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Partial reinforcement with a small number of acquisition trials : the effects of thwarting on extinction performance

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PARTIAL REINFORCEMENT WITH A SMALL NUMBER OF ACQUISITION TRIALS: THE EFFECTS OF THWARTING ON EXTINCTION PERFORMANCE

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VIRGINIA

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TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

Chapter I

INTRODUCTION

For a number of years, investigators have observed that rats that are partially reinforced for the response of runway locomotion show greater resistance to extinction of that response than do animals that receive continuous reinforcement(Finger, 1942; Logan, Beier & Kincaid, 1956; Black & Spence, 1965). This effect, the partial reinforcement extinction effect(PREE), is observed when animals receiving random partial reinforcement are compared to animals receiving continuous reinforcement. Spence(1960) and Amsel(1958) have both offered an explanation of this phenomenon that employs the concept of the fractional anticipatory frustration response(r_f). McCain, Love & Gruer(1962) pointed out that this explanation predicts that PREE will not be observed after a very small number of acquisition trials. The Spence(1960) and Amsel(1958) formulation maintains that r_f begins only after a number of rewarded trials when the classically conditioned fractional anticipatory goal response(r_g) has been established. In other words, the nonreward of the partial reinforcement technique does not become frustrating until anticipatory

reward has developed, and r_f can become associated with an approach response only after the prior development of r_g. With a small number of training, or acquisition trials, this process does not have time to develop, and the partially reinforced animals should not demonstrate the partial reinforcement effect. McCain and his associates proceeded to conduct a series of studies indicating that PREE can be observed after only a small number of partially reinforced acquisition trials(McCain, Love & Gruer, 1962; McCain, 1965a; McCain, 1965b; McCain, 1966). The first of these investigations demonstrated PREE after only three acquisition trials.

The "frustration" theory of Brown(1961, p.197) specifically indicates a reward technique that involves separating an animal from its food before it has finished eating. This is offered as an antecedent condition to "frustration" which can result in supression of runaway locomotion to the reward. This reward technique is referred to by Brown as "thwarting".

Most of the McCain studies which have found PREE with a small number of acquisition trials have employed a procedure that appears to be equivalent to the "thwarting" technique discussed by Brown(1961). The partially and continuously reinforced subjects(Ss) are rewarded, on acquisition trials,

by exposing them to food for a fixed period of time, usually 30 sec.(fixed-time reward technique). They are then removed from the food dish before they have eaten all of the available food. If thwarting the consummatory response does lead to the suppression of runway locomotion, a question can be raised as to how much, if any, of the PREE, using a small number of acquisition trials, can be accounted for simply by the reduced number of thwarts administered to McCain's partially reinforced groups.

The present study is an attempt to provide a setting in which to examine the possible contribution of the fixed-time reward technique to the PREE obtained by McCain and his associates.

Chapter II

METHOD

Subjects

Ss were fifty-six experimentally naive female albino rats of Wistar strain, 90 days old at the beginning of the experiment. Ss were housed two to a cage.

Apparatus

The apparatus was patterned after the one used by McCain(1962). A straight wood runway with a fixed start box(SB) and a fixed L-shaped goal box(GB) was employed. The entire apparatus was painted mid-gray, and was covered with a ¼ in. Plexiglas top, hinged for opening. One clear Plexiglas guillotine door separated the SB from the runway, and another separated the GB from the runway. Inside measurements of the SB were 5½ in. high by 8 in. long by 3½ in. wide. The GB was 7¼ in. across the inside of the foot of the L, which turned to the right, and was 12 in. long. Height and width were the same as the rest of the apparatus. A Standard Electric timer was started and stopped by the sequential interruption of two photoelectric cells, one placed in the runway 1½ in. from the SB door and the other placed just inside the GB, 1½ in. from the entrance door.

The L-shaped GB allowed placement of the food cup(a glass Petri dish) so that it could not be seen by the animal until after it had passed the photoelectric cell which stopped the last timer. Room lighting consisted of two 400 watt flourescent lamps 4 ft. long, placed 3 ft. above the runway, and covered with a layer of thin black muslin. This produced a general dim illumination throughout the 6 ft. 5 in. by 7 ft. by 7½ ft. high experimental room.

