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The effects of delay of reinforcement on subsequent running behavior under immediate reinforcement

Joseph A. Sgro
Lehigh University

The Effects of Delay of Reinforcement on Subsequent Running Behavior Under Immediate Reinforcement

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Joseph Anthony Sgro

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Solomon Weinstock
Professor in Charge

Josef Brozek
Head of the Department

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INTRODUCTION

In a variety of learning situations, delay of reinforcement has been found to result in a lower level of responding (Perin, 1943a, 1943b; Pubols, 1958; Ramond, 1954). There is some question (Harker, 1956) whether the asymptote of learning or only the rate of approach to asymptote is affected by delay. In addition, delay of reinforcement has been shown to increase resistance to extinction (Fehrer, 1956; Harker, 1956; Pubols, 1958).

Various theories have been offered to account for the effects of delay of reinforcement. The present experiment is designed to test an extension of a theory presented by Weinstock (1954, 1958) concerning the effects of partial reinforcement. According to this theory, continuous reinforcement may result in a response chain that contains "accessory non-functional movements." For example, Guthrie and Horton (1946) observed cats who, before pushing a pole to obtain release from a puzzle-box, touched a particular wall of the apparatus. Thus, if non-functional responses occur in a response chain followed by terminal reinforcement, they may be built into the chain of responses that is finally conditioned. Weinstock observed that non-reinforced trials would provide an opportunity for non-functional response components in the response chain to be eliminated. Trials on which reinforcement is delayed may provide the same opportunity. There is evidence that responses which compete with running are eliminated for, at least, a reasonable proportion of the Ss. Spence (1956) citing studies by Harker, Schilling, and Carlton, points out that some of the Ss spend the delay period in a fixed position at the place where the reinforcement is to be delivered.

Apparently, the Ss who spend the delay period without making competing responses run as rapidly as Ss who receive immediate reinforcement. It seems that the slower mean speed of running for groups of Ss under delayed reinforcement is due to the Ss who make competing responses in the delay period. For these Ss it might be expected that the competing responses would also occur in the alley, since many of the stimuli which occur in the goal box are also present in the alley.

According to the views developed above, it would be expected that the Ss who "sit" during the delay period would display a response chain with very few or no non-functional response components. On the other hand, the sitting response may generalize to the alley producing hesitations. If these Ss are switched to immediate reinforcement it would be expected that the hesitations would be eliminated (since they are no longer supported by the goal box behavior) and that the Ss would actually run faster than Ss who received all of their training under immediate reinforcement. Thus, the design of the present study consists of delay (0, 7.5, and 15 sec.) followed by a phase in which all groups receive immediate reinforcement.

It might be noted that the design of the present experiment is similar to that of an experiment by Harris, Smith, and Weinstock (1961) on partial reinforcement. In that study, partially reinforced Ss were switched to continuous reinforcement and showed faster running after the change and also faster running than Ss who had received only continuous reinforcement. Faster running was expected on the theoretical grounds that the non-reinforced trials of the partial reinforcement procedure should have led to a "purer" chain of responses.

In extinction, the same reasoning may be applied. The groups that have been delayed during acquisition would have had more habituation of the competing responses that occur in the goal box. After completion of a run in extinction, the probability of occurrence of a competing response should be smaller for the delay groups, and there should be less interference with the running response. Thus, the delay groups should be more resistant to extinction. Increased resistance to extinction of delay groups has been shown by Fehrer (1956), Harker (1956), and Pubols (1958). The present study seeks to replicate this finding.

METHOD

Subjects. The Ss were 75 female albino rats of a Wistar strain, 90-100 days old at the beginning of the experiment. They were selected from a larger group of 90 Ss. Each of the 90 Ss received 6 training trials with no delay of reinforcement. The 15 Ss with the smallest mean reciprocal running times for the 6 trials were discarded.

During the course of the study, five Ss were lost. Of these, three died from unknown causes, one was eliminated because it bit E repeatedly, and the other was discarded because it failed to run on the early acquisition trials.

