.01	0.53
SS/AB	41	0.03	

* $p < .05$

** $p < .01$

TABLE 4

Analyses of Variance on the Extinction Data for the

Four Speed Measures: Experiment 1

START	Source	df	MS	F
	A(Level of Training)	1	107.53	5.84*
	B(Type of Training)	2	779.88	42.42**
	AB	2	6.08	0.33
	SS/AB	41	18.38	
	C(Days)	7	140.31	56.32**
	AC	7	0.93	0.37
	BC	14	17.78	7.13**
	ABC	14	2.92	1.17
	SS/ABC	287	2.49	

RUN	Source	df	MS	F
	A(Level of Training)	1	1.37	2.34
	B(Type of Training)	2	43.85	74.93**
	AB	2	0.76	1.31
	SS/AB	41	0.58	
	C(Days)	7	13.93	134.44**
	AC	7	0.14	1.42
	BC	14	0.99	9.55**
	ABC	14	0.11	1.07
	SS/ABC	287	0.10	

GOAL	Source	df	MS	F
	A(Level of Training)	1	2.56	0.67
	B(Type of Training)	2	215.11	56.81**
	AB	2	6.18	1.63
	SS/AB	41	3.78	
	C(Days)	7	120.26	139.46**
	AC	7	0.25	0.30
	BC	14	7.39	8.57**
	ABC	14	0.42	0.49
	SS/ABC	287	0.86	

TOTAL	Source	df	MS	F
	A(Level of Training)	1	1.05	5.51
	B(Type of Training)	2	15.13	79.24**
	AB	2	0.24	1.29
	SS/AB	41	0.19	
	C(Days)	7	6.44	170.91**
	AC	7	0.03	0.80
	BC	14	0.42	11.25**
	ABC	14	0.02	0.64
	SS/ABC	287	0.03	

*$p < .05$
**$p < .01$

TABLE 5

Analyses of Variance on the Extinction Data (Excluding the CRF Groups) for the Four Speed Measures: Experiment 1

START Source	df	MS	F
A(Level of Training)	1	97.57	3.92
B(Type of Training)	1	22.08	0.88
AB	1	5.64	0.22
SS/AB	27	24.85	
C(Days)	7	79.15	26.64**
AC	7	0.94	0.31
BC	7	7.65	2.57*
ABC	7	4.59	1.54
SS/ABC	189	2.97	

RUN Source	df	MS	F
A(Level of Training)	1	1.42	2.03
B(Type of Training)	1	0.06	0.09
AB	1	1.34	1.92
SS/AB	27	0.69	
C(Days)	7	9.97	86.63**
AC	7	0.10	0.94
BC	7	0.57	5.00**
ABC	7	0.18	1.60
SS/ABC	189	0.11	

GOAL Source	df	MS	F
A(Level of Training)	1	6.49	1.26
B(Type of Training)	1	0.44	0.08
AB	1	7.54	1.46
SS/AB	27	5.13	
C(Days)	7	83.36	81.19**
AC	7	0.40	0.39
BC	7	3.54	3.45**
ABC	7	0.58	0.57
SS/ABC	189	1.02	

TOTAL Source	df	MS	F
A(Level of Training)	1	1.18	4.71*
B(Type of Training)	1	0.33	1.35
AB	1	0.29	1.17
SS/AB	27	0.25	
C(Days)	7	4.93	114.84**
AC	7	0.03	0.76
BC	7	0.18	4.35**
ABC	7	0.03	0.75
SS/ABC	189	0.04	

*$p < .05$
**$p < .01$

TABLE 6

Analyses of Variance on Terminal Acquisition Data for the Four Speed Measures: Experiment 2

	Source	df	MS	F
START				
	A(Groups)	3	22.47	1.50
	SS/A	35	14.88	
	B(Days)	5	0.28	0.58
	AB	15	0.64	1.33
	SS/AB	175	0.48	
RUN				
	A(Groups)	3	0.51	0.88
	SS/A	35	0.58	
	B(Days)	5	0.07	4.20**
	AB	15	0.06	0.37
	SS/AB	175	0.01	
GOAL				
	A(Groups)	3	4.60	1.84
	SS/A	35	2.49	
	B(Days)	5	0.81	6.74**
	AB	15	0.07	0.64
	SS/AB	175	0.12	
TOTAL				
	A(Groups)	3	0.139	0.73
	SS/A	35	0.188	
	B(Days)	5	0.027	2.92*
	AB	15	0.004	0.52
	SS/AB	175	0.009	

* $p < .05$

** $p < .01$

TABLE 7

Analyses of Variance on the Extinction Data for the Four Speed Measures: Experiment 2

	Source	df	MS	F
START				
	A(Groups)	3	333.59	21.35***
	SS/A	35	15.62	
	B(Days)	7	78.35	67.80***
	AB	21	6.01	5.20***
	SS/AB	245	1.15	
RUN				
	A(Groups)	3	18.34	26.28***
	SS/A	35	0.69	
	B(Days)	7	6.69	111.59***
	AB	21	0.29	4.94***
	SS/AB	245	0.06	
GOAL				
	A(Groups)	3	55.44	37.46***
	SS/A	35	1.47	
	B(Days)	7	16.75	83.24***
	AB	21	1.14	5.68***
	SS/AB	245	0.20	
TOTAL				
	A(Groups)	3	6.41	37.17***
	SS/A	35	0.17	
	B(Days)	7	2.22	132.87***
	AB	21	0.14	8.50***
	SS/AB	245	0.01	

*** $p < .001$

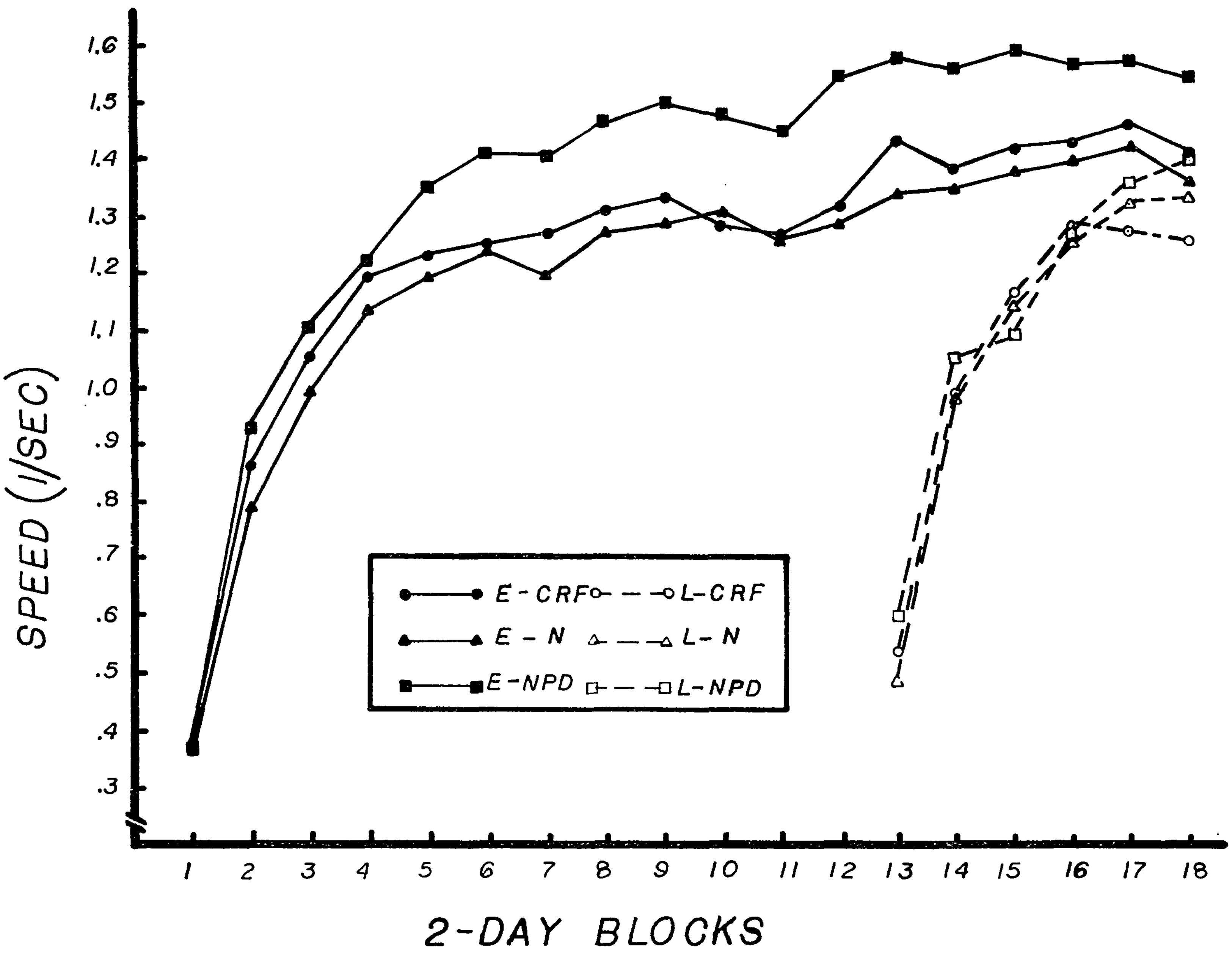
Figure Captions

Figure 1. Mean total speeds for the 36 days of training (in 2-day blocks) in Experiment 1.

Figure 2. Mean total speeds for the last day of training (A) and the eight days of extinction in Experiment 1.

Figure 3. Mean total speeds for the 36 days of training (in 2-day blocks) in Experiment 2.