Procedure

Experimental design. The experimental design included three levels of the percentage of reinforcement(100%, 50%, 0%) and two levels of reward technique(fixed-time vs. free-time). 14 Ss were randomly assigned to each of four experimental groups. The groups consisted of : (1) Ss given continuous reward using the fixed-time reward technique (group CT); (2) Ss given continuous reward, using a free-time reward technique, i.e., Ss are allowed to finish eating all available food on each acquisition trial(group C); (3) Ss given partial reward, using the fixed-time reward technique(group P); (4) Ss that were not rewarded on any trials, but were otherwise subjected to the same procedure as were the fixed-time groups(group N). The experiment was carried out in two replications of 28 Ss each.

Habituation. On days 1-7, all animals were maintained on a 23 hour deprivation schedule. During this time, each animal was handled 2 to 3 minutes daily. The time of handling coincided with the hour during which the animals were fed an unlimited supply of Purina Lab Chow Checkers. Water was available in the home cages at all times throughout the entire experiment. On days 8-12, all animals were allowed free exploration of the apparatus, 3 at a time, for 10 min. daily. The timer and photoelectric cells were in operation during the exploration period in order to acustom the animals to the noise. The 23 hr. deprivation schedule was maintained on days 8-11. During the feeding hour, wet mash was available in the home cages in addition to the food checkers. On day 12, approximately 24 hours before the beginning of the test day, all animals were fed for 20 min. instead of the usual hour.

Experimental training. The animals were brought in squads of 4(one S from each of the experimental groups), into the experimental room in a four-unit carrying cage which was placed behind a black cloth screen which shielded the experimenter's movements from the apparatus. A training trial was initiated by placing the S into the SB. When S

faced the SB door, the door was raised. When S passed the photoelectric cell, the timer was automatically activated, and the SB door was closed behind him. When the S passed through the open GB door, the timer was stopped, and the door was closed.

Acquisition. In order to equate the CT group with the C group as to regard magnitude, the following procedure was used. Each C group animal was paired with a CT group animal. The CT group animal was given acquisition trial 1 which exposed the animal to food for 30 sec. The amount of food eaten by the CT group animal was measured, and an equal amount of food was given to the C group animal with which it was paired for its acquisition trial 1. The CT group animal was then given acquisition trial 2, the amount of food consumed was measured and an equal amount was given to the paired member of the C group for its acquisition trial 2. This alternation procedure was continued for all acquisition trials. Thus, on each acquisition trial the CT group animal preceded the C group animal with which it was paired. In order to equate intertrial intervals among all experimental groups, the N group and the P group animals were paired and also run in a similar alternation pattern

although no food measurements were necessary, and either member of the pair could begin the series of acquisition trials.

The above procedure limited the running order of a group member within the fourteen 4-member squads to four possibilities. The orders were CT, C, P, N; CT, C, N, P; N, P, CT, C(all employed for 3 squads of animals), and P, N, CT, C(employed for 5 squads). The number of times each order was employed and its position of occurance within the entire acquisition procedure for all Ss was randomly chosen.

All Ss received 4 acquisition trials on day 13. The CT group animals were reinforced on every trial and were allowed to remain in the GB for 30 sec. during which time food, in the form of wet mash, was available in the food cup. Group C animals were reinforced on every acquisition trial, and remained in the GB until they consumed the amount of food eaten by the group CT animals with which they were paired. Group P animals were allowed to remain in the GB for 30 sec. during which time food was available in the food cup on 50% of the trials according to a NRNR pattern. Group N animals were allowed to remain in the GB for 30 sec. on

all trials, but received all non-reinforced trials. On all non-reinforced trials, an empty food dish was present in the GB. The intertrial interval was approximately 2 min.

A criterion of failure to reach the GB within 30 sec. on the first acquisition trial was established for elimination of an animal from the experiment. No animals were eliminated for this reason. Ss that did not reach the GB within 45 sec. on subsequent acquisition trials were guided by hand to the GB.

