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EFFECT OF SUCCESSIVE TRAINING OF DIFFERENT N-LENGTHS UNDER PARTIAL REINFORCEMENT ON RESISTANCE TO EXTINCTION

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EFFECT OF SUCCESSIVE TRAINING OF DIFFERENT N-LENGTHS UNDER PARTIAL REINFORCEMENT ON RESISTANCE TO EXTINCTION

BY

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CHAPTER I

INTRODUCTION

The Hull-Sheffield generalization-decrement or aftereffects hypothesis (Hull, 1952; Sheffield, 1949) holds that a trial of nonreinforcement(N) or reinforcement(R) gives rise to characteristic stimuli which are "aftereffects" of nonreinforcement and "aftereffects" of reinforcement, respectively. If N stimuli carry over to the next trial when R occurs, S learns to respond to N cues during acquisition. In extinction, there is less generalization-decrement for the partially reinforced Ss because of their responding to these N of extinction cues in acquisition, and greater resistance to extinction is exhibited for the partially as compared to the consistently reinforced Ss. In an attempt to manipulate the "aftereffects" of N and R, Sheffield(1949) investigated resistance to extinction as a function of partial reinforcement and distribution of practice. The Hull-Sheffield hypothesis assumes that the "aftereffects" of N and R dissipate in time. If acquisition trials are spaced, then the "aftereffects" of N and R should dissipate by the beginning of the next trial, and little or no aftereffect-carryover should occur. Thus, spaced acquisition trials for partially and continuously reinforced Ss should produce essentially no difference in resistance to extinction. Massing of acquisition trials, however, would permit the aftereffect-carryover, and partially reinforced Ss should be more resistant to extinction than continuously reinforced Ss. To test this assumption, she used rats in a straight-alley runway and combined three variables factorially: (a) intertrial interval in acquisition (15 seconds vs. 15 minutes), (b) intertrial interval in extinction (15 seconds vs. 15 minutes), and (c) reinforcement ratio (50% vs. 100%). She found that after massed training, resistance to extinction was significantly greater for the 50% reinforcement groups than the 100% reinforcement groups. After spaced training, there was no difference between the 50% and 100% groups in resistance to extinction. Her results were interpreted as supporting the dissipation of the aftereffects in time according to the Hull-Sheffield hypothesis since with spaced acquisition trials, there was no difference in resistance to extinction between the partially and continuously reinforced Ss.

Rubin (1953) attempted to demonstrate greater resistance to extinction of continuous as compared to partial reinforcement by effectively controlling both secondary reinforcement cues and stimulus-generalization cues. Both reinforcement groups were trained to run down a straight-alley runway and to push a panel at the back of a delay box. Thirty-one acquisition trials were given to both groups, 16 trials being reinforced in the partial group. Using number of responses made by *Ss* before the extinction criterion, a significant difference was obtained between the two groups. The continuous group was significantly greater in resistance to extinction than the partial group. However, the results could be interpreted only as being a function of either secondary reinforcement or stimulus-generalization or a combinatio of both. The experiment was viewed as supporting the Hull-Sheffield hypothesis.

Several studies have challenged the aftereffect dissipation assumption, particularly Wilson, Weiss, and Amsel (1957) who repeated Sheffield's experiment. In Experiment I, they used dry food as the reinforcement in an attempt to enhance the Sheffield effect. In Experiment II, they used water as the reinforcement in an attempt to reduce the duration of the aftereffect. A total of 144 *Ss* were used, 72 *Ss* in each experiment. Sheffield's design, apparatus, and procedure were duplicated. The results of Experiment I indicated that the partial reinforcement groups were found to be significantly more resistant to extinction than the continuous reinforcement groups regardless of the intertrial interval in acquisition. In Experiment II, they found that all the massed extinction groups (i.e., the 4 halved acquisition subgroups extinguished under the 15-second interval) were more resistant to extinction than the spaced extinction groups (i.e., the four halved acquisition subgroups extinguished under the 15 minute interval) after both massed and spaced training and after both partial and continuous reinforcement. The results were not in agreement with the Hull-Sheffield hypothesis.

Weinstock (1954) investigated four values of the percentage of reinforcement variable (100%, 80%, 50%, and 30%) on running speed of rats in an L-shaped runway. He used a 24-hour intertrial interval in attempting to reduce the duration of the aftereffects. He found that group differences in running speed during extinction were significant with an inverse relation between percentage of reinforcement and resistance to extinction. In view of the large intertrial interval used by Weinstock, the extinction results could not be handled by the Hull-Sheffield hypothesis.

Another test of the Hull-Sheffield hypothesis was made by Crum, Brown, and Bitterman (1951) who introduced variable delay of reward into the partial reinforcement field. They tested two groups of rats in a straight-alley runway. The consistent group was rewarded immediately after traversing the runway. The partial delay of reinforcement group was rewarded immediately on half of the acquisition trials and delayed for 30 seconds on the other half of the trials. According to the Hull-Sheffield hypothesis, there should be no difference in the extinction performance of the two groups because there would be no aftereffects of nonreinforcement available on succeeding trials in acquisition, only aftereffects of reinforcement. It was found that the partial delay of reward group was significantly more resistant to extinction than the consistent group. The Hull-Sheffield hypothesis was seen to be unable to fully account for the effects of partial reinforcement in terms of delay on resistance to extinction.

Scott and Wike (1956) attempted to replicate the findings of Crum, Brown, and Bitterman in addition to studying the effect of trial-spacing of practice. Trial-distribution and percentage of reinforcement were the independent variables. Four basic training conditions were used: (a) Massed(M) - 100%, (b) M - 50%, (c) Spaced(S) - 100%, and (d) S - 50%. In extinction, these four groups were subdivided equally and were extinguished under spaced and massed trials. For the 50% groups, Ss were partially delayed, the reward being given immediately on 5 trials daily and being delayed for 30 seconds on the remaining 5 trials daily. In extinction,the partial delayed groups ran significantly faster than the immediate reinforcement groups. The results indicated that partial delayed reinforcement was unrelated to the distribution of training. The results were seen as detrimental to the Hull-Sheffield hypothesis.

Longenecker, Krauskopf, and Bitterman (1952) investigated alternating and random partial reinforcement on resistance to extinction in an attempt to test the aftereffects hypothesis. Two groups of 15 human Ss each were used in this experiment. The GSR to shock was conditioned and extinguished for all Ss to a light CS. Each S received 5 preliminary unreinforced CS presentations, 22 conditioning trials, and a maximum of 30 extinction trials. A random, 50% partial reinforcement group was compared with an alternating 50% partial reinforcement group. The Hull-Sheffield hypothesis would predict greater resistance to extinction for the alternating group as compared to the random group because the aftereffect-carryover to the reinforced trial would be maximized for the alternating group. During acquisition, the random reinforcement group showed a slightly, but not significantly, greater GSR magnitude than the alternating reinforcement group. In trials to extinction, the random group was significantly more resistant to extinction than the alternating group. These results were interpreted as contrary to the Hull-Sheffield aftereffects hypothesis because the alternating group failed to show superior resistance to extinction.

Tyler, Wortz, and Bitterman (1953) compared the effects of alternating and random partial reinforcement in a runway on resistance to extinction in two groups of 15 Ss each. According to the Hull-Sheffield hypothesis, the alternating group rather than the random group should produce greater resistance to extinction because in the alternating group more aftereffects would become conditioned to the running response. They found that the random group was significantly greater in resistance to extinction than the alternating group. Again, results were obtained which opposed predictions based on the Hull-Sheffield hypothesis.