Figure 4. Mean total speeds for the last day of training (A) and the eight days of extinction in Experiment 2.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1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
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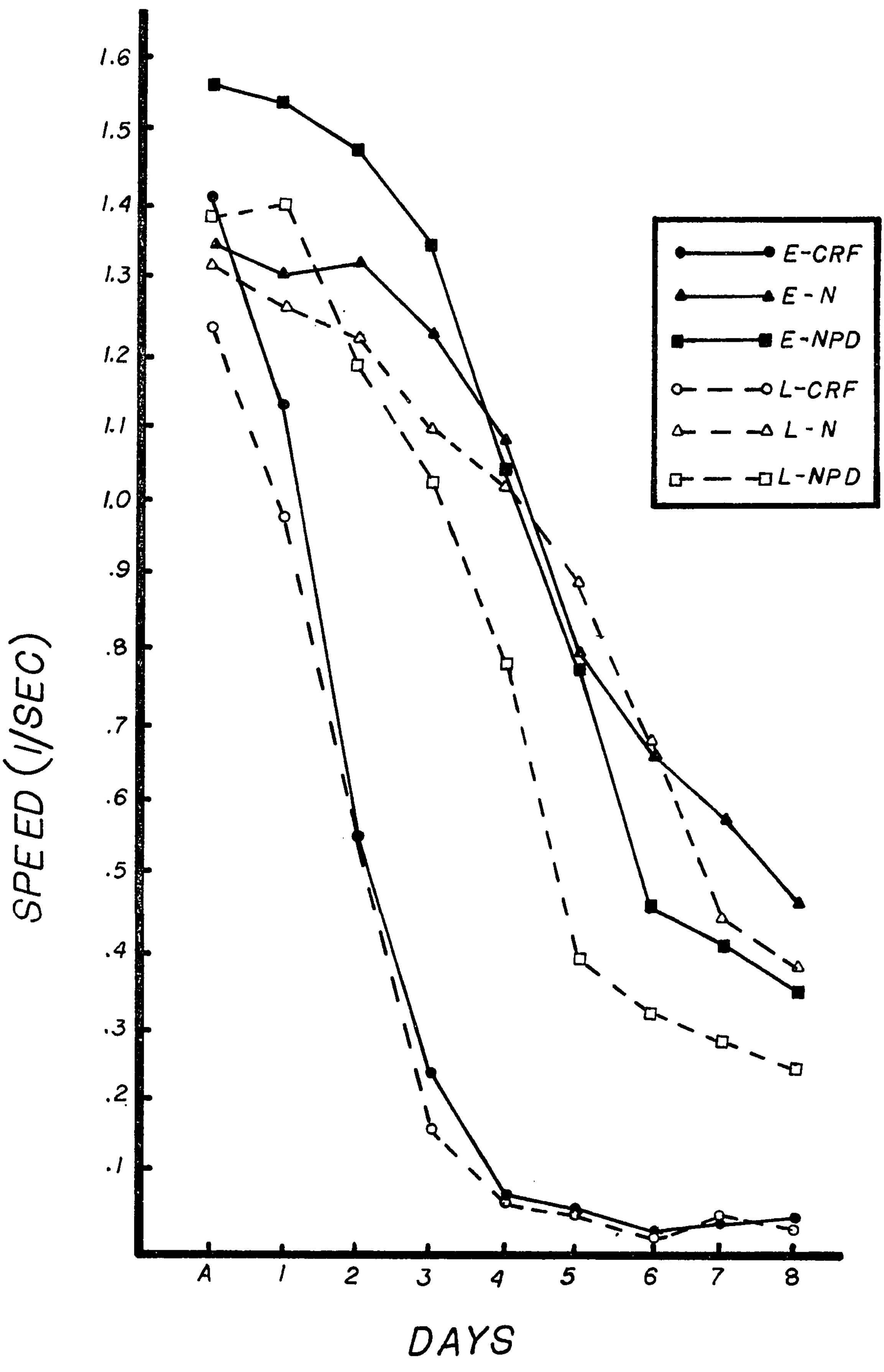
E-CRF
L-CRF
E-N
L-N
E-NPD
L-NPD
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
2-DAY BLOCKS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1.3
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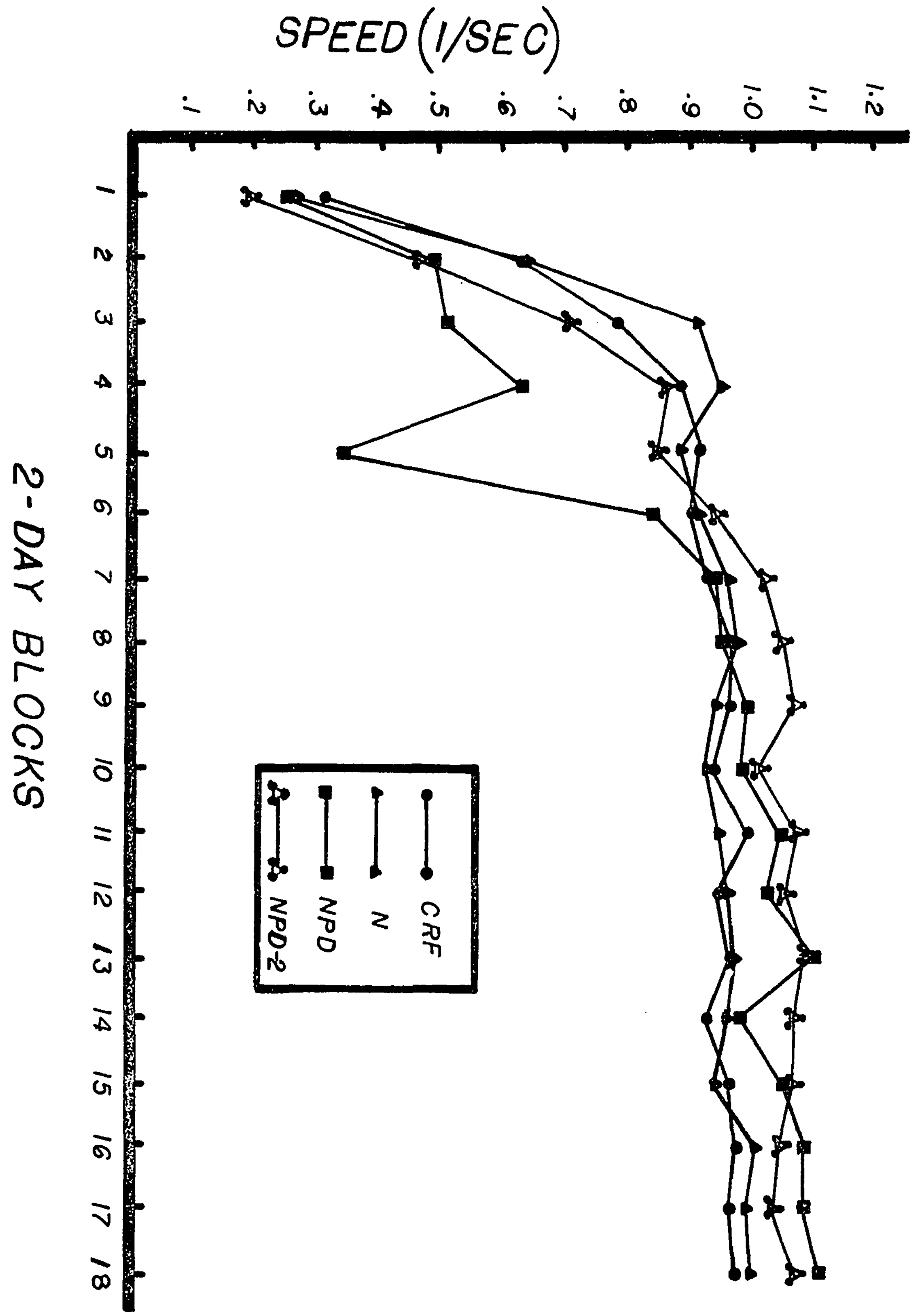
SPEED (I/SEC)
A
1
2
3
4
5
6
7
8
DAYS
E-CRF
E-N
E-NPD
L-CRF
L-N
L-NPD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.1
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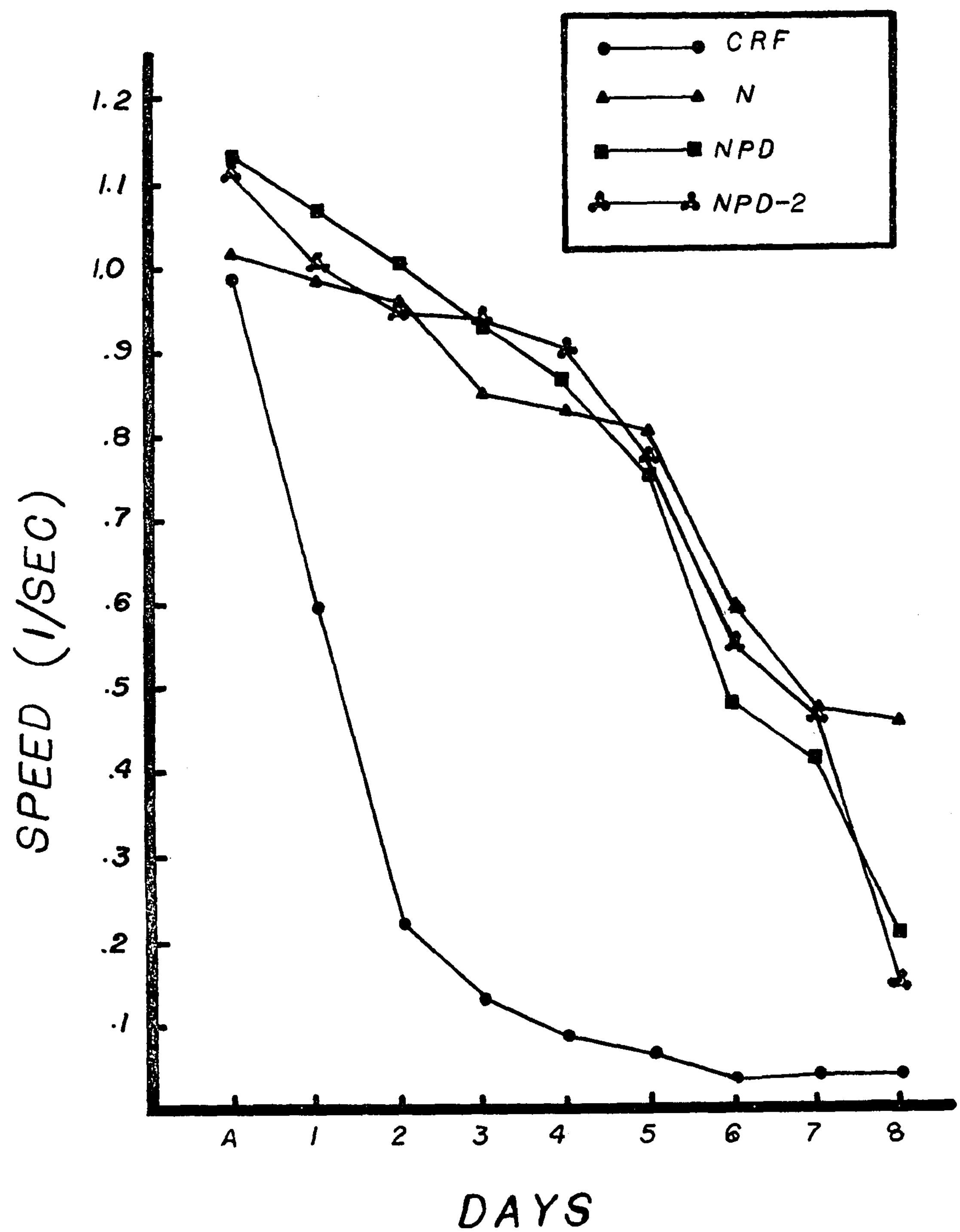
18
2-DAY BLOCKS
CRF
N
NPD
NPD-2