Extinction. On day 13, all Ss received 12 extinction trials. Each animal was subjected to the extinction procedure immediately following his last acquisition trial. Ss in a squad were run in the same order and under the alternation procedure as was used on acquisition trials. All Ss were allowed to remain in the GB for 15 sec. on each trial. Again, the intertrial interval was approximately 2 min. Ss that did not reach the GB within 45 sec. were guided by hand.

Chapter III

RESULTS

Before any analysis of the data was carried out, the one measure of performance, the time taken by the animal to traverse the distance between the two photocells, or running latency, was transformed as follows: For extinction trials, each animal's mean running latency for a block of trials was obtained, the blocks being extinction trials 2-3, 4-6, 7-9, and 10-12. The constant 1 was added to each animal's mean latency(M) for each block, and the resulting figures were transformed into logs. The constant 1 was utilized to prevent negative logs. These data are represented in Appendix A. The mean, for all Ss in a group, of these logs was calculated for each of the four blocks of extinction trials.

In order to further analyze the extinction data it was necessary to further transform the data so that each group's terminal running latency during acquisition would be taken into account. This was accomplished by utilizing a method recommended by Anderson(1963). The log(M+1), for each of the blocks of extinction trials, as described above,

was expressed as a proportion of their terminal running latency during acquisition. Acquisition trial 4 and extinction trial 1 were chosed as an estimate of terminal running latency for acquisition. Extinction trial 1 is included since as far as performance on that trial is concerned, it is not actually an extinction trial. The constant 1 was added to each animal's mean running latency for acquisition trial 4 plus extinction trial 1, and the log of the resulting sum was obtained. This log served as the divisor for the proportions; the dividends consisted of the log (M+1) for each block of extinction trials. Thus, each animal had 4 scores which expressed its performance during each block of extinction trials as a proportion of its terminal acquisition running latency. These data are presented in Appendix B. The mean, for all Ss in a group, of these proportions was calculated for each of the 4 blocks of extinction trials for purposes of group comparisons.

Extinction

Fig. 1 presents the mean proportion scores for the four experimental groups. The reference point is simply the terminal running latency for each group expressed as a proportion of itself. Inspection of Fig. 1 indicates