Tyler (1956) investigated the essential stimulus-generalization and secondary reinforcement features of the experiments by Sheffield and Rubin. Three groups of 12 rats each were trained to traverse a straight-alley runway and to jump to a goal box under conditions of spaced practice. One group was reinforced continuously on every trial in a white goal box (Group Cn). A second group was reinforced randomly on 50% of the acquisition trials in a white goal box on both reinforced and nonreinforced trials (Group Sa). A third group was reinforced on 50% of the acquisition trials (Group Rv), the reinforced trials occurring in a white goal box and the nonreinforced trials occurring in a black goal box. Extinction trials were spaced, and each group ran to the goal box associated with reinforcement in acquisition. The intertrial intervals in both acquisition and extinction were 15 minutes. Groups Cn and Sa permitted a comparison based on Sheffield's experiment while Groups Cn and Rv permitted a comparison based on Rubin's experiment. The hypothesis of the experiment was that since the aftereffect-carryover should be negligible with the spaced intervals, no groups should be favored in resistance to extinction from the aftereffects viewpoint. For all 3 extinction days, Groups Sa and Rv ran significantly faster than Cn. It was concluded that the continuously rewarded <u>Ss</u> extinguished more rapidly than the partially rewarded <u>Ss</u> despite spaced practice and secondary reinforcement features. The findings were viewed as contrary to the results obtained by Sheffield and Rubin.

Capaldi (1958) investigated the effects of different numbers of acquisition trials (70 vs. 140) and different patterns of 50% partial reinforcement (single alternation vs. random) on resistance to extinction in 4 groups of rats in a runway. The 4 groups were Random (R) - 70, R - 140, alternating (A) - 70, and A - 140. The Hull-Sheffield hypothesis predicts increased resistance to extinction as amount of training is increased. The R -70 and A - 70 groups would extinguish faster than the R - 140 and A - 140 groups. The results were reversed in the case of the A groups as R - 70 was the most resistant to extinction followed in order by R - 140, A - 70, and A - 140. The Hull-Sheffield was seen to be incapable of accounting completely for these results. Lewis (1956) provided support for Sheffield (1949) in that short rather than long intertrial intervals in acquisition were found to result in greater resistance to extinction in partially reinforced rather than continuously reinforced Ss. However, evidence was found which was contradictory to that of Sheffield. Less resistance to extinction was found in the massed extinction group as a whole than in the spaced extinction group as a whole. Sheffield's results showed slightly but not significantly greater resistance to extinction for the massed extinction group as a whole compared to the spaced extinction group.

Other experiments obtaining results contrary to the Hull-Sheffield aftereffects hypothesis were Fehrer (1956), Freides (1957), Katz (1957), and Boyle (1961). By and large, the Hull-Sheffield hypothesis has not enjoyed widespread acceptance.

A notable exception to the above was the experiment by Capaldi and Hart (1962, Experiment II) which investigated the influence of a small number of partial reinforcement trials (i.e., 18 trials) on resistance to extinction. Using continuous (C), single alternating (SA), and random (R) groups in a straight-alley runway, they found that the C group was least resistant to extinction, and the SA group was more resistant to extinction than the R group. The results were interpreted as supporting the Hull-Sheffield aftereffects hypothesis.

The inadequacies of the Hull-Sheffield hypothesis with moderate and extensive numbers of training trials for SA and random reinforcement patterns on resistance to extinction and the dissipation of the aftereffects, perhaps, led Capaldi (1964) to formulate a modified version of the aftereffects hypothesis. It holds that the aftereffect of nonreinforcement (S^N) or nonreinforcement stimulus complex (e.g., lack of food particles in the mouth, grinding of teeth, frustration, searching, etc.) is modified as a function of successive nonreinforced (N) trials. The modifying of an S^N seems to depend upon the absolute value of the S^N which is determined by a simple positive growth function where 100 is the theoretical limit of stimulus modification with the growth fraction being 1/10. The absolute value of the S^N is assumed to increase with an increase in successive S^Ns, however the difference in value between successive S^Ns is not constant, but diminishes with successive N trials. As the value of the S^N increases, (a) progressively greater numbers of the higher values of S^N receive generalized habit strength, and (b) progressively higher values of S^N receive generalized habit strength. If equal habit strengths exist at each S^N value that is conditioned, then resistance to extinction should increase as the S^N value increases in acquisition.

An experiment consistent with predictions from the modified aftereffects hypothesis was that of Kendler, Pliskoff, D'Amato, and Katz (1957, Experiment III) who investigated the influence of partial reinforcements and nonreinforcements on resistance to extinction. Three basic groups were used. Group 100 was rewarded continuously with food on every training trial. Group 50 was rewarded with food on 50% of the training trials and nonrewarded on the remaining 50% of the trials. Group 50-50 was rewarded with food on 50% of the training trials and with water on the remaining 50% of the trials. Forty six training trials were given to S̲s̲ in an L-shaped runway using a massed intertrial interval. In extinction, the 50-50 group was divided equally into Group 50-50E which ran to an empty food dish as did Groups 50 and 100. Group 50-50W ran to a dish half filled with water. If 50-50 S̲s̲ showed inferior extinction performance, perhaps due to generalization-decrement, then comparison of the two subgroups would indicate whether the decrement was due to the removal of the water or the water vessel or both. A minimum of 20 and a maximum of 50 extinction trials were given. The modified aftereffects hypothesis would predict that Group 50 which was trained on N-lengths one and two would be more resistant to extinction than either groups mentioned (50-50 and 100). For number of responses to the extinction criterion, there were no differences among the groups. Using a more stringent criterion, Group 50 was significantly higher in number of responses to the criterion than was Group 100 and Group 50-50. The results were interpreted in terms of a fractional anticipatory concept, but the modified aftereffects view seemed to account for the data.

Capaldi (1964) investigated a partial reinforcement variable termed N-length which was defined as the number of nonreinforced (N) trials occurring successively without being interrupted by a reinforced (R) trial. A single N trial preceding one or more R trials was designated as an N-length of one (N_1-length). Two successive N trials preceding one or more R trials was designated as an N-length of two (N_2-length), and so on. In that investigation, three hypotheses were tested. Resistance to extinction would increase with increases in (a) N-length, (b) the number of times the particular N-length occurred, and (c) the number of different N-lengths. The results confirmed all three hypotheses, and the modified aftereffects hypothesis held that (a) N-length reflects the particular value of S^N conditioned to the instrumental response, (b) the number of times the particular N-length occurs reflects the amount of habit strength available at that value of S^N, and (c) the number of different N-lengths reflects the number of different values of S^N conditioned to the instrumental responses.

An experiment in seeming accord with the modified aftereffects hypothesis was that of Gonzalez and Bitterman (1964) who compared the effects of percentage of reinforcement and number of unreinforced trials in succession on resistance to extinction. They trained 60 *Ss* in discrete trials to press a retractable lever under two levels of percentage of reinforcement (30% vs. 60%) combined factorially with two levels of number of unreinforced trials in succession (short vs. long). A continuous reinforcement group served as the control group. Thirty acquisition trials daily for 15 days were given to Ss in a Skinner box-like enclosure. In extinction, there were 30 trials daily. If S failed to respond to the inserted lever within 30 seconds, the lever was retracted automatically. Five consecutive nonresponses to the lever within 30 seconds constituted the extinction criterion. For mean number of trials to the criterion, the 30%-long run group was most resistant to extinction followed in order by the 60%-long run group, the 30%-short run group, the 60%-short run group, and the 100% consistent group. At the extinction criterion, differences in resistance to extinction were significantly related to differences in the length of run. Differences in percentage of reinforcement and total number of nonreinforcements were not significantly related to differences in resistance to extinction. It was indicated that the number of unreinforced trials in succession was a critical variable in determining resistance to extinction.

Another experiment consistent with the modified aftereffects hypothesis was that of Boren (1961) who investigated resistance to extinction following fixed ratio training in an operant situation. A continuous group was given 540 reinforcements on a 0:1 ratio. Five fixed ratio groups (2:1, 5:1, 9:1, 14:1, and 20:1) were given 40 reinforcements on a 2:1 ratio followed by 500 reinforcements at each appropriate fixed ratio level. The results indicated that as the size of the fixed ratio increased from 0:1 to 20:1, resistance to extinction increased. An approximately linear increasing relation was found between the fixed ratio and the number of extinction responses.