CRF
N
NPD
NPD-2
1.2
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SPEED (1/SEC)
A
1
2
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7
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DAYS

APPENDIX

Research Proposal

INTRODUCTION

The partial reinforcement effect (PRE) is one of the most robust phenomena in instrumental learning. It occurs when subjects that have received partial reinforcement in acquisition show greater resistance to extinction (R to E) than those that have received continuous reinforcement (CRF). This finding has been replicated under a host of conditions (Robbins, 1971) so that its occurrence is no longer surprising. Although the PRE was once a prime source for theoretical speculation (Amsel, 1967; Bitterman, Fedderson & Tyler, 1953; Capaldi, 1967; Lawrence & Festinger, 1962; Sheffield, 1949) it has recently been designated as a special case of a more encompassing phenomenon referred to by Amsel (1972a, 1972b) as "persistence".

According to this view "...persistence develops in responding whenever an organism learns...to maintain a response...in the face of any kind of stimulus which arouses a competing-disruptive response." (Amsel, 1972, p. 277). The main mechanism for the development of persistence is counterconditioning of the "competing-disruptive response" to the approach, or instrumental response. The basic difference between this position and Amsel's frustration theory (1958, 1962, 1967) is the enlarging of the class of disruptive stimulis from nonreinforcement to "any kind of disruptive stimulus" such as punishment. Similar to the assumptions of frustration theory, Amsel states that in many, if not all cases, these disruptive stimuli may elicit emotional responses such as fear or frustration.

Thus, the animal's disruptive responses and the counterconditioning of these responses may be mediated by these emotional responses and the stimuli arising from them. Therefore, if a hungry animal is trained with intermittent punishment to approach a food-baited goal box, its initial avoidance tendencies, whether mediated by fear of punishment or not, are counter-conditioned to the ongoing instrumental approach behavior. Resistence to extinction should thus be increased relative to a continuously reinforced animal lacking any experience with punishment. It is important to note that this learned persistence is assumed to occur as a result of transfer from one aversive event such as electric shock during acquisition to a qualitatively different aversive event such as nonreward during extinction. Amsel raises the interesting possibility that persistence may be,in the most general case, a non-specific unitary system through which the transfer of effects arising from one aversive event to another aversive event is complete. He concludes, however, that it is more likely that persistence transfers between overlapping systems whose emotional effects are most similar in nature.

This approach to the general problem of persistence derives its appeal from its apparent parsimony in dealing with various problems in instrumental learning. Although the most obvious groundwork of the theory is its application to the traditional multi-phased discrete trials experiments, it is not inconceivable to broaden its boundary conditions to subsume some of the literature on interactive effects of appetitive and aversive reinforcers in general.

There are some shortcomings of the theory that make unambiguous predictions untenable in some instances. Foremost among these is the lack of any assumptions regarding the "overlapping systems" between which transfer of persistence is supposed to occur. If persistence is not a nonspecific unitary system and if it does transfer through certain channels but not through others then these overlapping systems and these channels must be defined. One can only speculate that transfer of persistence occurs between punishment and nonreinforcement. This is mere speculation--albeit supported by the evidence--but it is post-hoc in nature, regardless of the evidence. The basic assumption of the theory states that any kind of stimulus which results in a competing disruptive response may, if counter-conditioning occurs, build persistence. However Amsel choses to limit the transfer of such persistence to cases involving overlapping systems of disruption. If this theory is to survive then the a priori definition of what constitutes overlapping systems is essential. There is no evidence regarding the transfer of persistence from the disruptive event of tail pinches to delay of reinforcement for example. If one were to conduct a study involving these events no a priori prediction could be made. Using this theory the experimenter could "explain" the results regardless of the outcome because he can assume the nature of these events after the fact. This type of "explanation" is scientifically unacceptable because of its lack of accompanying predictive power. If one cannot predict, one simply cannot explain.

The second major shortcoming of Amsel's persistence theory is the lack of any assumptions that would account for sequential variables and manipulations. According to the sequential theory (Capaldi, 1967, 1970) resistance to extinction in a partial reinforcement paradigm is increased when a rewarded trial follows a nonrewarded trial. This increase is assumed to be due to the association established between the memory of nonreinforcement (S^N) and the reinforced instrumental response (R_I) occurring on the subsequent trial. Such an association (S^N-R_I) is assumed to condition the R_I to the memory of nonreinforcement thereby increasing resistance to extinction when continuous nonreward is subsequently introduced. The overwhelming weight of the evidence (Capaldi, 1967, 1970) indicates that the sequential theory possesses strong predictive and explanatory powers. Amsel's original frustration theory (1967) simply lacks the predictive power needed to account for such sequential variables as magnitude of reinforcement (Leonard, 1969) and N-length (Capaldi, 1967), in addition to such phenomena as the within subjects partial reinforcement effects (Mellgren & Dyck, 1972). Although Capaldi's sequential theory was aimed primarily at partial reinforcement effects, numerous recent articles indicate that it can be extended to explain and predict findings related to increased resistance to extinction following partial punishment in acquisition (Capaldi & Levy, 1972; Dyck, Mellgren & Nation, 1974) or partial delay of reinforcement in acquisition (Mellgren, Haddad, Williams & Conkright, 1975).

Given such strong evidence for the operation of sequential variables in punishment and in delay of reinforcement situations, it is unwise to simply neglect these variables when dealing with the general problem of persistence. These variables constitute strong predictive tools that must be utilized. Their incorporation into any account of persistence may, at the most, add a measure of elegance and predictive strength and, at the least, provide the opportunity to systematically investigate and uncover their true role in determining persistence.

The goal of this project is an attempt to use the sequential theory, its assumptions and related variables, in an effort aimed at determining the complex nature of persistence. The most basic assumption will be that persistence is not a unitary nonspecific system. In its simplest form, this argument can be supported by the concept of generalization decrement. Animals trained with intermittent punishment, for example, suffer a generalization decrement when tested in extinction (continuous nonreward) and are typically less resistant to extinction than animals trained with partial reinforcement although both groups are more persistent than a continuously reinforced control group (Brown & Wagner, 1964; Dyck, Mellgren & Nation, 1974). If persistence were a unitary system no differences between the intermittent punishment and partial reinforcement groups would be observed. Evidence will be presented to support this argument.

The major task of this proposal will therefore be to investigate systematically those variables which seem to possess enough control over behavior in the partial reinforcement paradigm to deem their operation in the general problem area of persistence likely and reliable. It would therefore be logical to use the assumptions and variables of the sequential theory, to determine how different aversive events occurring in the acquisition phase of a discrete trial instrumental paradigm may influence persistence as measured by various procedures such as extinction, continuous punishment or continuous delay of reinforcement. This approach should prove fruitful in defining what constitutes "overlapping systems" of persistence, whether these systems interact, and if so then in what manner.

It should be noted that although the majority of experiments to be proposed here use discrete trial procedures, the implications of this theoretical approach are not necessarily procedure-bound. Although sequential manipulations have not been tested to any extent in the context of free operant procedures, it is important to assess the generality of the sequential theory and also the persistence approach discussed here using these procedures. There is no reason to believe that sequential variables affecting persistence operate in the discrete-trials instrumental situations only. On the contrary, given the remarkably similar results from a broad spectrum of research areas investigated using operant and discrete trials procedures (e.g. contrast effects) there is ample justification to pursue the study of persistence on more than one front. Platt (1971) and Bitgood and Platt (1971) have shown that given enough care in the design of reinforcement schedules, adequate analogues of discrete trial procedures can be used within the operant situation to study the same problem. This pioneering work can be used as a starting point for the design of experiments aimed at testing the proposed approach in operant situations. It is interesting to note here that persistence studies bear some resemblance to the classic studies on interactive effects of classical conditioning and operant behavior (Rescorla & Solomon, 1967). Both approaches make use of a combined schedule of appetitive and aversive events and study the effects of superimposing one on the other. Given the appropriate controls therefore, the study of persistence within operant procedures may lead to a better understanding of what these apparently distinct areas of research may or may not share in common.

