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RESISTANCE TO EXTINCTION AS A FUNCTION OF SUCROSE CONCENTRATION AND NUMBER OF ACQUISITION TRIALS

by
Robert Frank House

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of the requirements for the degree of
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Doctoral Committee:

Professor J. David Birch, Chairman
Professor Paul M. Fitts
Associate Professor Robert L. Isaacson
Associate Professor Wilfred M. Kincaid

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CHAPTER I

INTRODUCTION

A positive, monotonic relationship between response strength and the number of consistently rewarded trials (Ng) in a straight runway has been reported by a number of studies, e.g., Crespi (1942), Zeaman (1949). The runway literature, including the two studies just mentioned, has been consistent in indicating the same relationship between response strength and the amount of reward received on each trial. Thus, other variables held constant, the greater the Ng (up to asymptotic performance) and the greater the amount of reward, the greater the tendency to make the instrumental running response during acquisition.

Upon changing acquisition conditions to those of experimental extinction, i.e., withdrawing reward, probably the simplest expectation would be for the strength of the now unrewarded response to weaken over extinction trials. The greater the response strength at the end of acquisition, the greater the number of unrewarded trials required to extinguish the running response. This view of extinction would provide for positive relationships between resistance to extinction and the Ng or amount of reward variables.

That such an explanation is an oversimplification was made clear by such extra-extinction phenomena as spontaneous recovery and rapid relearning. Earlier embellishments of this simple view, e.g., Hull (1943), still provided for the positive, monotonic relationships mentioned above. Recently, however, results obtained under extinction conditions have indicated that the

hypothesis of a positive relationshp between resistance to extinction and Ng or magnitude of reward may have to be modified. Suggestions as to the nature of any required modification should arise from an examination of some of the pertinent findings.

North and Stimmel (1961) suggested that their results in conjunction with those of Lawrence and Miller (1947) indicated that the positive relationship between Ng and resistance to extinction (trials to criterion measure) holds only through the lower levels of the Ng dimension. Lawrence and Miller found a 16 trial group to be more resistant to extinction than an 8 trial group, while North and Stimmel found a 45 trial group to be more resistant than either a 90 or a 135 trial group. Subsequent research has shown a 60 trial group more resistant than a 16 trial group (Wagner, 1961, extinction speed/terminal acquisition speed proportion measure) and a 100 trial group no more resistant than a 170 trial group (Theios, 1962, trials to criterion measure). The conjectured relationship between Ng and resistance to extinction has not been demonstrated by the results of a single study involving the rat running down the straight runway for food. Separately, what has been shown is a positive relationship (Lawrence and Miller), a negative relationship (North and Stimmel), and no relationship (Theios). The picture becomes more confused when the data of Ison (1962) are added. Ison reported an inverse relationship between Ng and resistance to extinction (trials to criterion measure) for groups receiving either 10, 20, 60, 80, or 100 rewarded trials prior to extinction onset.

Among the many methodological differences among these studies, a variable of general theoretical interest, amount of reward, has been noted (e.g., Lawrence & Miller, 1947) as an uncontrolled, interstudy variable which might have contributed to such a complex pattern of results. Wagner's finding that 60 trials lead to greater resistance to extinction than 16 trials for a .08 gm. group but not for a 1.0 gm. group supports this idea. As with Ng, amount of reward has generally been assumed to relate positively and monotonically with measures of resistance to extinction. Two early studies which used speed measures and involved two (Lawrence and Miller) and four (Zeaman) levels of food reward reported results in support of a positive relationship.

More recent studies involving two levels of food reward (Armus, 1959, speed measure; Hulse, 1958, speed measure; and Wagner, 1961, speed proportion measure) have reported an inverse relationship between amount of reward and resistance to extinction. In an attempt to reconcile his results with Zeaman's, Armus suggested that the nature of the relationship between amount of reward and resistance to extinction might be dependent on the number of acquisition trials such that for a small number of acquisition trials (Zeaman gave 18) the relationship is positive but for larger numbers (Armus gave 75) the relationship is negative.

In summary, runway studies bearing on the relationship of Ng and amount of food reward to resistance to extinction have produced results indicating that the assumption of a monotonically

positive relationship for both variables may have to be modified to an assumption of nonmonotonicity for both variables. Further, investigators of both the amount of reward and Ng factors have suggested that the relationship for one factor is dependent on the level of the other factor, i.e., an interaction effect between amount of reward and Ng on resistance to extinction. A runway study with a design which incorporated several well-spaced levels of both Ng and amount of reward factors would appear to be well-suited to provide for the appearance of nonmonotonicity along either factor as well as to provide information on the nature of any interaction between factors. The primary purpose of this research was to implement such a design.

CHAPTER II

METHOD

Design

The experimental design was a simple factorial where each of two factors was represented by three levels; number of acquisition trials (30, 60, or 120 trials) and per cent sucrose solution (8, 16, or 32 per cent). This design results in nine independent treatment combinations (n = 15; N = 135). Each S received 22 experimental extinction trials on the day following completion of acquisition.