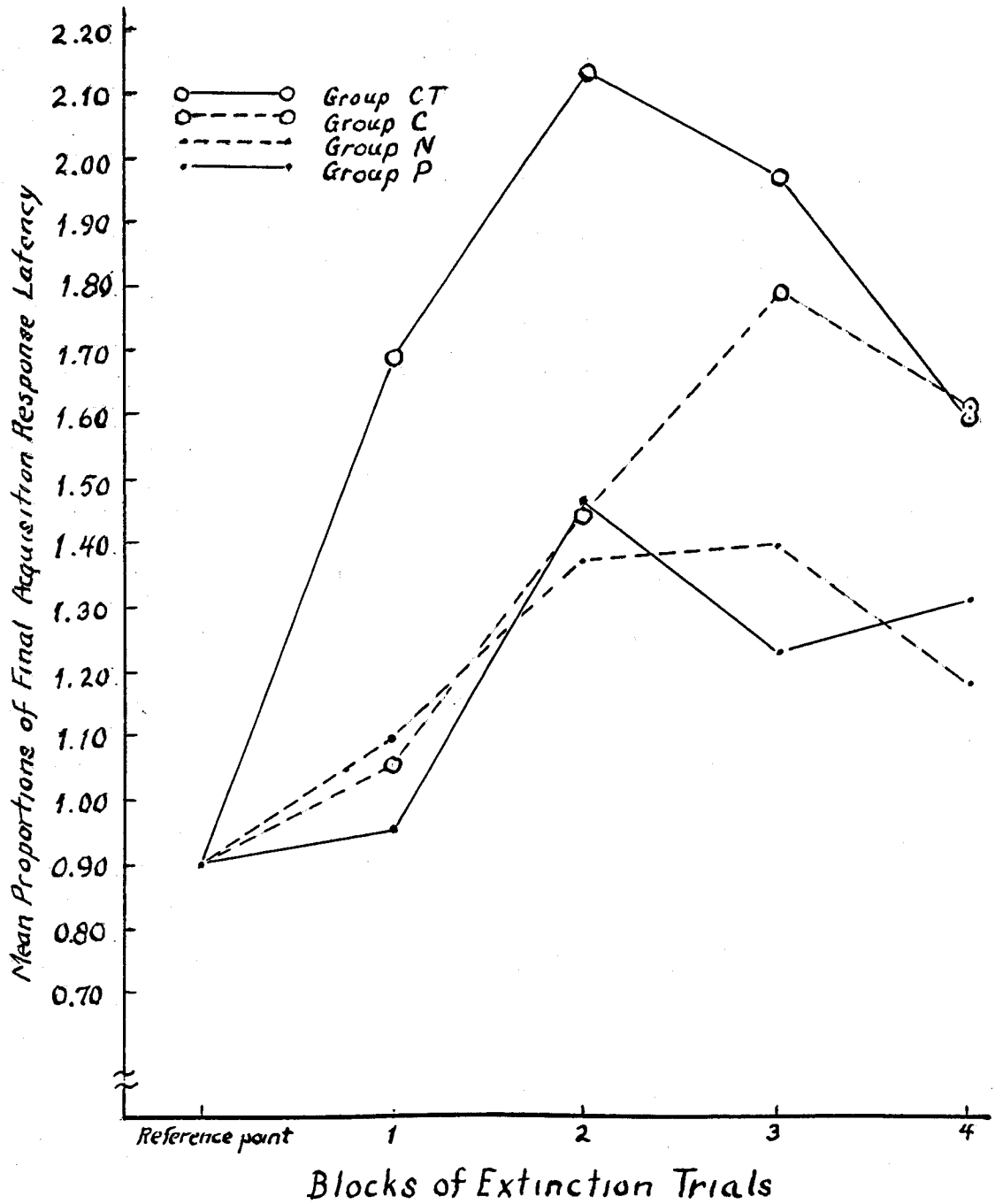

Fig. 1 Mean Proportions of Final Acquisition Response Latency as a Function of Blocks of Extinction Trials

that the group CT animals showed greater running latency than the group P animals during extinction on all of the blocks of trials. The group C animals showed greater running latency than the group P animals on all, but one, of the blocks of trials. The group CT animals show a greater running latency than the group C animals on all but the last block of trials. There appears to be no difference in performance between the group P and group N animals.

In order to evaluate these observations statistically, a separate analysis of variance appropriate for a 2 X 4 repeated measures design was computed for each of the following pairs of preplanned comparisons: group CT *vs.* group P; group P *vs.* group C; group CT *vs.* group C; group P *vs.* group N.

The results of these analyses(Tables I, II, III, and IV) showed that: (a) group CT showed significantly greater mean running latencies than did group P($F(1,26) = 4.67$; $p<.05$); (b) there was no reliable difference between group P and group C; (c) there was no reliable difference between group C and group CT; (d) there was no reliable difference between group P and group N.

An analysis between group P and group N was computed utilizing the data in the log form, i.e., before it was transformed into proportions. Due to the fact that the group N animals were never reinforced, they cannot be considered to have learned a specific running response. By comparing this group's performance with that of the group P animals, information can be obtained as to whether reinforcement influences extinction performance in the present situation.

The results of this analysis(Table V) showed that: (a) there was no reliable difference in mean performance between group P and group N; (b) there was no significant interaction between trials and reward technique.

Table I Summary Table of Analysis of Variance of Proportional Transfomations of Logarithmic Transformations of Individual Mean Running Latencies; Groups CT and P.

Source of Variation	df	ms	F
Between Subjects	27		
A(Reward Technique)	1	10.17	4.67*
Subjects within groups	26	2.18	
Within Subjects	84		
B(Trials)	3	1.13	4.04*
AB	3	.34	1.21
B by Subjects within groups	78	.28	

*p<.05

Table II Summary Table of Analysis of Variance of Proportional Transformations of Logarithmic Transformations of Individual Mean Running Latencies; Groups P and C.

Source of Variation	df	ms	F
Between Subjects	27		
A(Reward Technique)	1	1.45	1.08
Subjects within groups	26	1.34	
Within Subjects	84		
B(Trials)	3	1.61	6.19*
AB	3	.46	1.77
B by Subjects within groups	78	.26	

*$p < .05$

Table III Summary Table of Analysis of Variance of Proportional Transformations of Logarithmic Transformations of Individual Mean Running Latencies; Groups CT and C.