One point is noteworthy about Boren's partially reinforced groups. They were given 40 reinforcements on a 2:1 ratio prior to the shift. This, in actuality, constituted an irregular pattern of reinforcement (i.e., variable ratio reinforcement) since a ratio of 2:1 was combined with each respective fixed ratio group with the exception of the 2:1 group which remained the same. Interpreted in terms of the modified aftereffects view, habit strength was built up for the partially reinforced groups at S^{N2} (the aftereffect of nonreinforcement following two successive N trials) for 40 reinforcements followed by the building up of habit strength at S^{N2}, S^{N5}, S^{N9}, S^{N14}, and S^{N20}, respectively, for each group for 500 reinforcements. Boren's consistent reinforcement group received no such irregular reinforcement pattern. The modified aftereffects hypothesis would hold that four of Boren's fixed ratio groups (5:1, 9:1, 14:1, and 20:1) would be slightly greater in resistance to extinction than 4 equivalent groups not given the 40 pretraining reinforcements on the 2:1 ratio schedule. In Boren's study, this slightly increased resistance to extinction in the former groups would be determined by setting up a proportion of the number of experimental pretraining reinforcements to the total number of experimental pretraining and acquisition reinforcements together in the experiment. In Boren's experiment, this proportion would be $40/540 = 7.4\%$. Thus, the former groups should show approximately 8% increased resistance to extinction due to the experimental pretraining and not due to the experimental fixed ratio training as compared to the latter groups. Unfortunately, this slightly increased resistance to extinction in Boren's former groups would not be apparent since it would be masked under the fixed ratio training conditions. Thus, a comparison between the two sets of groups in Boren's experiment would be virtually impossible.

An independent experiment was called for which could determine the effects of experimental pretraining on resistance to extinction. The theoretical basis for this independent experiment was advanced by Capaldi(1964, p. 235) who states "that a fixed ratio group merely given, say, x reinforcements at S^{N4} would be less resistant to extinction than another pretrained at S^{N1} and then given x reinforcements at S^{N4} and this increase will be proportional to the number of reinforcements administered at S^{N1}."

The purpose of the present experiment was to test the foregoing theoretical interpretation by investigating the effect of successive training of different N-lengths under partial reinforcement on resistance to extinction in a discrete trials experimental situation.

The experiment used 4 groups. Two experimental groups were given 64 and 32 acquisition trials, respectively, phase I (pretraining) at S^{N1} under 50% partial reinforcement followed by 120 acquisition trials at S^{N4} under 50% partial reinforcement, phase II. The former experimental group was designated Group $64N_1$-$120N_4$ while the latter group was designated Group $32N_1$-$120N_4$. Two control groups were not given phase I trials, but received 120 acquisition trials at S^{N4}(phase II) and S^{N0}(continuous reinforcement), respectively, the former control group being under 50% partial reinforcement. The former control group was designated Group $120N_4$, and the latter group was designated Group $120N_0$.

It should be noted that the four groups were not given an equal number of reinforcements during the acquisition phases. Groups $64N_1$-$120N_4$, $32N_1$-$120N_4$, $120N_4$, and $120N_0$ were given 92, 76, 60, and 120 reinforcements, respectively. However, it should be noted that Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ did not receive 92 and 76 reinforcements, respectively, at S^{N4}. Rather, 32 and 16 reinforcements were given to Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$, respectively, at S^{N1} followed by 60 reinforcements for both groups at S^{N4}. Theoretically, the conditioning of S^{N1} and S^{N4} to the instrumental response should be different from conditioning only S^{N4} to the instrumental response for 184 trials, 152 trials, or 120 trials. In this investigation, it was felt that the crucial variable was the different S^Ns conditioned to the instrumental response even though the number of reinforcements were not constant over the groups.

Some recent partial reinforcement evidence suggests that increasing acquisition training tends to lead to decreased resistance to extinction (North and Stimmel, 1962; McCain, Lee, and Powell, 1962; Lewis and Duncan, 1958; Murrillo and Capaldi, 1961). Predictions from the present investigation are opposite in that according to the Capaldi contention, different N-lengths is a more important variable affecting resistance to extinction than amount of acquisition training per se.

It was hypothesized that (a) Group $64N_1$-$120N_4$ would be most resistant to extinction followed in order by Groups $32N_1$-$120N_4$, $120N_4$, and $120N_0$, and (b) Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ would be more resistant to extinction than Group $120N_4$ in proportion to the number of acquisition phase I reinforcements given at S^{N1} to the total number of acquisition phase I and II reinforcements together(i.e., 35% and 21%, respectively). In other words, Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$, successively conditioning S^{N1} and S^{N4} to the lever-pressing response, should be expected to be more resistant to extinction than Group $120N_4$. Habit strengths built up at the two successively conditioned S^Ns (as reflected by the two different N-lengths) would summate along a nonreinforced continuum from S^{N1} to about S^{N6}, the range of habit strength generalization for those particular values. Group $120N_4$, conditioning only S^{N4} to the lever-pressing response, would be expected to be less resistant to extinction than Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ because no summation would occur. Group $120N_0$, not conditioning any S^Ns to the lever-pressing response, would be expected to be the least resistant to extinction.

CHAPTER II

METHOD

Subjects. The Ss, approximately 130 days old at the beginning of the experiment, were 44 experimentally-naive, male rats. They were purchased from the Holtzman Company, Madison, Wisconsin. The Ss were housed individually in a temperature controlled room for the duration of the experiment.

Apparatus. The apparatus used in this experiment was similar to that used by Gonzalez and Bitterman (1964). It consisted of a sound resistant ice chest which enclosed a Skinner box, a Lehigh Valley Electronics retractable-lever housing, and a Gerbrands food pellet feeder. External to the ice chest was a Lafayette timer which measured the response latencies of Ss. A white noise and the hum of an electric fan within the ice chest served to mask extraneous sounds within the experimental room. The Skinner box dimensions were 9¼ x 8½ x 7¼ inches. Several stainless steel, circular rods 3/8 inch in diameter served as the floor of the Skinner box. The front and back walls were metal while the side walls and top were plexiglass. Fastened to the center of the front wall and external to the Skinner box was the retractable-lever housing. The retractable-lever, approximately 2 inches above the floor, was inserted into the Skinner box through a slot in the center of the front wall. A force of approximately 10 - 12 grams was required to depress the lever. Mounted 3 inches above the retractable-lever was a 7-watt lamp which served to illuminate the lever when it was inserted. The lever-lamp was turned on with the insertion of the lever into the Skinner box and was turned off by a depression of the lever by S. On the lower, left side of the front wall was a food tray to which the Gerbrands food pellet feeder was connected. Mounted 2 inches above the food tray was another 7-watt lamp which served to illuminate the food tray immediately after the lever had been depressed. The lever-lamp and the food tray lamp were the only sources of illumination within the interior of the ice chest as it was dark at all other times. During preliminary training, E pushed a button which activated the discharge of a 97 mg. Noyes food pellet from the feeder and the onset of the food tray lamp for a given period of time. E controlled the insertion of the lever for all acquisition and extinction trials by pushing a button connected to the circuitry, and the responses of Ss activated the retraction of the lever. The task of E was to (a) push a button for a reinforced or nonreinforced trial which activated simultaneously the insertion of the lever and the onset of the lever-lamp, (b) record the response latencies of Ss from the latency-timer, and (c) reset the latency-timer during the inter-trial interval for the next trial.

Procedure.

Preliminary training. On Day 1, Ss were placed in individual cages on a 23 hour food deprivation schedule, and the feeding of one hour daily was maintained for the duration of the experiment. Also, the 44 Ss were divided randomly into 4 groups of 11 Ss each. On Days 2 - 10, each S was handled for 10 minutes daily on a table top immediately prior to feeding.