Finally, the present approach has direct implications for an area conceptually related to appetitive reinforcement, namely escape conditioning. Parallels between the two areas have been appealing for their inherent theoretical parsimony. Sequential variables for example have been shown to operate in escape conditioning (Nation, Mellgren & Wrather, 1975; Seybert, Mellgren, Jobe & Eckert, 1974). Furthermore transfer effects from escape conditioning to the extinction of a food reinforced response have recently been found (Mellgren, Haddad, Dyck & Eckert, in press). At this time these effects are most readily explainable via a general persistence theory like Amsel's. It therefore follows that the present approach to persistence may have direct implications to the case of escape conditioning as well as to appetitively reinforced instrumental behavior. In fact the addition of predictive power obtained from sequential variables may prove most helpful in enriching the application of a general persistance approach, as proposed here, to the case of escape conditioning.

BACKGROUND

The most relevant class of experiments which seems to lend support to Amsel's persistence theory has been concerned with transfer effects between different disruptive stimuli such as nonreinforcement and punishment. Brown and Wagner's (1964) pioneering study is a good example of this class. They trained rats to traverse a runway under one of three conditions. During the first phase of the experiment one group (P) received food reinforcement with punishment (electric shock) superimposed on 50% of the trials. A second group (N) received a 50% partial reinforcement (PRF) schedule while the third group (C) received a continuously reinforced (CRF) schedule. In the second phase of the experiment, the three groups were divided into two subgroups, one receiving regular extinction and the other receiving a schedule of continuous reinforcement with punishment superimposed on every trial (CP). The results showed Group N to be more resistent to extinction than Groups P and C while Group P was more resistant to continuous punishment than Groups N or C. The superiority of Group P in continuous punishment was generally interpreted as evidence for anticipatory fear responses, presumed to have resulted from punishment, which were counterconditioned in the same manner as those of anticipatory frustration thereby resulting in increased resistance to continuous punishment. The finding that Group C was inferior to Group P and N in both regular and punished extinction however prompted some (D'Amato, 1969;

McAllister & McAllister, 1971; Wagner, 1969) to argue that the effects of anticipatory fear and anticipatory frustration reactions share a functional similarity and that their effects transfer from one to the other.

Subsequent to Brown and Wagner's (1964) findings and the various implicit predictions they could generate regarding the similarities between partial reinforcement and intermittent punishment (IP), a host of experimenters embarked on investigating what came to be known as the intermittent punishment effect (IPE). This effect is directly analogous to the PRE. It occurs when rats trained with IP are found to be more resistant to CP than rats trained with a CRF schedule. Confining his investigations to the IPE, Banks (1966a, 1966b) illustrated the robustness and reliability of this effect. In a three-phase experiment, Banks (1966 a) compared the performance of a group of rats that received IP training with a control group that received a CRF schedule only. In the first phase food deprived rats of both groups received 75 trials of training to run down a straight alleyway to receive food on a CRF schedule. In the second phase (80 trials) the experimental group received IP superimposed on 30% of the food reinforced trials while the control group was continued on its CRF schedule in the runway with noncontingent punishment delivered in a different apparatus. When both groups were shifted to continous punishment superimposed on a CRF schedule in the third phase, the control group ceased running by the sixth trial while the IP trained group did not show any signs of slowing down.

In the investigations cited thus far, punishment was superimposed on the rewarded trials. Banks (1966 b) has shown however that IP superimposed on the nonrewarded trials of a partial reinforcement (PRF) schedule increased resistance to CP relative to a control condition that had received PRF training. The IP group was also more resistant to continuous punishment than a control condition where the punishment trials superimposed on the PRF schedule were delivered via a placement procedure in an apparatus different from the testing apparatus (i.e. noncontingent punishment). In a further effort to illustrate the reliability of the IPE and its conceptual and theoretical relatedness to the PRE, Banks (1967) obtained an IPE even when the training and testing apparatus were different and also when the training and testing phases were separated by blocks of nonpunished rewarded trials.

These studies illustrate clearly one analogy between the functions of nonreward and punishment. The intermittent use of either event during the acquisition of a response results in increased persistence when that persistence is measured by continuous administration the same event encountered during acquisition. This analogy falls clearly within the domain of Amsel's persistence theory since the basic assumption of the theory deals with the functional similarity of various aversive events. With the exception of Brown and Wagner's (1964) study however, these data leave untouched the theory's more important question on whether presistence is a unitary nonspecific system or not. Brown and Wagner's finding that both IP training and partial reinforcement training result in a higher level of persistence relative to a CRF condition, regardless of the testing procedure, indicates that some transfer does occur between the effects of punishment and nonreward. Recall however that Group P was less resistant to extinction than Group N but more resistant to CP than Group N. This latter finding illustrates clearly that although some transfer of persistence does occur, such transfer is not complete.

Quantitative Variables

Subsequent to Brown and Wagner's (1964) study, other investigators have reported similar findings supporting the argument that persistence may not be a unitary nonspecific system. Banks and Torney (1969) reported three experiments in which IP training resulted in an increased resistance to CP but did not result in an increase in resistance to extinction relative to a CRF control group. In light of Brown and Wagner's (1964) findings, the authors argued that the failure to observe any increase in resistance to extinction may have been due to the small magnitude of reward (1 pellet) or to the light shock intensities (0.3 mA for 0.1 sec) that they had employed. Brown and Wagner had used a reward magnitude three times as high and a shock level twice as intense as Banks and Torney's. Although it is reasonable to assume that these differences may account for these disparate results, one cannot disregard Banks and Torney's final conclusion that the transfer of persistence effects between qualitatively different aversive events may be limited by fairly narrow boundary conditions.

This conclusion was supported by two studies (Torney, 1973; Linden, 1974) which used different persistence testing procedures, different reinforcement schedules and different shock intensities. Using a mild punishment (.32 mA) during acquisition and an intense (3.0 mA) shock during CP to test for response persistence, Torney (1973) reported that only the group that had received a combined schedule of PRF <u>and</u> IP during the acquisition phase of his experiment (Group PRF-IP) showed any significant resistance to CP. A second group which had received IP superimposed on a CRF schedule during acquisition (Group CRF-IP) was slightly more resistant to CP than the non-shock CRF and PRF control groups which did not differ from each other. This latter result shows that an otherwise expected PRE may not transfer to a persistence testing procedure using intense continuous punishment, indicating that persistence <u>is not</u> a totally unitary nonspecific system. In fact, a common place IPE may not be obtainable under these conditions. Only Group PRF-IP which has been trained with a greater degree of aversive stimulation during acquisition (i.e. combinations of nonreward and punishment) showed any increase in persistence. This question of aversiveness and shock intensity remains to be somewhat troublesome however. Linden (1974) has suggested recently that the behavioral reaction to punishment rather than its intensity may be the critical factor in determining any accrual of persistence. He argues that a response-contingent electric shock given during acquisition must have a suppressive effect in order to produce an increase in resistance to extinction. Linden argues further that Banks and Torney's (1969) failure to observe increased resistance to extinction after IP training might have been due to the lack of a suppressive effect by the IP (.3 mA) that they employed. It should be noted however that the same level of punishment has been reported (Banks, 1966 a) to increase resistance to CP. Thus Linden's argument is limited to the case of transfer of persistence from IP training to extinction. This limitation may be viewed as a weakness in the argument or, alternatively, as a further indication that transfer of persistence is not always complete; that is, persistence is not a unitary non-specific system.

Qualitative Variables

Although the majority of published reports concerned with persistence have emphasized the quantitative differences between various shock intensities and the transfer of effects between punishment and nonreward, a few investigators have reported on the transfer of persistence between qualitatively different punishers. In an earlier report for example Terris, German and Enzie (1969) trained two groups of rats to obtain food in a straight runway and one of the groups was also given electric shock. Each of the groups was then divided into two subgroups one of which received shock and the other received air blast while eating in their homecage. The time taken to recover from the initial effects of the aversive stimulus in the homecage and once again approach the food and begin eating was used as an index of persistence. The results showed that subjects trained to resist shock in the runway recovered from the effects of shock and from the effects of air blast in the homecage testing situation faster than did the CRF control subjects. Similar results were reported in a more recent study by Banks and Torney (1969) in which subjects that had been trained with IP in the form of electric shock were more resistant to the detrimental effects of continous punishment in the form of tail pinches than the CRF subjects. These studies present clear evidence that persistence effects do transfer between qualitatively different punishers. Although they were not designed, nor can they be used, to assess the specific or the nonspecific nature of the persistence system, they do present an intriguing paradigm which might prove to be fruitful in this assessment.