Source of Variation	df	ms	F
Between Subjects	27		
A(Reward Technique)	1	3.93	1.73
Subjects within groups	26	2.27	
Within Subjects	84		
B(Trials)	3	1.48	4.11*
AB	3	.82	2.28
B by Subjects within groups	78	.36	

*$p < .05$

Table IV Summary Table of Analysis of Variance of Proportional Transformations of Logarithmic Transformations of Individual Mean Running Latencies; Groups N and P.

Source of Variation	df	ms	F
Between Subjects	27		
A(Reward Technique)	1	.00	.00
Subjects within groups	26	1.05	
Within Subjects	84		
B(Trials)	3	.76	5.43*
AB	3	.16	1.14
B by Subjects within groups	78	.14	

*$p < .05$

Table V Summary Table of Analysis of Variance of Logarithmic Transformations of Individual Mean Running Latencies; Groups N and P.

Source of Variation	df	ms	F
Between Subjects	27		
A(Reward Technique)	1	1.58	.85
Subjects within groups	26	.19	
Within Subjects	84		
B(Trials)	3	.19	3.13*
AB	3	.07	1.16
B by Subjects within groups	78	.06	

*p<.05

Chapter IV

DISCUSSION

If only the comparison made between group CT and group P is considered, it can be said that PREE was obtained after only four acquisition trials. This finding supports McCain's(1962) thesis in that the animals that are reinforced on 50% of the acquisition trials are more resistant to extinction than are the animals that are reinforced on all acquisition trials. However, when group P was compared to group C, there was no significant difference in extinction performances. Thus, it is possible that thwarting had the effect of producing at least some of the difference between the extinction performances of group CT and group P which has been interpreted as PREE by McCain. However, the comparison between group CT and group C was not statistically significant.

Consistent, in part, with the present findings, Surridge, Rashotte and Amsel(1967) found no difference in resistance to extinction between a partially reinforced group of animals and a continuously reinforced group after four acquisition trials. These investigators seem to maintain support for Amsel's(1962) interpretation of the partial

reinforcement effect discussed earlier in this paper. It is not clear whether this study involved thwarting since it employed a fixed amount of reward, but Ss were detained in the GB for a fixed amount of time, and it is not reported whether the alloted period of time was sufficient for the animals to finish eating the available food. In contrast to the Surridge, Rashotte and Amsel(1967) and the present findings, McCain(1966) obtained PREE in an investigation which employed no thwarting procedure whatever. All animals in this study were reinforced with a fixed amount of food on reinforced acquisition trials.

The fact that no reliable difference is observed between group P and group N, when comparing the proportional scores, suggests one of two conclusions, either group P was very resistant to extinction, or reinforcement did not effect this group's extinction performance in the present situation. Since there was no difference, however, between group N and group P in the comparison utilizing absolute running latencies, as expressed by the simple log transformations, it can be said that reinforcement has not effected the "extinction" performance of group P.

The Surridge, Rashotte and Amsel(1967) study and one by McCain(1965b), which are similar to the present investigation,

also employed a group that was not reinforced as does the present study. The former also found no group N vs. group P differences. McCain(1965b), on the other hand, did find a difference between their group N and group P. These radically different findings indicate that further investigation is necessary in this area.

In recent years, there has been an increase in the number of studies investigating extinction differences between partial and continuous reinforcement groups. Studies such as those by Capaldi, Hart and Stanley(1963), Black and Spence(1965) and Spence, Platt and Matsumoto(1965) have employed the fixed-time reward technique, or thwarting procedure, while investigating the partial reinforcement effect. Since this technique seems to have at least some influence on extinction performance, further studies in this area should not proceed without an increased knowledge of the precise effects of thwarting.

Since thwarting, in the present experiment, seems to result in some of the differences which are found in extinction performance between partially and continuously reinforced animals after a small number of extinction trials, it can be hypothesized that the Brown(1961) technique of

producing frustration interferes in some way with the approach response. Spence(1960) and Amsel(1958) also maintain that early in the formation of r_f, there is a period of time during which the approach response is subject to interference from competing avoidance responses. Future studies can perhaps clarify whether these two methods of producing frustration are functionally similar.