Apparatus. The apparatus was straight runway with an L-shaped goal box. The apparatus was made of 3/4 in. plywood, and was 5 in. wide and 5 in. high throughout. The starting box, alley, and goal box were 9 1/2 in., 39 in. and 17 in. in length, respectively. Guillotine doors separated the starting box from the alley and the alley from the goal box. The arm of the L-shaped goal box was 12 1/2 in. long.

A drinking tube, similar to the tubes used during regular watering periods, was located at the end wall of the arm of the L. A horizontal sliding door could be inserted 1 1/2 in. in front of the drinking tube to prevent access to reinforcement during the delay intervals and during extinction.

The entire apparatus was left in its natural finish and was covered with 1/4 in. thick hinged Plexiglas.

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Lighting was provided by four 40w. bulbs 21 1/2 in. apart placed 37 1/2 in. above the apparatus. The entire apparatus was placed on a table 31 in. high.

Slots were cut in the side walls to permit the passage of light beams. A microswitch on the starting box door started two standard Electric .01-sec. Timers when the door was opened. When S broke a photoelectric beam 1 1/8 in. from the starting box door, the first timer stopped. The second timer stopped when S had interrupted a photoelectric beam 8 1/2 in. beyond the entry to the goal box. Interruption of the second photocell beam also started a third timer. This was used to time the delay period and the interval during which the S was given access to the drinking tube.

Procedure. The Ss were assigned haphazardly to cages, three to four in a cage. After two days of habituation to the animal colony, they were placed on a 22 1/2 hr. water deprivation schedule. For the next five days, each S was handled approximately 60 sec. daily.

The Ss were assigned randomly to one of three groups which received 0, 7.5 and 15 sec. delay of reinforcement, respectively, under 21 to 22 hrs. of water deprivation and with an intertrial interval of 24 hrs. All Ss were given six trials of training with no delay of reinforcement. On trials 7 through 41 the Ss were reinforced according to the groups to which they had been assigned. On trials 42 through 77, all Ss received no delay of reinforcement. On trials 78 through 96, Ss received extinction. During extinction, Ss remained in the goal box for 20 sec.

The typical procedure on a trial consisted of removing S from its home cage and placing it in the starting box. Five sec. later, E manually opened the guillotine door. After S entered the goal box, a guillotine door was closed preventing retracing. On all training and test trials excluding extinction, Ss were allowed 30 sec. access to the drinking tube. They were then removed from the apparatus and returned to their home cages.

Latency was defined as the interval from the opening of the starting box door until S broke a photoelectric beam 1 1/8 in. from the starting box door. Running time was defined as the time between the opening of the door and the breaking of a second beam 8 1/2 in. inside the goal box.

RESULTS

The reciprocals of the running time and latency measures were determined for each trial. All analyses were performed using the reciprocal measures.

Acquisition-Delay Phase. In Fig. 1, the mean reciprocal running times are presented in blocks of 6 trials. It may be seen that during the first 7 blocks of trials group 7.5 and group 15 crossed at various points and showed roughly the same level of conditioning. Group 0 was distinctly superior to both delay groups.