A different approach for the study of persistence involves the transfer of effects across different procedures employing different motivational systems. In a recent report by Mellgren, Haddad, Dyck and Eckert (in press) a three-phase procedure was used to assess transfer of persistence from negative to positive reinforcement. In the first phase rats were given either escape (from shock) training, an appetitive CRF schedule or were handled only. In the second phase, continuous food reinforcement was given for all groups and in the third phase resistance to extinction was measured. Rats trained with escape conditioning were found to be the most resistant to extinction while the CRF-only group and the group that was handled in the first phase did not differ from each other. Follow-up experiments revealed that resistance to extinction was an increasing function of the magnitude of negative reinforcement used in the first phase; i.e., the higher levels of shock from which rats escaped in the first phase resulted in higher resistance to extinction. Finally these transfer effects were found to be limited to the case where compatible responses during all three phases were used. Thus jumping to escape shock in the first phase did not result in an increased resistance to extinction for a running response. In agreement with Amsel's persistence theory these results indicate that an association between one response and a disruptive event such as shock can transfer to a different aversive event such as nonreward. Due to the novelty of this approach however, experiments testing alternative theoretical approaches (e.g., the sequential theory) that hold potential promise for the evaluation of persistence effects have yet to be carried out. It is interesting to note that a negative reinforcement procedure can affect the persistence of an appetitively reinforced response.

Sequential Variables

Fallon (1968, 1969) attempted to test the generality of the findings on transfer of persistence by using thirst motivated rats in an operant paradigm. In addition, Fallon superimposed shock on rewarded trials, nonrewarded trials and both rewarded and nonrewarded trials in an attempt to investigate the extent to which locus of punishment affected resistance to extinction. A 50% schedule of reinforcement was used for all four groups. One group (R) received shock everytime a rewarded trial occurred; another (Group N) received shock everytime a nonreward trial occurred and a third group (H) was shocked on half the rewarded trials and half the nonrewarded trials. The fourth group (C) received a 50% partial reinforcement schedule with no accompanying punishment. Fallon reported that, relative to the partial reinforcement group (C), Group H exhibited increased resistance to both regular and punished extinction while Group N showed increased resistance to punished extinction only. Group R however did not exhibit any increased persistence relative to Group C. The failure of Group N to show increased resistance to extinction, argued Fallon, was due to "...a loss in discriminative support." In other words, nonreinforcement during regular extinction was a novel situation which resulted in a high level of generalization decrement. Fallon then argues that the inferiority of Group R was due to pairing punishment with reward which may have resulted in a "functional" magnitude of reward smaller than that received by other groups (Fallon, 1968, 1971). A clearer picture of these results can be obtained however if a sequential analysis of the procedure is undertaken. According to the sequential hypothesis (Capaldi, 1967). The greater the similarity between the aversive event preceding rewarded trials during acquisition and that occurring during the second response persistence phase, the less generalization decrement occurs and more habit strength generalizes to the second phase. This is generally referred to as the <u>specificity</u> assumption of the sequential theory. Group H in Fallon's experiments had received N-R transitions and P-R transitions during acquisition thus its resistance to both nonreward and punishment was increased. Group N however had received P-R transitions only, since all nonrewarded trials were punished, thus less generalization decrement occured when testing with punished extinction than with regular extinction which which is consistent with the finding that Group N exhibited increased resistance to punished extinction but not to regular extinction. Finally Group R did not receive any transitions from any purely aversive events to immediate reward. By receiving punishment on all rewarded trials, Group R experienced transitions from punished reward to punished reward, from punished reward to nonreward and from nonreward to punished reward. Thus the instrumental response occurring on nonrewarded or on punished trials was never followed by immediate, nonpunished, reward and therefore did not gain any appreciable increase in habit strength.

The foregoing analysis can be very useful in predicting the outcome of experiments on transfer of persistence especially since recent evidence clearly illustrates the operation of sequential variables in punishment as well as nonreward situations. Capaldi and Levy (1972) have shown that when sequential variables are adequately controlled and manipulated, predictions consistent with the sequential theory are confirmed. In their first experiment Capaldi and Levi used three groups one of which received PR transitions only, the second received R-P transitions only and the third N-R transitions only. Although the first and the second groups had received the same amount and percentage of punishment Group P-R showed an increase in resistance to continuous punishment relative to groups R-P and N-R. In their second study Capaldi & Levy showed that when different groups receive the same amount and percentage of small and large reward and the same amount and percentage of punishment the only critical variable that determines the level of resistance to continuous punishment is the magnitude of reward occurring on trials following punished trials. The larger the magnitude of reinforcement on these trials the higher is resistance to continuous punishment, a finding consistent with Leonard's (1969) sequential analysis of the effects of magnitude of reinforcement in the PRE paradigm. The results of these experiments clearly illustrate that persistence due to punishment training accrues in much the same way as in the partial reinforcement case. Although the amount and percentage of reward in IP training are potentially important in determining the level of persistence, it is the sequence of reward and punishment and the magnitude of reward only on the trials following punished trials that are the primary variables.

A direct test of the operation of the sequential theory's specificity assumption in punishment has recently been reported by Dyck, Mellgren and Nation (1974). In their first study three groups were employed. One group received a CRF schedule and the other two received a schedule consisting of 66% reward, 17% nonreward and 17% punishment. Of the two IP training groups, one (Group PR) received schedules allowing for the occurrence of P-R transitions only (e.g. PRRN) and the other (Group NR) received schedules allowing for the occurrence of N-R transitions only (e.g. NRRP). During the second phase of the experiment all three groups were divided into two subgroups one receiving continuous nonreward and the other receiving CP. The results showed Group PR to be more resistant to CP than Group NR and Group NR to be more resistant to continuous nonreward than Group PR. The CRF group was less resistant than both experimental groups regardless of the persistence testing procedure employed in the second phase. This experiment provides direct evidence supporting the sequential assumption that only the similarity of the aversive event preceding reward in acquisition and the aversive event encountered in the persistence testing phase is the variable determining the extent to which generalization decrement occurs. The sequential analysis provided here for Fallon's results is consistent with this hypothesis. It should be noted here that Brown and Wagner's (1964) results are almost identical with Dyck et al's (1974) findings. The only difference is that these ten years of research and theory development have allowed us to finally discard the numerous speculations about the functional similarities between anticipatory fear and frustration and about the functional magnitude of reward, and focus instead on the variables that allow us the privilege of prediction rather than the enigma of post-hoc explanation.

It is both surprising and disturbing that a noticeable disregard of these important sequential variables can still be detected even in recent literature. Using a within-subject design, Banks (1973) for example recently investigated the effect of delivering IP to one response (climbing) on the IPE of an incompatible response (running). These two responses have been shown by Ross (1969) to be incompatible. Banks hypothesized that if the incompatibility of the two responses is important in mediating the IPE, the response that is not IP-trained should not accrue any persistence. Accordingly subjects were trained to approach food by climbing in one apparatus and running in another distinctively different apparatus. Reinforcement was withheld on one third of the trials in each of the apparatuses and punishment was delivered on the nonreinforced climbing trials. The control group received its two punished trials per day by being placed in a third distinctively different apparatus. All sequences of running, climbing, reinforced, nonreinforced and punished trials were randomized. The results showed that the IP training of the climbing response increased resistance to continuous punishment for both the climbing and the running responses. Banks then concluded that although a response-specific mechanism may be implicated in the IPE, its role could not be a primary one. Unfortunately neither this nor any other conclusion regarding response specificity is justifiable from the results of this experiment because of the inherent inadequacies of the randomization used in the design of the experiment. By randomizing all trial sequences, Banks may have sequentially conditioned the running response: If reinforced running trials occurred after punished climbing trials, the instrumental response of running would have been associated with and conditioned to the punishment occurring on the preceding climbing trial. There is overwhelming evidence (Mellgren & Dyck, 1972; Mellgren, Dyck, Seybert & Wrather, 1973) that indicates that when such transitions occur in a within-subject design the reinforced response immediately following a nonrewarded trial occurring in a different apparatus gains an appreciable increase in resistance to extinction. In light of the evidence cited thus far which indicates that sequential variables operate in punishment as well as nonreward situations, it is likely that Banks may have unwittingly conditioned the running response to the effects of punishment thereby increasing its resistance to continuous punishment and thus masking any decremental effects of response incompatibility like those reported by Mellgren, Haddad, Dyck and Eckert (in press).

The studies of Banks (1973) and Fallon (1968, 1969, 1971) have been presented and analyzed at length here in an effort to illustrate the pitfalls inherent in drawing conclusions, and consequently theorizing, from experiments designed without the proper sequential controls. The significance of these controls cannot be taken lightly especially in the face of the accumulating evidence indicating that the sequential theory is not a miniature hypothesis that can be applied to the case of nonreward only. It is obvious that an important element in the evaluation of any theory is its generality. Recent evidence indicates that although the sequential theory is specific enough for predicting the outcomes of experiments on the PRE, it is also robust enough to handle the case of delay of reward as well as punishment. In a recent study by Mellgren, Haddad, Williams and Conkright (1975) the sequential assumption of specificity and the sequential variable of length were investigated in a design comparing partial reinforcement (PR) to partial delay of reinforcement (PD). Five groups of rats received either PR training, PD training or a CRF schedule during acquisition. One PR group received one, two or three nonrewarded trials followed by an immediately rewarded trial (N-length of 3) while the other received an N-length of one only. Similarly one PD group received one, two or three delay of reward trials followed by an immediately rewarded trial (D-length of 3) while the other received a D-length of one only. During the second, response persistence, phase all five groups were split in half and given either continuous nonreward or continuous delay of reward. The results showed that the PR groups were more resistant to extinction than the PD groups while the reverse was true when testing with continuous delay of reward. This finding is in agreement with Brown and Wagner's (1964) results and Dyck et.al.'s (1974) results and constitutes strong evidence for the operation of the specificity assumption in the case of delay of reward as well as in the case of punishment and nonreward. In addition, the sequential variable of <u>length</u> also transfered to the second phase. The PR and the PD groups that had received multiple N or D lengths of 1, 2 or 3 were more resistant to continuous nonreward <u>and</u> to continuous delay of reward than the PR and PD groups that had received N-lengths and D-lengths of only one. That N-lengths of three should result in higher resistance to extinction than N-lengths of one and that D-lengths of three should result in higher resistance to continuous delay of reward than D-length of one is predicted by the specificity assumption. N-lengths of three and D-lengths of three are more similar to continuous nonreward and continuous delay of reward respectively and the habit strength resulting from their conditioning should therefore suffer less generalization decrement than N-lengths of one and D-lengths of one. The finding that these groups were more persistent regardless of the testing procedure provides very strong evidence not only for the robustness of the sequential variable of length but also for the generality of the specificity assumption.