McCain(1966) reports results of experiments which are compatible with an aftereffects interpretation of PREE. The aftereffects interpretation maintains that in a partial reinforcement situation, some of the nonreinforced trials are followed by reinforced trials, and that stimulus aftereffects of nonreinforcement become associated with the ongoing response. McCain(1966), in pointing out the applicability of the aftereffects interpretation, formulates that PREE should be observed as long as at least one nonreinforced trial precedes a reinforced trial. Examination of thwarting in this sort of situation also should prove fruitful.

Chapter V

SUMMARY

In order to examine the effects of thwarting on PREE after a small number of acquisition trials, fifty-six animals were trained to run a straight alley runway under four experimental conditions. Two groups were subjected to thwarting(fixed-time reward technique), one receiving a NRNR pattern of partial reinforcement; the other receiving continuous reinforcement. A third group was subjected to continuous reinforcement administered by a free-time reward technique. A fourth group was not reinforced, but was otherwise subjected to the same procedure as were the thwarted groups.

The only reliable difference was between the continuous reward and partial reward groups run under the fixed-time reward technique. The absence of a reliable difference between the continuous reinforcement, free-time reward group and the partial reinforcement, fixed-time reward group was interpreted as evidence that thwarting may be responsible to some degree for PREE. The lack of any reliable difference between the partial reinforcement, fixed-time group and the non-reinforced group was interpreted as evidence that partial reinforcement over 4 acquisition trials does not influence

"extinction" performance.

These results were discussed in relationship to previous findings regarding the partial reinforcement effect after a small number of acquisition trials, and implications to other investigations which examine differences between partial and continuous reinforcement were pointed out.

APPENDIX A

Logarithmic Transformations of Individual Mean Running Latencies

Logarithmic transformations of individual mean running latencies Group C: 100% reinforcement -- 11 extinction trials.

	Blocks of trials			
Subjects	1	2	3	4
1	.535	.918	1.339	1.216
2	1.473	1.727	1.877	1.954
3	1.006	1.378	1.202	1.054
4	1.066	.723	1.492	1.219
5	1.253	1.121	.866	1.573
6	.752	1.165	1.926	1.759
7	.919	1.153	1.245	.906
8	1.949	.903	1.447	2.344
9	.830	1.611	3.607	2.189
10	1.003	2.121	1.699	.873
11	.445	.548	.519	1.268
12	1.074	4.601	3.789	3.206
13	1.392	1.294	1.790	1.398
14	.809	.795	2.326	1.403

Logarithmic transformations of individual mean running latencies Group CT: 100% reinforcement -- 11 extinction trials.

	Blocks of trials			
Subjects	1	2	3	4
1	1.157	.719	.831	.501
2	2.270	2.271	2.276	1.882
3	.938	1.959	1.735	1.023
4	1.088	.628	.792	.822
5	1.344	1.856	2.101	2.214
6	1.159	1.631	1.493	.859
7	2.502	3.189	2.465	1.269
8	3.081	4.884	4.627	4.884
9	2.196	2.462	1.711	1.619
10	1.041	1.813	1.353	1.216
11	1.203	1.609	2.037	1.950
12	3.376	3.509	.913	1.696
13	1.189	1.590	1.527	1.221
14	.969	1.552	3.695	1.125

Logarithmic transformations of individual mean running latencies Group P: 50% reinforcement -- 11 extinction trials.

	Blocks of trials			
Subjects	1	2	3	4
1	1.487	1.562	1.422	2.159
2	.549	.616	1.082	1.439
3	.717	.987	.927	.951
4	1.115	.733	.721	1.138
5	1.119	1.096	.695	.771
6	.693	1.415	.669	1.151
7	.963	1.366	.563	.497
8	1.077	.886	.612	.805
9	.936	1.114	.768	.646
10	1.124	2.669	2.414	1.883
11	1.408	3.155	2.267	3.225
12	.766	2.646	2.345	2.159
13	.828	.927	.868	.805
14	.550	1.122	1.864	.795

Logarithmic transformations of individual mean running latencies Group N: 0% reinforcement -- 11 extinction trials.