On Day 11, the lever remained inserted and the free-responding operant level for lever-pressing of each S was measured for 15 minutes in the Skinner box. A 7-watt light attached to the interior wall of the ice chest remained on continuously for each S's session. At the end of the 15 minutes, S was returned to the home cage for the remainder of the one hour feeding period. On Day 12, Ss were placed into the Skinner box and the operant level for lever-pressing for discrete trials was measured for 12 minutes followed by 3 minutes of feeding at the food tray. E started each trial by activating the onset of the lever-lamp, the insertion of the lever, and the start of the latency-timer. S's lever-press retracted the lever, turned off the lever-lamp, and stopped the latency-timer. Immediately after the retraction of the lever, the 15 second intertrial interval began. At the end of the 15 seconds, E started the next trial, and the cycle was repeated. If no response had been made by the 12th minute of the session, E retracted the lever, turned off the lever-lamp, and stopped the latency-timer. This lever retraction was not counted as a response and no latency was recorded. After the lever had been retracted, the food tray lamp was turned on and remained on for a 3 minute feeding period at the food tray. Then, five 45 mg. Noyes food pellets were discharged into the food tray. As soon as S had consumed these 5 pellets, five additional pellets were discharged. Twenty-five pellets were given to each S during the 3 minute feeding period at the food tray. After the 3 minute feeding period had elapsed, each S was returned to the home cage for the remainder of the one hour feeding period. No significant differences among groups were found for the free-responding and discrete-trial operant sessions.

On Days 13, 14, and 15, the lever remained retracted, and Ss were food tray trained individually. E activated the onset of the food tray lamp and the discharge of a 97 mg. Noyes food pellet. The food pellets were discharged by E at varying intervals during each of the three days. The food tray lamp was turned on for 15, 10, and 5 seconds, respectively, for these three days. The purpose of progressively decreasing the duration of the food tray lamp was to train Ss to take the food pellet quickly. For the remainder of preliminary training, the food tray lamp was turned on for 3 seconds following each lever-press.

On Days 16, 17, and 18, the lever remained in the Skinner box, and Ss were trained to press the lever under continuous reinforcement. During these days, the lever-lamp was turned on continuously. On Day 19, a food pellet was discharged after each of 20 lever presses by Ss. At the end of the session, Ss were returned to the home cage.

Experimental training. On Day 20, differential group treatment began. Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ were given 16 experimental pretraining trials daily for 4 and 2 days, respectively, at S^{N1} using a single alternating, 50% partial reinforcement patterns: RNRNRNRN, etc. Group $120N_4$ was given 8 acquisition trials daily for 15 days at S^{N4} using a 50% partial reinforcement pattern: RNNNNRRR. Group $120N_0$ was given 8 acquisition trials daily for 15 days at S^{N0} (continuous reinforcement). Beginning on Day 22, Group $32N_1$-$120N_4$ was given 8 acquisition trials daily for 15 days at S^{N4} using a 50% partial reinforcement pattern: RNNNNRRR. Beginning on Day 24, Group $64N_1$-$120N_4$ was given 8 acquisition trials daily for 15 days at S^{N4} using the same previously mentioned 50% partial reinforcement pattern: RNNNNRRR.

During experimental training, S was placed into the Skinner box. Then, the start of each trial was controlled by E who pushed the appropriate reinforcement or nonreinforcement button which simultaneously (a) inserted the lever, (b) turned on the lever-lamp, and (c) started the latency-timer. On reinforced trials, S's lever-press (a) retracted the lever, (b) turned off the lever-lamp, (c) stopped the latency-timer, (d) turned on the 3 second food tray lamp, and (e) discharged a 97 mg. Noyes food pellet. Then, the 15 second intertrial interval was started. On nonreinforced trials, S's lever-press (a) retracted the lever, (b) turned off the lever-lamp, and (c) stopped the latency-timer. The food tray lamp was not turned on and there was no discharge of a food pellet. Immediately after the lever-press by S, the 15 second intertrial interval was started. At the end of the 15 seconds, E started another trial. After the last daily trial, S was returned to the home cage for the remainder of the hour feeding period.

Extinction began on the day following the completion of the 120 acquisition trials for each of the 4 groups. Each S's running time during the day and deprivation schedule remained exactly the same in extinction as in acquisition. Twelve discrete extinction trials were given daily to Ss until the extinction criterion was met. The criterion consisted of 5 consecutive failures to respond to the inserted lever within 30 seconds on a given day. For any failure to respond to the lever within 30 seconds, a latency of 30 seconds was recorded for that trial. The same procedure applied to the extinction trials as was followed for the nonreinforced acquisition trials with one exception. If S failed to respond to the lever within 30 seconds, E (a) retracted the lever, (b) turned off the lever-lamp, (c) stopped the latency-timer, and (d) started the 15 second intertrial interval.

CHAPTER III

RESULTS

Acquisition phase I performance of Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ is shown in Figure 1. Mean latency of response for Group $64N_1$-$120N_4$ decreased considerably by the end of the fourth acquisition phase I day to a level of about 4.3 seconds. Mean latency of response for Group $32N_1$-$120N_4$ decreased considerably by the end of the second acquisition phase I day to a level of about 4.8 seconds. To test the differences between Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ for the first two days of acquisition phase I, an independent samples t test was used. The obtained t did not meet significance ($t = 0.29$, $df = 10$). Both groups performed at approximately similar levels.

The use of temporal response measures often leads to a lack of homogeneity of error variance. In order to determine whether data transformation was necessary, Hartley's F_{max} test for homogeneity of error variance was performed on the appropriate group variances of the response latencies for acquisition phase II. The assumption of homogeneity of error variance was retained ($F = 3.69$, $df = 4/10$).