Project Plan

Theory

The foregoing review illustrates clearly that the traditional experimental paradigm for the study of persistence has always been a transfer paradigm. The proposed project plan to be outlined here will therefore rely heavily on this transfer paradigm in an effort to minimize confusion and render the present theoretical approach and the accompanying experiments more susceptible to theoretical and empirical scrutiny. In the typical transfer of persistence experiment, the animals receive training with some aversive event during the first phase of the experiment and are then tested by continuous presentations of the same, or a different, aversive event during the second phase. The animals' performance during the second phase is clearly dependent on the level of generalization decrement caused by differences between the events received in the first phase and those received in the second phase of the experiment.

Assumption A. The basic assumption of the present proposal involves the division of these transfer effects into two types to be called specific and nonspecific transfer. Specific transfer is said to occur when the aversive events encountered in the first and second phases are the same. The most obvious examples of specific transfer are the partial reinforcement effect and the intermittent punishment effect. In the PRE case, the only aversive event encountered in the first and the second phases of the experiment is nonreward; similarly in the IPE case, only punishment is encountered in the two phases. Nonspecific transfer, on the other hand, is said to occur when the aversive event encountered during the first phase is qualitatively different from that received during the second, persistence testing, phase. Thus a group which receives partial reinforcement in acquisition and is then tested with continuous punishment or continuous delay would experience nonspecific transfer only. It should be noted here that Capaldi's (1967) specificity assumption is not replaced, nor does it contradict this first assumption. For example, if two groups receive extended training with partial reinforcement, one with N-lengths of one only and the other with N-lengths of three only, the present assumption does not force one to predict equivalent levels of resistance to extinction simply because both groups received specific transfer. On the contrary, the predictions would be consistent with Capaldi's specificity assumption. Although both groups would experience specific transfer only, the assymptotic levels of their habit strengths would be different. Variables such as N-length, number of N-R transitions or magnitude of reward are therefore not replaced by the present assumption; they will rather be subsumed under this assumption. Thus the dichotomy in types of transfer proposed here constitutes a basic premise whose utility is not only theoretical and predictive, but also conceptual in nature.

The habit strength established during the first phase of the experiment is assumed to be a function of such sequential variables as N-R transitions and magnitude of the rewarded trial which immediately follows an N trial as proposed by Capaldi (1967). An N-R transition is assumed to condition the instrumental response occurring on the R trial to the memory of nonreward from the previous trial, thereby increasing habit strength. Furthermore, the asymptote of this habit strength is assumed to be an increasing function of the rewarded trial of an N-R transition. These and other sequential variables are also assumed to operate in the case of punishment (Capaldi & Levy, 1972; Dyck, Mellgren & Nation, 1974), delay of reward (Mellgren, Haddad, Williams & Conkright, 1975) or any other aversive event that may be encountered in the first phase such as tail pinches or air puffs. In other words, the strength and assymptotic level of the habit established in the first phase is assumed to be a direct function of the sequential variables proposed by Capaldi. The sole difference between Capaldi's theory and the present approach involves the transfer of the habit strength established in the first phase to the second, testing, phase. If Capaldi's approach to generalization decrement were to be extended to the general problem of persistence one would have to rely on various continua describing the extent of similarity between various aversive events. Recall that in Capaldi's treatment of delay of reinforcement a delayed trial was assumed to fall somewhere between a nonreinforced trial and a reinforced trial on his specificity continuum. However if one were to extend this approach to the use of punishment superimposed on an R trial or an N trial or to such aversive events as tail pinches or air puffs, one might have to rely on a multi-dimensional continuum from which prediction would be highly complex if not impossible. This approach could especially be frustrating in cases where more than one aversive event is used in the first phase of the experiment. The elegance of the present approach stems from the inherent parsimony of reducing this maze of continua to a simple dichotomy of specific and nonspecific transfer. Although this dichotomy may at first glance appear cumbersome and complex, it is rather a modest and a parsimonious approach compared to the ambiguity of Amsel's "overlapping systems" or to Capaldi's multi-dimensional continua.

Assumption B. The second assumption states that animals that undergo specific transfer suffer less generalization decrement than animals that undergo nonspecific transfer. For example if two groups receive equivalent training with two different aversive events, A or B, and if the second phase testing is carried out with continuous presentations of A then the group trained with A in the first phase will suffer less generalization decrement than the group trained with B and will therefore show a higher level of persistence. This assumption is supported by virtually all of the literature cited thus far (e.g., in the case of punishment and nonreward see Brown & Wagner, 1964; and in the case of delay and nonreward see Mellgren, Haddad, Williams & Conkright, 1975).

Assumption C. In cases where first phase training is carried out with more than one aversive event, it is assumed that habit strengths established through associations with different aversive events and undergoing both specific and nonspecific transfer will summate. The nature of this summation is defined by the following boundary conditions all of which are related to the level of the habit strengths established during acquisition.

1. At sub-asymptotic levels, habit strengths established through associations with different aversive events, whether undergoing specific or nonspecific transfer, summate to increase persistence.
2. At asymptotic levels, habit strength established through associations with aversive events other than the one received during the second persistence testing phase (i.e., nonspecific transfer only) will summate to increase persistence. The accrued increase in persistence will not however exceed that exhibited by a group experiencing specific transfer of its asymptotic habit strength. At extended training for example, a group receiving both partial delay and intermittent punishment should be more resistant to extinction than control groups receiving delay alone or punishment alone. It should however be less resistant to extinction than a group receiving extended training with partial reinforcement (i.e., specific transfer).
3. At asymptotic levels, the habit strength established through associations with the same aversive event encountered in the second persistence phase (i.e., specific transfer) will <u>not</u> summate with habit strengths established through associations with other aversive events even if the latter were at assymptote. For example, resistence to extinction of a group that had received extended training with partial reinforcement may not be increased by any further training with partial delay or intermittent punishment.

The finding that the strength of a "response" may be increased through associations with an aversive event other than that encountered in the second persistence testing phase indicates clearly that some degree of persistence does transfer. It therefore follows logically that the strength of a response may be increased through associations with more than one aversive event as assumption C states. The sole limitation on this summation hypothesis is stated in assumption C^3 and concerns the specific transfer of an asymptotic habit strength. The robust finding that nonspecific transfer results in a lesser level of persistence than specific transfer provides considerable support for the assumption that persistence resulting from the specific transfer of an asymptotic habit strength cannot be increased further by any amount of nonspecific training.

Experiments

It was noted earlier that previous theoretical interpretations of persistence effects have relied, almost exclusively, on analyzing the level of similarity between the various aversive events on the basis of one dimension, namely the relative aversiveness of these events. Recall however that these earlier studies had only assumed the levels of aversiveness of these events on a post-hoc basis and that none had taken enough care to empirically determine the nature of the events they were to use. Since the present approach views extinction effects as generalization decrement phenomena, no assumptions regarding the relative aversiveness of events encountered by the animal have been made. This does not however preclude the necessity for empirically predetermining the appropriate levels of aversiveness for the events to be used in the experiments proposed here. The best way to rule out post-hoc misinterpretations of data regarding specific and nonspecific transfer is to employ aversive events that are basically equivalent in terms of aversiveness. By accomplishing this first crucial step one can then effectively rule out the arguments concerning aversiveness and concentrate on investigating the differences and/or the similarities between specific and nonspecific transfer effects. If for example one group were to receive a partial reinforcement schedule and another an intermittent punishment schedule during the first phase and if the intensity and the duration of punishment and the nonreinforcement confinement duration to be used were empirically determined to be equivalent in aversiveness then any differences between the two groups during the second phase can be related exclusively to specific and nonspecific transfer. For example, the argument that the PRE group's reduced resistance to continuous punishment relative to the intermittent punishment group was due to the higher level of aversiveness of punishment can be automatically discarded. It should be emphasized here that the object of this approach is not to discredit frustration - like explanations but rather to ensure that the results can unequivocally support or refute the assumptions made here. The unnecessary confounding is therefore being eliminated so that the results will not degenerate into post-hoc speculation. On a more esoteric level predetermining the levels of aversiveness is necessary because inter-experiment comparisons are inadequate. Aversiveness levels of various punished intensities, delay of reward durations or nonreinforcement confinement durations are in fact laboratory-specific. It is neither reliable nor accurate to assume that a .3 mA shock administered in one laboratory is less aversive than a .4 mA shock administered in a different laboratory outfitted with different apparatuses, different power sources and different shockers. It is our contention that the behavioral reaction to aversive events must be pre determined in order to minimize the risk of misinterpretation.

Experiment 1. All the experiments to be proposed here will use the aversive events of nonreward, punishment and delay of reward since these have constituted the traditional events used in the study of persistence and since their intensities and aversiveness level can be easily measured and manipulated. The purpose of this first experiment is to obtain equivalent aversiveness levels for these three events. The apparatus to be used will consist of three short runways connected in parallel to a common start box. Each runway will have an individually electrifiable grid floor and a pellet dispenser to control the delay duration. The two peripheral runways will be painted grey and the middle one painted striped. The start box will be moveable so that the animal will have a choice between the middle and the right runways or a choice between the middle and the left runways. By moving the start box position the animal will be forced to make a choice between the two runways on the basis of the events associated with each stimulus rather than on position alone (See Fig. 1). Thus for each rat the striped runway will be on the left side for half the trials and on the right side for the other half. The runways will also be equipped with photoelectric cells and timers in order to obtain speed as well as choice data.