Subjects

The Ss were 151 male, pigmented rats obtained from the departmental colony at the University of Michigan. Their ages ranged from 120 to 150 days at the beginning of the experiment. Sixteen Ss were discarded, five for refusal to eat (day 1), two for refusal to run (day 2), one accidental death (during extinction), and eight, one entire squad, because of experimenter error.

Apparatus

A. The pretraining apparatus consisted of a small end-box, gray, except for a black panel at the goal end. The stem of the box, 1 1/2 in. wide by 4 1/2 in. high by 7 1/4 in. long, flared into a chamber, 4 3/4 in. wide by 5 1/2 in. long. The stem and chamber were covered by hinged hardward cloth and placement was possible from the end or the top of the box. Affixed to the far end of the chamber was a 1/4 tsp. measure, bent at a right angle with the spoon portion extending out from the wall to form a food cup.

B. The experimental apparatus was a straight, enclosed runway, painted flat black throughout. The inside dimensions were 4 in. wide by 6 in. high by 52 1/2 in. long. The apparatus was trichotomized by two unpainted, aluminum doors into a start box (SB), alley, and goal box (GB) with respective lengths of 11 in., 20 in., and 21 1/2 in. Each section was covered by a separate, hinged hardward cloth top. The guillotine doors were manually operated and were mounted on brown masonite panels extending 22 in. above and 16 in. to either side of the center of the alley. A third masonite panel was located 4 1/2 in. beyond the end of the runway. Illumination was provided by three, 40-watt florescent tubes located 5 1/2 ft. above and parallel to the runway. The food cup was a 1/2 tsp. measure, clipped into the recess of a holder formed from unpainted aluminum.

Experimental Measures

The runway was transected at four points by infra-red masked photo-electric beams (PE) which controlled four, .01 Standard Electric timers. Starting time was measured from SB door up to PE1 located 5 in. down the runway. An initial running time measure was recorded from PE1 to PE2, located 10 in. further down the runway. A second running time was recorded over a second, 10 in. segment (PE2-PE3) which was bisected by the GB retrace door. The GB latency was recorded over a final 10 in. segment (PE3-PE4). Photo-electric beam 4 was located 6 1/2 in. prior to the end of the runway and 4 1/2 in. before the food cup holder. The "click" of the microswitch on the SB door, as well as the

termination "click" of each timer, was audible to the experimenter.

Pretraining

Upon removal from the colony, Ss were weighed and individually housed in a 48 cage, self-demand watering unit. A regimen of 15 gm. of food, once a day, was immediately put into effect and this regimen obtained throughout the experiment. At the beginning of an experimental session, food deprivation was 19-21 hours. For a minimum of six days the Ss were exercised on a large training table in groups and handled individually 3-5 min.

On the third day before experimental sessions began (E-3), a set of 16-24 Ss was rank ordered by weight, marked off in sets of three, and within a set of three, randomly assigned to one of the three reward levels. The Ss were then assigned at random to an experimental squad (7-9 Ss) with the limitation that all three reward levels be represented in each squad. All squads of a particular set of 16-24 animals received the same number of acquisition trials. Assignment of squads to a level of the trials factor was such that each level was represented in the early, middle, and late stages of the research. The research was conducted at night.

On day E-3, each S received one placement in the gray end-box. Placement was from the end and the reward was a full measure of the proper percentage of sucrose solution. On day E-2, each S received consecutively massed trials to a criterion of three successive trials with latencies of less than 1 min. The reward

was 3-5 drops of the appropriate concentration. On day E-1, a squad of Ss was placed in individual carrying cages, transported to the pretraining room (different from the experimental room), and administered spaced trials, in rotation, to a criterion of three successive trials with latencies under 20 sec. The reward was two drops of the appropriate concentration. On days E-2 and E-3, latencies were recorded by stopwatch to the nearest second, placement was from the top, and subsequent to the end-box training, the Ss, in squads of 2-3, were given 10 min. exploration in the runway apparatus. The food cup and holder were absent during the exploratory periods.

Acquisition

The Ss were brought into the experimental room in individual carrying cages and allowed 10-15 minutes to "settle down". Squads of 7-9 animals were run in rotation. A trial was initiated when the S oriented to the SB door or 5 sec. after placement, whichever occurred first. A subject was discarded for two successive 5 min. start latencies (2 Ss). A trial terminated approximately 20 sec. after the last timer stopped. If a S failed to drink in 30 min., it was discarded (5 Ss). A minimum intertrial interval of 8 min. obtained. Water was available, ad lib., during the intertrial period. Fifteen trials a day were given which resulted in acquisition periods of 2, 4, or 8 days for the 30, 60, and 120 trial groups, respectively. The reward was two drops of the appropriate sucrose concentration (8, 16, or 32 per cent). Sucrose solutions were prepared by the per cent by weight

method, e.g., the 8% solution was prepared by adding 8 gm. of commercial sugar to 92 cc. of tap water. The solutions were stored in bottles with glass tops and fresh solutions were prepared every 2-3 days. Upon completion of a day's session, the animals were returned to their individual cages and fed their daily food ration.