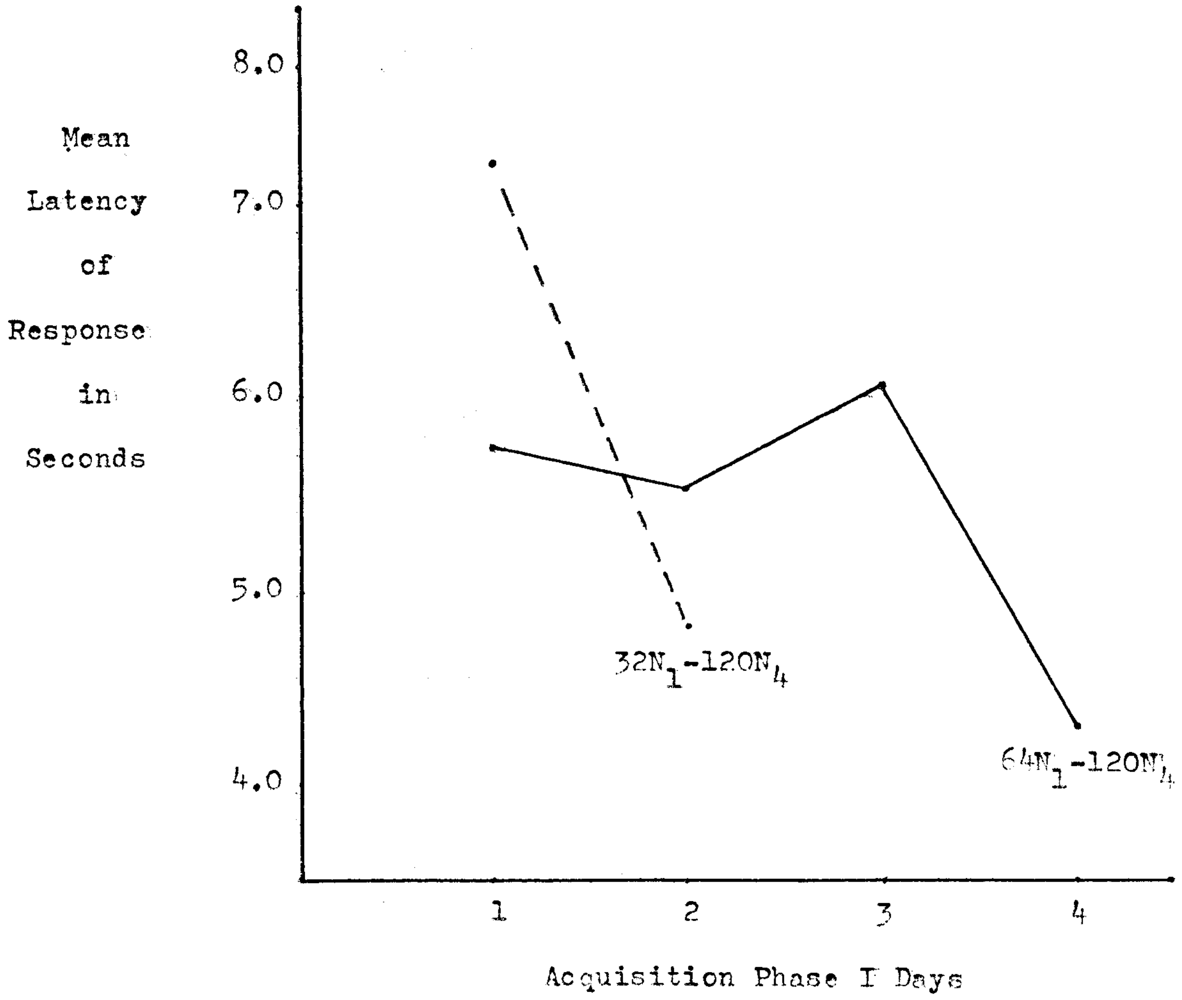


Figure 1. Acquisition phase I performance of Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$.

Acquisition phase II performance of all four groups is shown in Figure 2. Mean latency of response declined in a negatively accelerated fashion for all groups to levels ranging from 1.79 seconds to 3.12 seconds for the last block of days. Group $64N_1$-$120N_4$ tended to respond consistently the fastest over the course of acquisition phase II followed in order by Groups $32N_1$-$120N_4$, $120N_0$, and $120N_4$.

A 4(Groups) x 5(Blocks of acquisition phase II days) multi-factor analysis of variance was used to test for any significant differences between treatments(see Table I). A main effect, blocks of days, was significant beyond the .01 level (F = 25.78, df = 4/160). Responding was faster as a function of increased acquisition phase II training. No significant group differences in responding over acquisition phase II were found. Two single factor analyses of variance were built into the design to test for any performance differences for the first and last blocks of acquisition phase II days. Significant group mean response latency differences were found neither for the first block of acquisition phase II days (F = 2.42, df = 3/40) nor for the last block of acquisition phase II days (F = 1.61, df = 3/40). Over the course of acquisition phase II, no group differences in mean latency of response on reinforced and nonreinforced trials were observed. All four groups tended to respond as fast on reinforced as well as on nonreinforced trials.

Performance on the initial three extinction days is shown in Figure 3. Group $64N_1$-$120N_4$ responded consistently the fastest of all four groups. Groups $32N_1$-$120N_4$&$120N_4$ responded almost

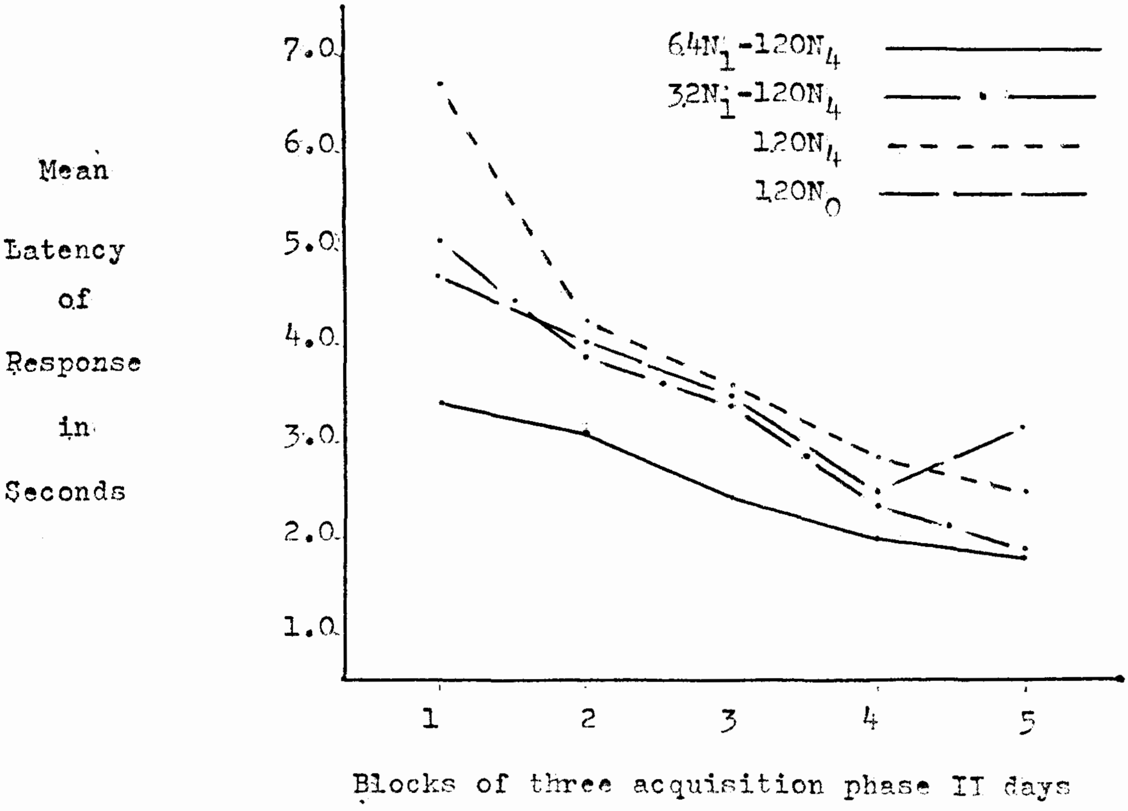


Figure 2. Acquisition phase II performance of all groups.

TABLE I

ANALYSIS OF VARIANCE OF THE COURSE OF ACQUISITION PHASE II

Source	df	MS	F
Between Ss	43		
A (Groups)	3	11,559.0	1.10
Ss w/n groups	40	10,460.3	
Within Ss	176		
B (Blocks of Days)	4	30,683.7	25.78**
AB (Groups x Blocks)	12	1,753.5	1.47
B x Ss w/n groups	160	1,190.3	