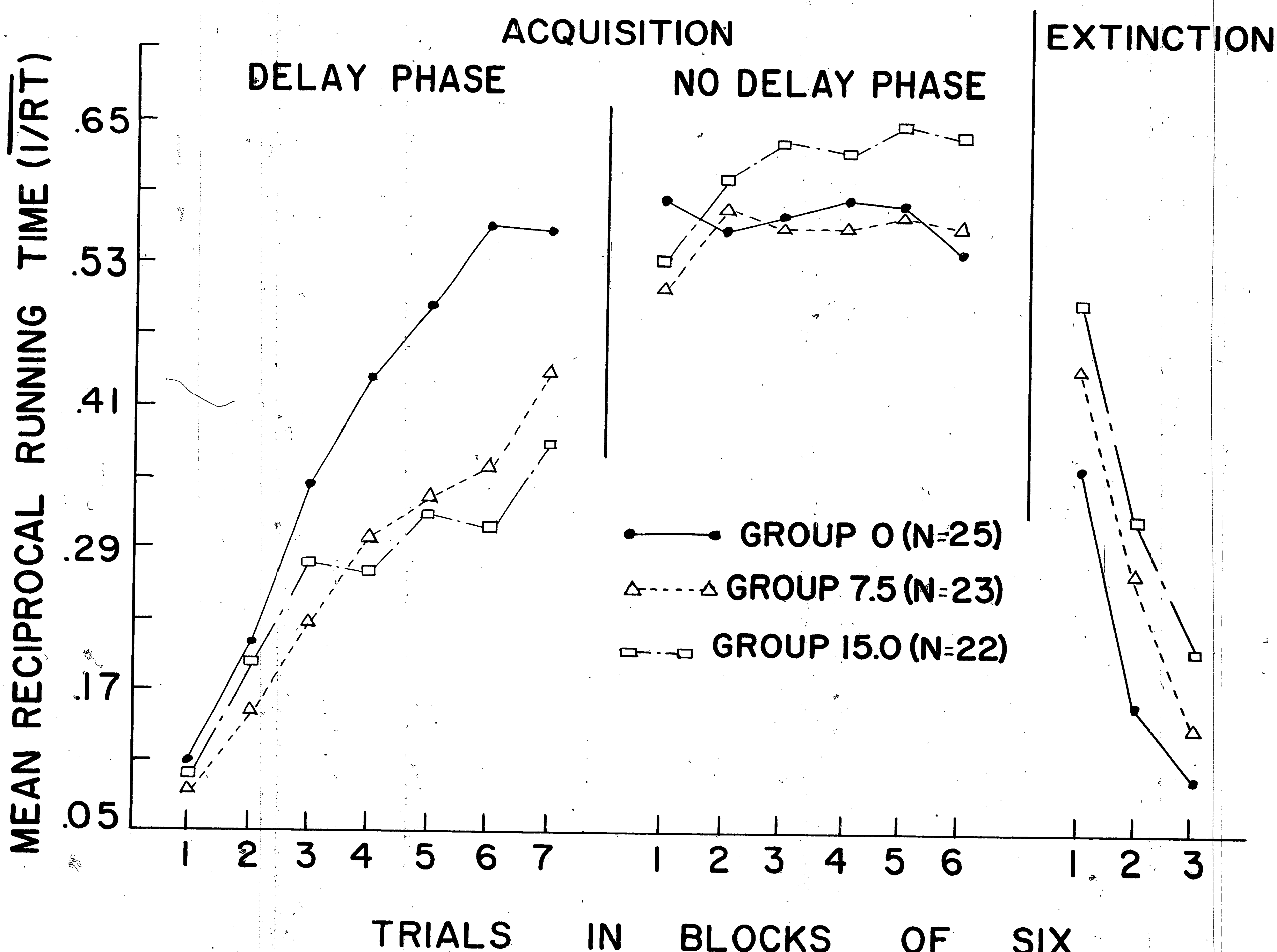
A Kruskal-Wallis H test was performed on the mean reciprocal running times for the last two blocks of trials. An H of 14.16 with 2 d.f., obtained for the delay of reinforcement variable, is significant at the 5% level. A Kruskal-Wallis H test on the mean reciprocal latencies for the same two blocks of trials yielded an H of 14.88 with 2 d.f. which is significant at the 5% level.

Acquisition-No Delay Phase. From Fig. 1, it may be seen that group 15 is superior to the other two groups from the second block of trials on.

A Kruskal-Wallis H test on reciprocal running time for trial blocks 5 and 6 yielded an H of 6.60 with 2 d.f. which is significant at the 5% level. A similar analysis on the mean reciprocal latencies yielded an H of 3.72 with 2 d.f. which is not significant at the 5% level.