Insert Figure 1 about here

Three groups of food deprived rats will be employed; one will chose between nonreward and delay (ND) the second between nonreward and punishment (NP) and the third between delay and punishment (DP). It should be noted here that the groups used in this and all subsequent experiments will be matched on the basis of age, body weight, deprivation handling schedules. Each group in this experiment will receive eight trials per day. Two of these trials will be reinforced and the other six will constitute the appropriate aversive events. The first reinforced trial of each day will be a free choice trial. If the animal choses the striped runway, it will be forced to traverse the grey runway on its second reinforced trial and vice versa. This will insure that the animal receives the same amount of immediate reward in both alleys. Similarly half of the six aversive trials will be free choice and the other half forced to the opposite side so that the animal receives equivalent training with both aversive events assigned to its group. Thus animals in group NP will receive three N trials per day in the striped alley and three P trials in the grey alley. Half the animals in each group will have one event associated with the grey alley and the other half will have the same event associated with the striped alley. In addition the start box position will be shifted at least once every day so that the animals' choice may not be contaminated with any position habits.

The data will be collected from the four free choice trials. Both choice and speed data will be used to evaluate the groups' preferences. Initially the animals will receive five 45 mg Noyes pellets on R trials, a 30 sec nonreinforcement confinement duration on N trials, 5 pellets with a delay period of 30 sec on D trials and 5 pellets dispensed at the same time a .2 mA ½ sec shock is delivered on P trials. These values seem to be relatively equivalent in their aversiveness; however this is only an intuitive observation of the behavior of rats at our laboratory. The purpose of this experiment is to determine if these values do indeed yield the same level of aversiveness. If not, the magnitude of reward, the intensity of shock and the durations of delay and nonreward confinement will be individually changed until the animals show no significant preference for any of them. New groups of rats will naturally be employed for every change in magnitude or intensity. It should be noted that as few as four rats per group will initially be employed until all appreciable preferences begin to fade.

Experiment 2. Since all subsequent studies will employ a transfer paradigm, it is important to ascertain the equivalence of the final values obtained in Experiment 1 in a transfer paradigm. To accomplish this three groups will receive 10 days of training with a CRF schedule employing 5 trials per day with a reward magnitude of five 45 mg Noyes pellets. During the second phase one group will receive extinction, one will receive continuous delay of reward and the third will receive continuous punishment. The levels of these events will of course be obtained from the final results of Experiment 1. It is predicted that the persistence levels of these three groups during the second phase will be equivalent since none would have experienced any of these aversive events during the first phase and since the three events would be of equal aversiveness values. Together with Experiment 1, this experiment should provide enough empirical evidence that whatever the final values of N, D, and P are, they would carry the same level of aversiveness. These values will then be used in all subsequent experiments thus insuring the proper empirical framework for the study of specific and nonspecific transfer.

Experiment 3. This experiment is designed to test assumption 1 which defines the nature of specific and nonspecific transfer, and assumption B which states that animals that undergo specific transfer suffer less generalization decrement and are typically more persistent. In addition, by using training that would yield sub-asymptotic habit strength assumption C1 states that habits undergoing specific and nonspecific transfer may summate at sub-asymptotic levels, will also be tested. It was suggested earlier that the level of habit strength would be manipulated by the number of transitions (i.e., N-R, D-R, P-R transitions). It is generally found that the asymptotic habit strength for a PRF group is not reached until the animal receives a minimum of 12-15 N-R transitions. Consequently in this experiment a maximum of 12 transitions will be used whereas in subsequent experiments, in which asymptotic habit strength will be investigated, 18 or more transitions will be used.

Four groups of rats will be conditioned to run in a straight runway. The first group will receive a CRF schedule; the second a PRF schedule consisting of 12 N-R transitions (Group N). The third group will receive 6 P-R and 6 D-R transitions (Group PD) and the last group will receive 4 N-R, 4 P-R, and 4 D-R transitions (Group NPD). The animals will receive 4 trials per day for 15 days. Three of these days, each constituting a 4-trial CRF schedule, will be interspersed among the other 12 days. During these 12 days Groups N, PD and NPD will receive one aversive event per day and 3 R trials. The locus of the aversive trial will be changed daily among the first three trials of the day and for Groups NPD and PD the same aversive event will not be administered for more than two consecutive days. All intertrial intervals (ITI) will be 5 minutes.

During the second phase all groups will receive 4 N trials per day for six days. From assumptions 1 and 2 it is predicted that Group N will be more resistant to extinction than Group PD. Although both groups would have received the same total number of transitions and the same number of aversive events and although these events share a common level of aversiveness, Group N should suffer less generalization decrement than Group PD because it would have undergone specific transfer only. Group NPD should also be less resistant to extinction than Group N. However because assumption C1 allows for the sub-asymptotic habit strengths established through associations with different aversive events and undergoing both specific and nonspecific transfer to summate Group NPD should be more resistant to extinction than Group PD. The specific transfer of the habit strength established by the 3 N-R transitions of Group NPD should result in less generalization decrement than P-R or D-R transitions alone. It should be noted here that 3 N-R transitions may not result in enough increased persistence over Group PD for this difference to be statistically significant. Subsequent studies to be proposed here will however be more specifically designed to test this assumption. Finally all groups should be more resistant to extinction than the CRF control group.

Experiments 4 and 5. Since the aversiveness levels of N, P and D used here are equivalent, testing with continuous punishment and continuous delay should yield results analogous to those predicted for experiment 3 and provide further evidence for the assumptions presented here. When testing with continuous punishment the same procedure as in experiment 3 will be employed. The three groups of interest will however be Group P (12 P-R transitions), Group ND (6 N-R and 6 D-R transitions), and Group NPD. In terms of resistance to continuous punishment these groups should be ordered P > NPD > ND. Similarly when testing with continuous delay of reward the group most resistant to continuous delay should be Group D (12 D-R transitions), followed by Group NPD, followed by Group NP (6 N-R and 6 P-R transitions). These complimentary studies are necessary for providing evidence that specific and nonspecific transfer operate in the same fashion regardless of the aversive event employed. Unfortunately such cross-checking has been severely lacking in the study of persistence.

Experiment 6. This experiment is designed to test assumptions C1 and C2 which define the boundary conditions under which asymptotic and sub-asymptotic habit strengths may summate. According to these assumptions persistence may be increased by the summation of habit strengths established through associations with aversive events other than the one encountered in the second persistence testing phase but only to a level that may approach but not exceed the observed persistence level of a group experiencing specific transfer of an asymptotic habit strength.

Four groups of deprived rats will be used. Five trials per day will be given and all ITIs will be 5 min. The first phase will consist of 18 days of training and the second 6 days of extinction. During the first phase Group CRF will receive 5 R trials per day; Group 18-N will receive a PRF schedule consisting of a total of 18 N-R transitions to insure the establishment of asymptotic habit strength. Group 18-PD will receive training with intermittent punishment (18 P-R transitions) and partial delay (18 D-R transitions) to insure the establishment of asymptotic habit strengths for both of these associations. Group 9-PD will receive training with intermittent punishment and partial delay also but only 9 P-R and 9 D-R transitions will be used so that the habit strengths established by each event will be less than asymptotic. The schedules to be used during this first phase will be constructed with "lengths" of 1 and 2 and daily order of trials will be changed to insure that no patterning may occur. The same percentage of aversive events will be used for the experimental groups. During the second persistence phase all groups will receive at least 6 days of 5 N trials per day.

It is predicted that Group CRF will be the least resistant to extinction. More importantly, the three experimental groups are predicted to exhibit differential persistence levels with Group 18-N being the most resistant to extinction. Group 18-PD should in turn be more resistant to extinction than Group 9-PD. These predictions follow from assumption C. Group 9-PD should acquire some habit strength through its 9 P-R and 9 D-R transitions and through nonspecific transfer of this habit strength it should exhibit increased persistence over the CRF control group (assumption C1). However because nonspecific transfer suffers more generalization decrement than specific transfer (assumption B), Group 9-PD should be less resistant to extinction than Group 18-N regardless of the equal percentage and number of aversive events and transitions experienced by both groups. Group 18-PD should also be more persistent than Group 9-PD due to its higher level of habit strength from which nonspecific transfer would occur. Finally Group 18-PD should be less resistant to extinction than Group 18-N because the summation of its habit strengths would not be sufficient to overcome the increased generalization decrement suffered through nonspecific transfer (assumption C2). It should be noted that Group 18-PD would have received twice as many transitions as Group 18-N. This inequity is established by design in order to provide the strongest possible test for the assumptions proposed here.

Experiments 7 and 8. Like Experiments 4 and 5, these experiments are necessary for providing evidence that the expected results of Experiment 6 are not specific to the case of extinction. These will therefore be replications of the design used in Experiment 6 with the exception that the testing procedures will constitute continuous delay and continuous punishment instead of extinction. Like Experiments 4 and 5, the training given during the first phase will also be changed to fit the testing procedures. For example when testing with continuous delay the experimental groups will be 18-D, 18-NP and 9-NP.

Experiment 9. To provide an adequate test of assumption C3 an extended period of training will be used in this experiment to insure the establishment of asymptotic levels of habit strengths. Assumption C3 allows for asymptotic habit strengths established through presentations of aversive events other than the one encountered in the second persistence phase (nonspecific transfer) to summate. This summation cannot however result in a level of persistence higher than that obtained from the specific transfer of an asymptotic habit strength.