$F_{.99}$ (4, 160) = 3.48

** = significant at the .01 level

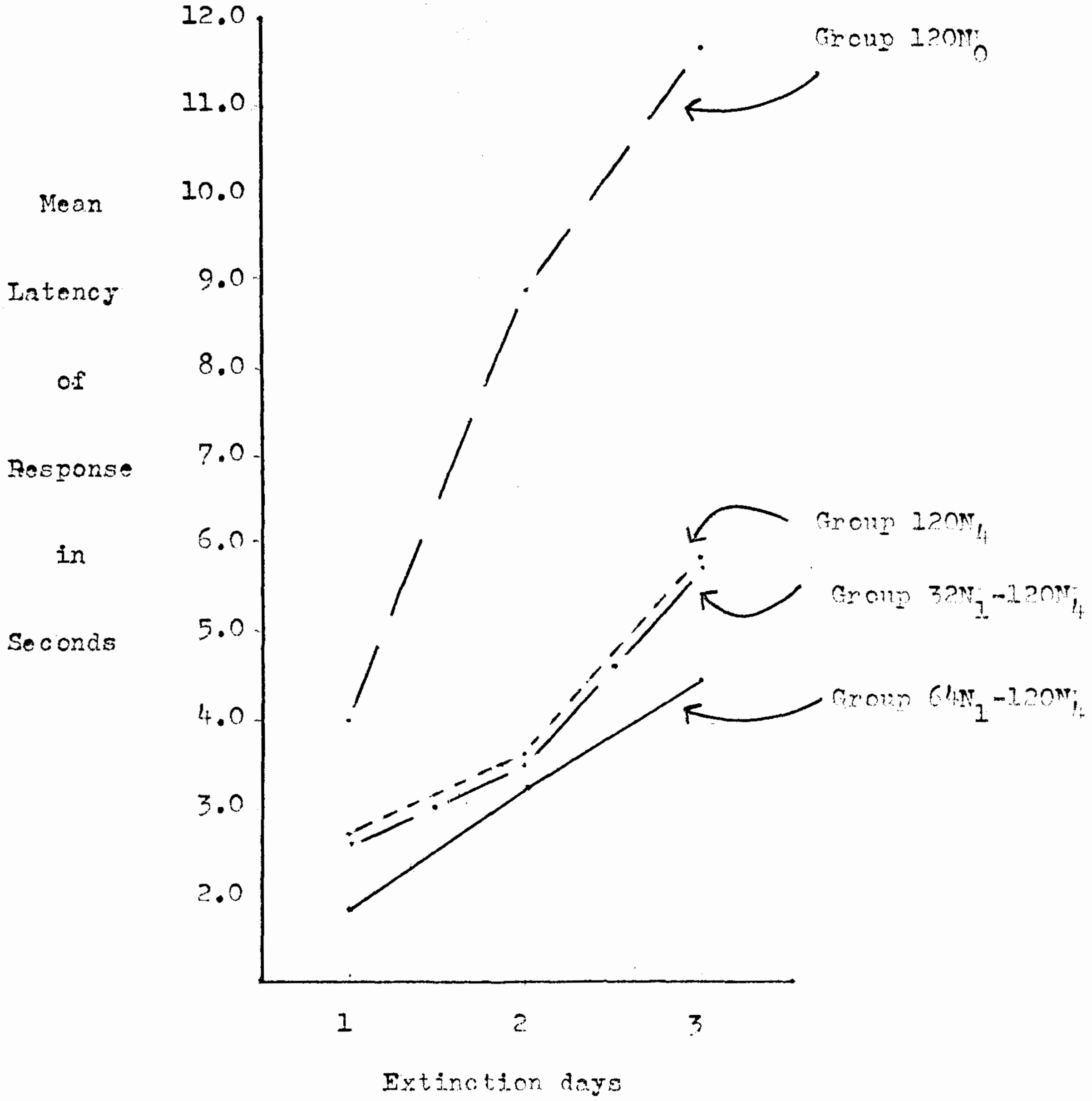


Figure 3. Performance of all groups on the first three extinction days.

identically and responded slightly slower than Group $64N_1$-$120N_4$. Group $120N_0$ responded consistently the slowest of the four groups. A 4(Groups) x 3(Extinction days) multifactor analysis of variance of mean response latencies(see Table II) yielded a significant Groups by Days interaction (F = 3.18, df = 6/80), a significant main effect of Groups (F = 7.18, df = 3/40), and a significant main effect of Days (F = 33.05, df = 2/80).

A clear-cut interpretation of the significant main effects was prevented by the interaction, but an analysis of variance for simple main effects was permitted(see Table III). The simple effects analysis of variance yielded two significant simple main effects: (a) groups at extinction day 2 and (b) groups at extinction day 3. The differences within each of the two simple simple main effects were analyzed by the Duncan q' statistic(see Tables IV and V).

From Tables IV and V, it can be seen that (a) Group $120N_0$ responded significantly slower on extinction days 2 and 3 than any of the partial groups, (b) the three partial groups were not significantly different in responding among themselves, and (c) the groups from most to least resistance to extinction were Groups $64N_1$-$120N_4$, $32N_1$-$120N_4$, $120N_4$, and $120N_0$.

Resistance to extinction of the four groups is shown in Figure 4. At each criterion, Group $64N_1$-$120N_4$ was most resistant to extinction followed by Groups $120N_4$, $32N_1$-$120N_4$, and $120N_0$. A single factor analysis of variance was used to test for treatment differences at the fifth and final extinction criterion(see Table VI). A significant treatment effect was obtained (F = 8.85,

TABLE II

ANALYSIS OF VARIANCE OF THE COURSE OF EXTINCTION FOR THE INITIAL THREE EXTINCTION DAYS

Source	df	MS	F
Between _Ss_	43		
A (Groups)	3	24,455.8	7.18**
_Ss_ w/n groups	40	3,404.6	
Within _Ss_	88		
B (Days)	2	26,712.5	33.05**
AB (Groups x Days)	6	2,573.7	3.18**
B x _Ss_ w/n groups	80	808.2	

$F_{.99}(3, 40) = 4.31$

$F_{.99}(2, 80) = 4.98$

$F_{.99}(6, 80) = 3.12$

** = significant at the .01 level

TABLE III

ANALYSIS OF VARIANCE FOR SIMPLE EFFECTS OF EXTINCTION PERFORMANCE FOR THE INITIAL THREE EXTINCTION DAYS

Source	df	MS	F
A at b_1 (Groups at day 1)	3	1,215.4	0.73
A at b_2 (Groups at day 2)	3	11,935.6	7.13**
A at b_3 (Groups at day 3)	3	16,452.4	9.83**
Within cell	120	1,673.7	

$F_{.99}(3,120) = 3.95$

** = significant at the .01 level

TABLE IV

DUNCAN q' TEST FOR DIFFERENCES BETWEEN ORDERED MEANS FOR ALL GROUPS ON THE SECOND EXTINCTION DAY

Group	$64N_1$-$120N_4$	$32N_1$-$120N_4$	$120N_4$	$120N_0$
Ordered means	38.59	41.32	42.55	106.62
$q'_{.99}(k, 40)$		3.82	3.99	4.10
$s_x\ q'_{.99}(k, 40)$		47.14	49.24	50.59
$64N_1$-$120N_4$			3.96	68.03^{**}
$32N_1$-$120N_4$			1.23	65.30^{**}
$120N_4$				64.07^{**}