Mean reciprocal running time was computed for each S for trials 55 through 78. A procedure similar to one suggested by Scheffe (1959) for testing homogeneity of variance was used to test whether Group 0 differed in variability from either Group 7.5 or Group 15. The mean reciprocal running times for each group were randomly subdivided into sets of three and the variance of each set of three was computed. The logs of the variances were then computed and Dunnett's test (Dunnett, 1955) was then computed on the log variances. Although the within group variance of Group 0 was roughly twice that of both Group 7.5 and Group 15, Dunnett's test yielded

Fig. 1. Mean reciprocal running time plotted as a function of trials in blocks of six.


ACQUISITION
DELAY PHASE
NO DELAY PHASE
EXTINCTION
MEAN RECIPROCAL RUNNING TIME (1/RT)
.65
.53
.41
.29
.17
.05
GROUP 0 (N=25)
GROUP 7.5 (N=23)
GROUP 15.0 (N=22)
1 2 3 4 5 6 7
1 2 3 4 5 6
1 2 3
TRIALS IN BLOCKS OF SIX

"$\underline{t}$"s which were not significant at the 5% level for both the comparisons of Group 0 with Group 7.5 and Group 0 with Group 15.

The variance of the reciprocal running time was computed for each $\underline{S}$ across trials 55 through 78. The log of the variance was then computed to transform to a normally distributed variable. An analysis of variance was then performed on the transformed variable and yielded an $\underline{F}$ of 1.88, with 2 and 67 d.f., which is not significant at the 5% level.

Extinction. From Fig. 1, it can be seen that all three groups extinquished rapidly. It would appear that Group 15 showed greatest resistance to extinction followed by Group 7.5 and Group 0. However, the differences in extinction could be due to differences at the end of the no delay phase. Thus, covariance analysis were performed on the mean reciprocal latencies and running times for all 18 extinction trials (trials 79-96), the first 9 trials (trials 79-86) and the last 9 trials (trials 87-96) with the mean reciprocal on the last 12 trials of the no delay phase as the control variable. The covariance analysis were performed to remove the effects of the different terminal speeds of running. The results of the analysis of covariance are presented in Tables 1, 2, and 3. The differences on the reciprocal running time measure were all significant at the 5% level. The differences on the reciprocal latency measure all failed to reach significance.

Table 1

(a) Summary of analysis of covariance for mean reciprocal running time for extinction trials (79-96)

Source	Sum of Squares	df	Mean Square	F
Total	863,827.20	68		
Estimated Error	736,234.02	66	11,155.06	
Adjusted Means	127,593.18	2	63,796.59	5.72*

(b) Summary of analysis of covariance for mean reciprocal latency for extinction trials (79-96)

Source	Sum of Squares	df	Mean Square	F
Total	53,513,804.27	68		
Estimated Error	52,827,725.80	66	800,420.09	
Adjusted Means	686,078.47	2	343,039.24	-

*F.05 (2,66) = 2.39

Table 2

(a) Summary of analysis of covariance for mean reciprocal running time for extinction trials (79-86)

Source	Sum of Squares	df	Mean Square	F
Total	976,457.58	68		
Estimated Error	845,151.83	66	12,805.33	
Adjusted Means	131,305.74	2	65,652.87	5.126*

(b) Summary of analysis of covariance for mean reciprocal latency for extinction trials (79-86)

Source	Sum of Squares	df	Mean Square	F
Total	67,560,887.05	68		
Estimated Error	65,466,070.22	66	991,910.15	
Adjusted Means	2,094,816.83	2	1,047,408.42	-

*$F_{.05}\ (2,66) = 2.39$

Table 3

(a) Summary of analysis of covariance for mean reciprocal running time for extinction trials (87-96)

Source	Sum of Squares	df	Mean Square	F
Total	1,246,778.03	68		
Estimated Error	1,039,915.50	66	15,756.30	
Adjusted Means	206,862.53	2	103,431.27	6.56*

(b) Summary of analysis of covariance for mean reciprocal latency for extinction trials (87-96)

Source	Sum of Squares	df	Mean Square	F
Total	82,148,043.80	68		
Estimated Error	82,118,849.05	66	1,244,244.99	
Adjusted Means	29,194.75	2	14,597.38	-

*F.05 (2,66) = 2.39

DISCUSSION

The following major results will be discussed.