	Blocks of trials			
Subjects	1	2	3	4
1	1.224	1.709	1.581	1.309
2	1.292	1.606	2.065	1.890
3	.959	1.369	.469	1.233
4	.746	.699	.839	.439
5	1.159	1.240	.713	.503
6	1.575	1.685	1.881	1.784
7	.598	1.441	1.829	1.734
8	1.396	1.661	1.848	1.584
9	1.202	.991	1.285	.540
10	.817	.824	.601	.692
11	1.221	2.811	2.674	1.900
12	1.297	1.487	1.775	1.437
13	1.062	.976	.938	.981
14	1.090	1.372	1.386	1.172

APPENDIX B

Proportional Transformations of Logarithmic Transformations of Individual Mean Running Latencies

Proportional transformations of logarithmic transformations of individual mean running latencies Group P: 50% reinforcement -- 11 extinction trials.

Subjects	Blocks of trials 1	2	3	4
1	.97727	1.02653	.93450	1.41847
2	.43457	.48714	.85491	1.13767
3	.68124	.93752	.99081	.90309
4	1.11860	.73560	.72346	1.14168
5	.86747	.85003	.53908	.59770
6	.51322	1.04727	.49554	.85187
7	.99870	1.41681	.58433	.51587
8	.96988	.79796	.55145	.72509
9	.41996	.49969	.34439	.29003
10	.42325	1.00518	.90902	.70927
11	.50920	1.14137	.82020	1.16673
12	.37107	1.28149	1.13545	1.04571
13	.83123	.93044	.87157	.80821
14	.27646	.56348	.93651	.39967

Proportional transformations of logarithmic transformations of individual mean running latencies Group N: 0% reinforcement -- 11 extinction trials.

Subjects	Blocks of trials 1	2	3	4
1	.79818	1.15280	1.03100	.85370
2	.73239	.91062	1.17114	1.07188
3	.97955	1.39777	.47857	1.25912
4	.92117	.86273	1.03703	.54283
5	1.00173	1.07135	.61595	.43457
6	1.21906	1.30363	1.45530	1.38041
7	.53656	1.29314	1.64128	1.55582
8	.83315	.99078	1.10278	.94498
9	1.24576	1.02694	1.33163	.55991
10	1.07591	1.08493	.79099	.91169
11	.40824	.94002	.89432	.63548
12	1.21431	1.39270	1.66276	1.34557
13	1.57357	1.44700	1.39088	1.45469
14	.73480	.72428	.92117	.39270

Proportional transformations of logarithmic transformations of individual mean running latencies Group C: 100% reinforcement -- 11 extinction trials.

	Blocks of trials			
Subjects	1	2	3	4
1	.42975	.73719	1.07555	.97727
2	1.13194	1.32756	1.44248	1.50161
3	.48714	.66745	.58206	.51055
4	.60206	.40824	.84261	.68842
5	.79727	.71349	.55145	1.00115
6	.50786	.78746	1.30125	1.18893
7	.85248	1.07021	1.15565	.84073
8	1.16967	.54158	.86806	1.40637
9	.28103	.54531	1.22089	.74115
10	.47276	.99957	.80072	.41162
11	.30320	.36549	.34635	.84510
12	.33244	1.42472	1.17319	.99255
13	.82413	.76641	1.06004	.82802
14	.26245	.25768	.75435	.45484

Proportional transformations of logarithmic transformations of individual mean running latencies Group CT: 100% reinforcement -- 11 extinction trials.

Subjects	Blocks of trials 1	2	3	4
1	1.61130	1.00100	1.15665	.69810
2	1.26021	1.26068	1.26340	1.04454
3	.48287	1.00817	.89265	.52634
4	1.08955	.62941	.79309	.82347
5	.74429	1.02776	1.16346	1.22608
6	.97128	1.36680	1.25188	.72016
7	.84696	1.07954	.83442	.42975
8	1.04993	1.66276	1.57530	1.66276
9	.86629	.97128	.67486	.63849
10	.59770	1.04077	.77670	.69810
11	.94939	1.26928	1.60670	1.53845
12	1.25888	1.30856	.34044	.63246
13	.82217	1.09899	1.05538	.84386
14	.28103	.45025	1.07171	.32634

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