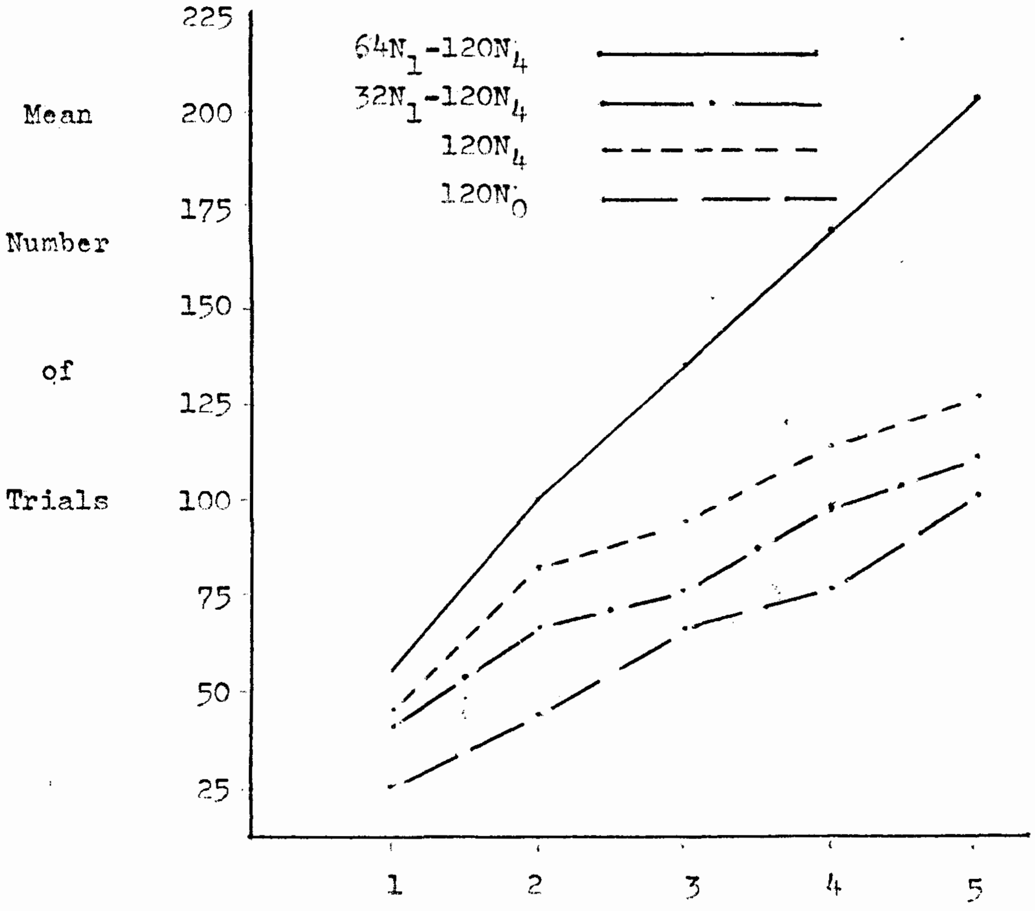
** = significant at .01 level

TABLE V

DUNCAN q' TEST FOR DIFFERENCES BETWEEN ORDERED MEANS FOR ALL GROUPS ON THE THIRD EXTINCTION DAY

Group	$64N_1$-$120N_4$	$32N_1$-$120N_4$	$120N_4$	$120N_0$
Ordered means	53.26	68.29	68.35	139.33
$q'_{.99}(k, 40)$		3.82	3.99	4.10
$s_x\ q_{.99}(k, 40)$		47.14	49.24	50.59
$64N_1$-$120N_4$			15.09	86.07^{**}
$32N_1$-$120N_4$			0.06	71.04^{**}
$120N_4$				70.98^{**}

** = significant at .01 level



Successive criteria(one nonresponse, two nonresponses, ... five nonresponses to the inserted lever within 30 seconds)

Figure 4. Resistance to extinction of the four groups.

TABLE VI

ANALYSIS OF VARIANCE OF THE MEAN NUMBER OF TRIALS TO REACH THE FIFTH EXTINCTION CRITERION

Source	df	MS	F
SS_{treat}	3	24,181	8.85**
$SS_{w/n\ treat}$	40	2,731	
SS_{total}	43		

$F_{.99}(3, 40) = 4.31$

** = significant at .01 level

TABLE VII

DUNCAN q' TEST FOR DIFFERENCES BETWEEN ORDERED MEANS FOR MEAN NUMBER OF TRIALS TO THE FIFTH EXTINCTION CRITERION

Group	$120N_0$	$32N_1$-$120N_4$	$120N_4$	$64N_1$-$120N_4$
Ordered means	101.55	110.45	126.27	204.27
$q'_{.95}(k, 40)$		2.89	3.04	3.12
$q'_{.99}(k, 40)$		3.82	3.99	4.10
$s_x\ q'_{.95}(k, 40)$		45.95	48.34	49.61
$s_x\ q'_{.99}(k, 40)$		60.74	63.44	64.19
$120N_0$			24.72	102.72**
$32N_1$-$120N_4$			15.82	93.82**
$120N_4$				78.00**

** = significant at .01 level

df= 3/40). The differences between treatments were analyzed by the Duncan q' statistic(see Table VII). Group $64N_1$-$120N_4$ was found to take a significantly greater number of trials to reach the fifth criterion than any of the other groups ($p < .01$). Comparison of mean number of trials to the fifth extinction criterion for Groups $64N_1$-$120N_4$ and $120N_4$ revealed that the extinction performance of Group $64N_1$-$120N_4$ was 38% better than that of Group $120N_4$. The remaining three groups (i.e., $120N_4$, $32N_1$-$120N_4$, and $120N_0$) were not significantly different among themselves in mean number of trials to the fifth extinction criterion.

CHAPTER IV

DISCUSSION

The present experiment was designed to test the theoretical interpretation that the conditioning successively of different S^Ns to the lever-pressing response would lead to increased resistance to extinction. It was hypothesized that (a) Group $64N_1$-$120N_4$ would be most resistant to extinction followed by Groups $32N_1$-$120N_4$, $120N_4$, and $120N_0$, and (b) the extinction performances of Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$, who conditioned S^{N1} and S^{N4} differentially to the lever-pressing response, would be better than that of Group $120N_4$ by approximately 35% and 21%, respectively.

The results of this experiment partially supported the experimental hypotheses as reflected by the extinction performance of Group $64N_1$-$120N_4$. On the first three extinction days, Group $64N_1$-$120N_4$ responded consistently the fastest of the four groups. For these three extinction days, Group $64N_1$-$120N_4$ was seen to respond about 20% faster than Group $120N_4$. For mean number of trials to the successive extinction criteria, Group $64N_1$-$120N_4$

clearly required a greater number of trials to meet each extinction criterion. At the fifth criterion, Group $64N_1$-$120N_4$ took a significantly greater number of trials to extinguish than any of the other groups and required about 38% more trials than did Group $120N_4$.

Group $64N_1$-$120N_4$ successively conditioned two different S^Ns to the instrumental response. Summation of habit strengths of S^{N1} and S^{N4} theoretically occurred and resulted in heightened resistance to extinction. The extinction performance of Group $64N_1$-$120N_4$ clearly supported the hypotheses: (a) Group $64N_1$-$120N_4$ was consistently the most resistant to extinction of the four groups, and (b) Group $64N_1$-$120N_4$ was 38% more resistant to extinction than Group $120N_4$(slightly exceeding the hypothesized 35% difference). The performance of Group $64N_1$-$120N_4$ in acquisition and extinction did not support any relation that increased acquisition training leads to decreased resistance to extinction.

The extinction performance of Group $32N_1$-$120N_4$ was unexpected and did not support the hypotheses. For the first three extinction days, the performance of Group $32N_1$-$120N_4$ was almost identical to that of Group $120N_4$. The performance of Group $32N_1$-$120N_4$ was expected to be somewhat better than that of Group $120N_4$. For mean number of trials to successive extinction criteria, Group $32N_1$-$120N_4$ took fewer trials to reach every criterion than did Group $120N_4$. Clearly, Group $32N_1$-$120N_4$ was performing at a level lower than that which was hypothesized. The performance of Group

$32N_1$-$120N_4$ was consistent with an increased acquisition training, decreased resistance to extinction relationship. An alternative explanation of the failure of Group $32N_1$-$120N_4$ to exhibit greater resistance to extinction than Group $120N_4$ might be found in the conditioning of S^{N1} to the instrumental response. Perhaps, sixteen reinforcements were not adequate to condition S^{N1} to the instrumental response. This assumed to be the case, little or no summation of habit strengths of S^{N1} and S^{N4} would be theoretically expected. Assuming the above, Group $32N_1$-$120N_4$, when compared to Group $120N_4$, would be expected to exhibit similar rather than greater resistance to extinction. This alternative seems plausible in that mean response latency on the first three extinction days and mean number of trials to the fifth criterion were highly similar for both groups.

Concerning the failure of Group $32N_1$-$120N_4$ to exhibit greater resistance to extinction than Group $120N_4$, let us look at some parallel evidence(i.e., frustration theory) based on the conditioning of frustration to the instrumental response in an attempt to shed some light on the topic at hand. The frustrative interpretation of partial reinforcement on extinction holds that the partial reinforcement effect(PRE) will be evident only after a critical number of trials is experienced, only after frustration stimuli have been conditioned to the response. This critical number of trials depends upon the training situation(Amsel, 1958). Amsel (1958) cited an unpublished study in which number of acquisition trials(24 vs. 84) was varied with percentage of reinforcement(50% vs. 100%) in an eight foot runway. The result of interest to the present experiment was the finding that the 23 trial continuous group was slightly more resistant to extinction than the 24 trial pertial group. Evidently, frustration was not conditioned fully to the instrumental responses of the 24 trial partial group. Slightly more trials were needed for the development of the frustration effect(FE). Cited in Amsel(1958) was a study by Wagner(1957) who investigated motivational aspects of nonreward. He found that the FE was developed adequately between acquisition trials 29 and 36.