Four groups of deprived rats will be trained to traverse a runway. During the first training phase Group CRF will receive 5 R trials per day for 36 days. Group 18-NPD will receive 36 days of training also but these will include 18 N-R transitions, 18 P-R transitions and 18 D-R transitions. This will insure that all three associatons are built to asymptotic strength and will therefore provide the opportunity to study the summation of specific and nonspecific training at asymptotic levels. Group 54-N will receive the same total number of transitions as Group 18-NPD with the exception that all will be N-R transitions thus allowing for specific transfer only. Finally Group 18-N will start training on the 25th day of the first phase and will receive during its 12 days of training a total of 18 N-R transitions. Comparisons between this group and Group 18-NPD would then determine whether nonspecific training can summate with the asymptotic level of specific training to increase persistence. The three experimental groups will receive "lengths" of 1 and 2 divided equally between the transitions to insure the absence of any patterning. The percentage of reward will naturally be held equal for the three groups. During the second persistence testing phase all groups will receive a minimum of 6 extinction days each consisting of 5 N trials. All ITIs will be 5 min.

It is predicted that Group CRF will be the least resistant to extinction since it would not have received any specific or nonspecific transfer (assumptions A and B). Groups 54 N and 18-N should exhibit the same level of persistence since both would have received asymptotic training. Group 18-NPD should be equally resistant to extinction as Groups 54-N and 18-N. According to assumption C3 the habit strength established through the 18 P-R and the 18 D-R transitions cannot summate with that established through the 18 N-R transitions because the latter would be at asymptote. This experiment would therefore provide a direct test for assumption C3.

Experiments 10 and 11. Like Experiments 4 and 5 the Experiments 7 and 8 these will be experiments designed to investigate the generality of the results obtained in Experiment 9. Second phase testing will therefore be carried out with continuous delay in Experiment 10 and continuous punishment in Experiment 11. The training schedules of the three experimental groups will also be appropriately changed. For example Experiment 10 will employ Groups 54-D, 18-D and 18-NPD.

Discussion.

Although it may appear at first glance that the experiments proposed here represent a limited class of research, the potential for a wider range of applicability is in fact very real. The experiments proposed here represent only the primary stage that must be carried out before any further expansion can be undertaken. At this stage, it would be ludicrous to propose experiments using paradigms other than the appetitive discrete-trials procedure which has been the backbone of research on persistence. After this primary testing phase has been completed however, the present approach can then be applied to different paradigms. As discussed earlier in this proposal, the escape conditioning paradigm and the free operant analogues to discrete trial procedures are prime candidates for the investigation of persistence effects. The application of the present approach to these paradigms may result in a more comprehensive understanding of the similarities as well as the differences between these various paradigms and also a better understanding of the general problem of persistence.

The limitations placed on the aversiveness of the various events used in the proposed experiments should not imply that aversiveness is being discredited as an explanatory mechanism. It is clear that both the aversiveness level and the stimulus properties (i.e., specificity) of the aversive events encountered during the first training phase are important determinants of the accrued persistence levels. The goal of the present project is to focus on the specificity component in order to achieve the level of explanatory and predictive power needed for the understanding of this component. Thus the limitations placed on the aversiveness levels employed here are a function of the de-confounding necessitated by proper experimental design. Once the proposed experiments are carried out and if the present assumptions are confirmed, any further expansion of the present approach would have to incorporate the aversiveness varible. This expansion can be done systematically only when the operation of the specificity component is well understood. To propose factorial experiments that would investigate both components before each has been investigated separately would be fruitless and would only compound the present problem of post-hoc analysis.

It should be noted that the proposed nonspecific transfer is related to the early studies on varied reinforcement (McClelland & McGowan, 1953). It is generally found that the more variable the training conditions are made the higher is the resulting resistance to extinction. McNamara and Wike (1958) for example have reported that animals trained with either different cues, responses, delay periods, drives or with different rewards were more resistant to extinction than animals trained with a regular CRF schedule. In addition, the combination of all these varied conditions resulted in a still higher level of resistance to extinction. These findings are somewhat similar to the assumptions made here that nonspecific transfer of different habit strengths can summate to increase persistence. The present approach emphasizes the active conditioning of responses by making use of the sequential transitions rather than the mere exposure to variable training conditions. It is our contention that such transitions are infinitely more effective in increasing habit strength than a mere change in what the animal may encounter. Recall that Capaldi and Levy (1972) have compared the effects of P-R transitions and R-P transitions and found the former to be much more effective in increasing persistence. It is understandable that the early studies on varied reinforcement, such as McNamara and Wike's (1958), did not compare their varied reinforcement procedures with sequential manipulations or with what is being called here specific transfer. The present approach provides therefore a new framework for a better understanding of the similarities and/or differences between nonspecific transfer and varied reinforcement.

The theoretical approach proposed here derives its value from the several important contributions it lends to our understanding of persistence. Foremost among these is the ability to explain existing data. Recall from the literature review provided earlier in this proposal that virtually all of the existing data related to the problem of persistence consists of studies dealing with comparisons between specific and nonspecific transfer and their effects on the accrued persistence levels of various groups. The creation of this dichotomy and the definition of these transfer effects provides a theoretical and conceptual framework within which some apparently disparate data can be consolidated into a set of coherent results. A novel theoretical approach is useless if it can be refuted by existing data. This theoretical approach provides an explanatory mechanism rather than a source of conflict for existing data.

The most important function of a theory may well be the ability to predict a set of outcomes considerably larger than the set of assumptions it makes. The major impetus for the construction of the present theoretical approach has been the lack of predictive power in the existing theoretical accounts of persistence and the inevitable plethora of post-hoc data analysis. The experiments proposed here represent the most basic and strict tests of the predictive powers of the present approach. If the predicted outcomes of these experiments are verified the present approach would have to be considered a novel tool with predictive powers that go beyond the limitations of the existing accounts of persistence. The novelty of the present approach should not therefore be viewed as the goal of this project. The novelty is only a necessary tool for expanding our predictive powers beyond the present limitations.

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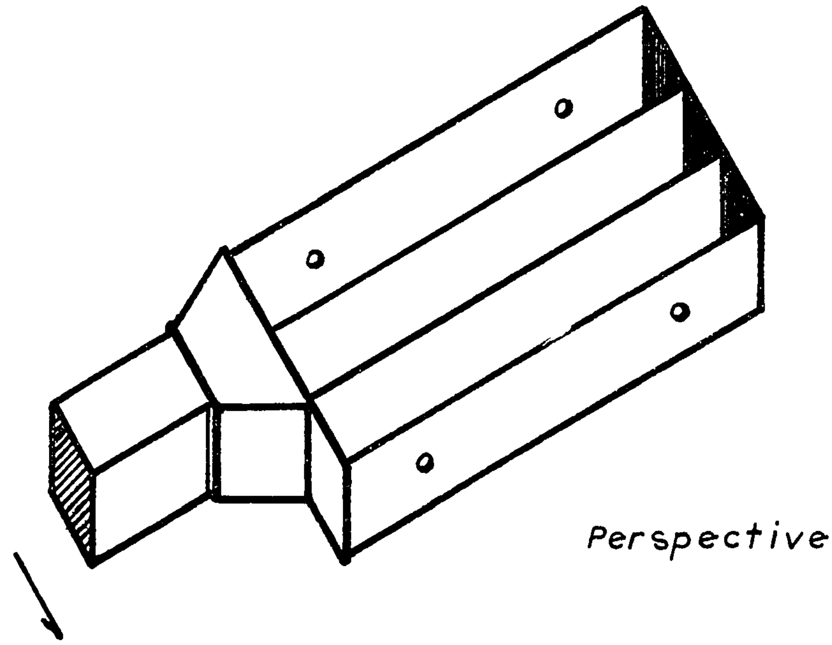
Figure Caption

Fig. 1 The apparatus to be used in Experiment 1. Three parallel runways with a common, moveable start box.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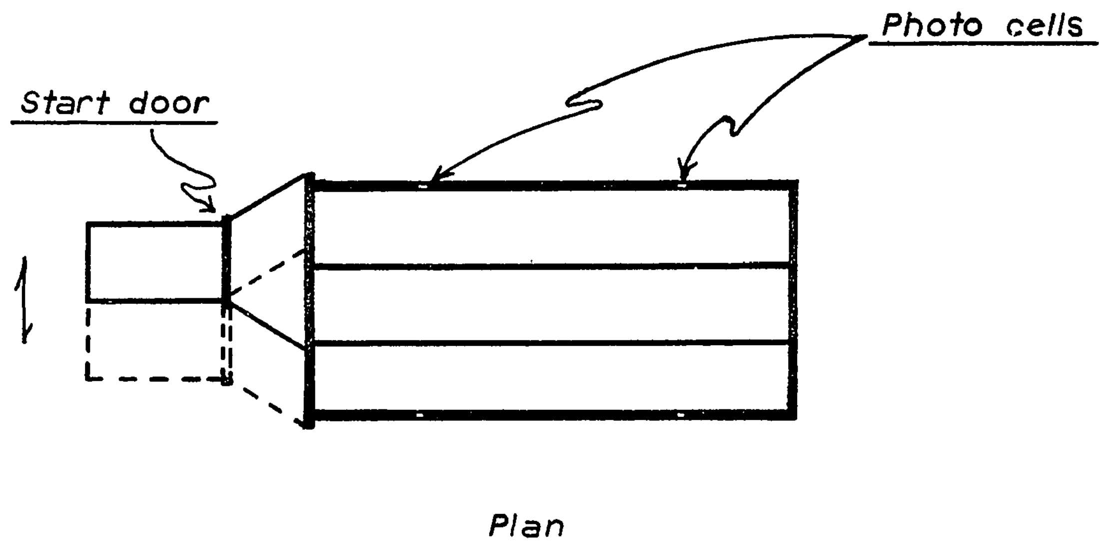
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