1. In the delay phase of the experiment, Group 0 ran faster than Group 7.5 and Group 15.

2. In the no-delay phase Group 15 ran faster than Group 0 and 7.5.

3. In the extinction phase the longer the delay, the greater the resistance to extinction.

The results of the delay phase serve to replicate the findings of Harker (1956), Perin (1943a, 1943b, Pubols (1958), and Ramond (1954). The casual observation was made that some of the delay of reinforcement Ss remained close to the place where reinforcement was to be delivered while others moved about the goal box during the delay period. It appeared that Ss in Group 15 moved about the goal box more than Ss in Group 7.5. This observation is similar to observations made by Harker and Schilling (Spence, 1956) and lends support to an interference theory of the effect of delay of reinforcement on speed of running. The interference theory states that competing responses made in the goal box generalize to the alley and result in slower running. Since Group 15 showed more competing behavior in the goal box, it might be expected to run more slowly than Group 7.5. It should be noted, however, that the difference in speed of running between the two delay groups was small.

The faster running of Group 15 in the no-delay phase of the experiment lends support to the theoretical views that gave rise to the present experiment. While the prediction that the delay groups would run more rapidly was confirmed, it should be noted that the result might well be expected largely on empirical grounds. Partial reinforcement may be regarded as delay of reinforcement with an "infinite" or very long delay. Whatever process resulted in the faster running of the partially reinforced Ss in a comparable switch to no-delay in the study by Harris, Smith, and Weinstock (1961) might also be regarded as operation in a finite delay of reinforcement situation.

Again, if partial reinforcement is regarded as "infinite" delay of reinforcement, it might be expected that the greater resistance to extinction of partially as compared with continuously reinforced Ss would also appear in a finite delay of reinforcement situation. The extinction result of the present study, along with the prior studies (Fehrer, 1956; Harker, 1956; Pubols, 1958) whose results it replicates, serve to support the above view. It should be noted that the extinction result is predicted by the theoretical views leading to this study. To some extent those views receive support both from the extinction and no-delay phase results of the present experiment.

Our final point merits discussion, the failure to find significant differences on the latency measure during the no-delay phase and during extinction. Generally, running time measures have been found to be more sensitive to the effects of various experimental variables than latency measures. In the present experiment, in particular, the method of obtaining the latency measure might be expected to produce a large amount of variance. Specifically, the timers were started by a microswitch which was activated when the door was fully open. Any irregularity in the opening of the door would increase the unreliability of both time measures, but would have a larger proportional effect on latency than running time.

SUMMARY

This experiment tested the hypothesis that delay of reinforcement would result in superior running behavior during subsequent trials with immediate reinforcement.

Three groups of 25 albino rats each were given 42 trials with 0, 7.5, and 15 sec. delay of reinforcement, respectively, in a runway. All Ss were then given 36 trials with no delay of reinforcement, followed by 18 extinction trials. All trials were given under 21 to 22 hours of water deprivation and 24 hour intertrial interval.

In the delay phase Group 0 ran significantly faster than Group 7.5 and Group 15. In the no-delay phase, Group 15 ran significantly faster than Group 0 and Group 7.5. Covariance analyses, in which the terminal running speed for the no-delay phase was used as the control variable, showed that the effects of delay was to increase resistance to extinction.

The theoretical implications of the results were discussed.

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VITA

Joseph Anthony Sgro was born in New Haven, Connecticut on November 22, 1937, the son of Tullia V. and Fred Sgro. He graduated from Hopkins Grammar School, New Haven, Connecticut in June, 1955 and entered Trinity College, Hartford, Connecticut in September of the same year. In June, 1959, he received the Bachelor of Arts degree in Psychology, and in September of the same year, he entered the graduate school of Lehigh University. He was the recipient of a Lehigh University Graduate Scholarship. In October, 1961, he received the Master of Science degree in Psychology.