Amsel's results indicate that, perhaps, 32 trials or 16 reinforcements are not sufficient to condition S^{N1} adequately to the instrumental response in the present investigation.

Another aspect of the extinction performance of Group $32N_1$-$120N_4$ was the failure to demonstrate the PRE. Group $32N_1$-$120N_4$ was more but not significantly more resistant to extinction than Group $120N_0$, the continuously reinforced group. Perhaps, this performance failure also was related to the possible failure to condition S^{N1} adequately to the response.

Resistance to extinction of Group $120N_4$ seemed consistent with the hypotheses since (a) the extinction performance in terms of number of trials to criterion for Group $120N_4$ was about 38% poorer than Group $64N_1$-$120N_4$, and (b) it was not significantly different in resistance to extinction than Group $32N_1$-$120N_4$. However, resistance to extinction of Group $120N_4$, like Group $32N_1$-$120N_4$, was not significantly greater than that of Group $120N_0$. A speculative attempt to account for the failure of Group $120N_4$ to be significantly more resistant to extinction than Group $120N_0$ might involve the training environment and its relationship to the conditioning of S^Ns to the instrumental response. Perhaps, conditioning S^Ns to a lever-press under discrete trials in a Skinner box is slightly more difficult than conditioning S^Ns in a runway under discrete trials since the latter requires more effort to respond and may be more compatible with the conditioning of S^Ns. If this were the case, then partially rewarded Ss would be affected directly by such an implication, the effect being to reduce resistance to extinction. Continuously rewarded Ss, on the other hand, would never experience a nonrewarded trial, hence would be less influenced by the foregoing supposition, and resistance to extinction would be unaffected.

Some of the results of the present experiment directly supported the hypotheses and others were encouraging in their relation to the predictions based on Capaldi's modified aftereffects hypothesis. An explanation of the failure of Group $32N_1$-$120N_4$ to perform in accord with the experimental hypotheses was advanced which was consistent with the modified aftereffects view. Much more research is needed to investigate and test various aspects concerning this interpretation of partial reinforcement on resistance to extinction. The present experiment was such a research investigation.

Future research on the conditioning of different S^Ns to the response in a Skinner box would include several recommendations based on the procedures and results of the experiment. First, and foremost, it would be important to consider using a total number of acquisition phase I reinforcements or trials in excess of 16 or 32, respectively. Secondly, it might be advisable to increase the total number of acquisition phase II trials to at least 250 or 300 to attempt to insure a stable asymptotic level for all groups. It should be noted that Gonzalez and Bitterman (1964) gave 450 training trials to Ss in an investigation designed to study the effects of percentage of reinforcement and number of nonreinforced trials in succession on resistance to extinction. Thirdly, it is recommended that the discrete-trials retractable lever be positioned in the extreme right hand corner(away from the food tray) of the front wall of the Skinner box. This would require Ss to exert more effort in making a response. Lastly, it is recommended that Ss be trained to lever-press in the actual discrete-trials situation prior to experimental training. The present study trained Ss under a continuous free-responding situation followed by discrete-trials training. This procedure was satisfactory for Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ since they first experienced exactly the same alternating nonreinforced and reinforced pattern under discrete-trials, however, Group $120N_4$ first experienced discrete-trials under a different reinforcement pattern, that being S^{N4}(i.e., RNNNNRRR). Clearly, it can be seen that first experience with discrete-trials was confounded with the pattern of reinforcement first encountered. Just how much this did or could affect the learning and extinguishing of a response is unknown at present.

CHAPTER V

SUMMARY

This experiment was designed to test a theoretical interpretation based on Capaldi's modified aftereffects hypothesis. It held that the conditioning successively of different S^{N}s to the lever-pressing response would lead to increased resistance to extinction.

Four groups of eleven, male Holtzman rats each were trained to press a retractable lever in a Skinner box under discrete-trials. Group $64N_1$-$120N_4$ was given 64 trials of 50% partial reinforcement which provided the opportunity for S^{N1} to become conditioned to the lever-pressing response. Following these 64 trials, Group $64N_1$-$120N_4$ was given 120 trials of 50% partial reinforcement which provided the opportunity for S^{N4} to become conditioned to the response. Group $32N_1$-$120N_4$ was given 32 trials of 50% partial reinforcement at S^{N1} followed by 120 trials of 50% partial reinforcement at S^{N4}. Group $120N_4$ was given no opportunity to condition S^{N1} to the instrumental response, but was given 120 trials of 50% partial reinforcement at S^{N4}. Group $120N_0$ was continuously reinforced and no S^{N}s whatsoever could be conditioned to the instrumental lever-pressing response.

It was hypothesized that Group $64N_1$-$120N_4$ would be most resistant to extinction followed by Groups $32N_1$-$120N_4$, $120N_4$, and $120N_0$. Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$, conditioning S^{N1} and S^{N4} to the instrumental response, were expected to be more resistant to extinction than Groups $120N_4$ and $120N_0$. Habit strengths built up at the two S^Ns would summate , generalized habit strength would be projected to higher S^Ns, and <u>Ss</u> would be more resistant to extinction since generalized habit strength of higher S^Ns would sustain extinction responding. It was further hypothesized that Groups $64N_1$-$120N_4$ and $32N_1$-$120N_4$ would be more resistant to extinction than Group $120N_4$ based on the number of reinforcements given at S^{N1}(i.e., 35% and 21%, respectively).

The results were interpreted as partial support for the experimental hypotheses. Group $64N_1$-$120N_4$ was consistently the most resistant to extinction both in mean latency of response for the first three extinction days and in mean number of trials to the successive extinction criteria. Group $64N_1$-$120N_4$ slightly exceeded the hypothesized 35% difference by requiring 38% more trials to reach the fifth and final extinction criterion when compared to Group $120N_4$. The extinction performance of Group $32N_1$-$120N_4$ failed to exhibit greater resistance to extinction than Group $120N_4$ and was not significantly more resistant to extinction than Group $120N_0$. This failure of Group $32N_1$-$120N_4$ was discussed in terms of a possible inadequate conditioning of S^{N1} to the response for acquisition phase I. Resistance to extinction of Group $120N_4$ appeared to be in line with the hypotheses, however, it was not significantly greater than that of Group $120N_0$. A speculative explanation was suggested concerning this insignificance. Four recommendations for future research in the area of conditioning different S^Ns to a response were presented and discussed.

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VITA

Edward Dale Walters was born on September 25, 1939, in Dayton, Ohio. He attended Van Buren Junior High School and was graduated from Fairmont High School in June, 1957. In September, 1957, he entered Ohio University, planning to study chemistry. In his sophomore year, he switched his major to psychology and in February, 1962, he was graduated from Ohio University with an A. B. in Psychology. On February 13, 1962, he was employed as an assistant research psychologist in the Environmental Stress Branch, Training Research Division, Behavioral Sciences Laboratory, Aerospace Medical Laboratories, Wright-Patterson Air Force Base. Ohio, working on problems related to human performance under a variety of experimental tasks, stressors, and environmental factors. On July 20, 1963, he was married to Miss Pam Molen in Dayton, Ohio. On September 5, 1963, he resigned his civilian position with the United States Air Force to enroll in the Graduate School of the University of Richmond, Virginia. During the 1963-64 year, he was a Williams Teaching Fellow in the Department of Psychology. He will receive his Masters of Arts in Psychology in August, 1965.