Extinction

Each S received 22 experimental extinction trials on the day following the completion of acquisition. The experimental situation was unchanged except for the absence of reward. The inter-trial interval became progressively longer, reaching intervals of 20 min. toward the end of extinction. If the latency required to traverse any of the four, photo-beam delineated segments of the runway reached 5 min., the trial was terminated and S was removed from the runway segment and placed near the food cup for 20 sec.

CHAPTER III

RESULTS

For purposes of statistical analysis, the individual latency data were transformed (100/latency) to speed scores. The results presented were restricted to three measures (start, initial alley, and goal speeds) because preliminary analyses indicated the other measures (terminal alley, total alley, and total speeds) to be redundant.

Pretraining

The ad lib. weight of the animals was balanced over the per cent levels but not over levels of the number of acquisition trials (Ng). In order to evaluate the balancing procedure, a 3 x 3 analysis of variance was computed on the ad lib. weight scores. The analysis resulted in Fs < 1 for the per cent main effect, as expected, and for the % x Ng interaction. The Ng main effect was significant at the .01 level (F = 5.28, 2, 126 df). Subsequent t analyses indicated the 30 and 60 trial levels to be similar but heavier than the 120 trial level.

As a check on the importance of the weight variable, correlations (based on all 135 Ss) were computed between ad lib. body weight and each of the three measures for terminal acquisition and terminal extinction. The absolute magnitude of all six correlations was less than .10. The consistently small magnitudes suggested that, for this experiment, little of the variance of terminal acquisition or terminal extinction measures might be attributed to ad lib. weight of the Ss. Crespi (1942) and Zeaman (1949) have reported similar findings.

The median latency of the last three pretraining trials was computed for each S. A 3 x 3 analysis of variance on the latency data resulted in Fs < 1 for the Ng and Ng x % effects and nonsignificant for the per cent effect ($P < .10$). Statistics based on the total sample of 135 indicated that the Ss had learned to approach and drink the sucrose solution, e.g., range = 1-9 sec., mean = 1.8 sec., and the median = 1 sec.

Terminal Acquisition

Each S's median response speed was computed for the last 7 acquisition trials on the start speed, alley speed and goal speed measures. The group mean and SD of the terminal median response speed for each of the nine independent groups on each of the three measures is presented in Table 1. A separate 3 x 3 analysis of variance was performed on each measure. The results from the three analyses were consistent in showing (1) little or no tendency for the Ng and per cent variables to interact (Fs < 1 for start and alley; $p > .20$ for goal), (2) some tendency for Ss that received 32% or 16% sucrose solution to run faster than Ss which received the 8% solution ($F = 2.85$, 2, 126 df., $P < .10$ for start; $F = 2.83$, 2, 126 df, $P < .10$ for alley; $F < 1$ for goal), and (3) reliable differences between Ng levels ($F = 22.49$, 2, 126 df., $P < .001$ for start; $F = 6.40$, 2, 126 df., $P < .005$ for alley; $F = 4.64$, 2, 126 df., $P < .025$ for goal).

Subsequent analysis of the Ng data by t test showed the same thing for all three measures, i.e., the 120 and 60 trial levels were similar but significantly faster than the 30 trial level.

TABLE 1

TERMINAL ACQUISITION: GROUP MEAN SPEED (100/Lat.) AND SD FOR START, ALLEY, AND GOAL MEASURES (n = 15)

Start Speeds

Per Cent Sucrose Solution	Number of Acquisition Trials: 30 Trials Mean	30 Trials SD	60 Trials Mean	60 Trials SD	120 Trials Mean	120 Trials SD	Overall Mean
8%	112.27	76.86	212.00	82.28	200.33	49.53	174.87
16%	152.80	81.47	239.80	79.06	232.87	63.82	208.49
32%	142.40	69.62	224.87	62.51	249.93	77.37	205.73
Overall Mean	135.82		225.56		227.71		

Alley Speeds

8%	215.73	87.05	274.27	76.21	253.40	46.65	247.80
16%	246.73	74.25	289.13	63.68	274.07	69.72	269.98
32%	242.67	57.30	302.87	74.77	312.33	100.56	285.96
Overall Mean	235.04		288.76		279.93		

Goal Speeds

8%	228.33	71.25	266.93	63.43	271.33	37.27	255.53
16%	261.60	80.58	267.73	39.99	262.07	52.78	263.80
32%	230.27	58.67	304.07	54.48	279.33	85.73	271.22
Overall Mean	240.07		279.58		270.91		

For the t analyses, the error term (126 df) from the relevant analysis of variance was used. For all three measures, ts < 1 were found for the 60 vs. 120 trial comparison. The ts for the combined 60 and 120 vs. 30 trial comparison (6.707, 3.537, and 2.987 for the start, alley, and goal speeds, respectively) all attained the .01 level of significance.

Extinction, Criterion Measure

An extensive analysis of the extinction data in terms of trials to several levels of a temporal criterion was precluded by the fact that, even for very short latency values, some subjects failed to meet criterion within the extinction period. For example, one, three, and five Ss failed to have latency scores that exceeded 1 sec. in the start, alley, and GB sections, respectively. As the criterion was increased, proportionally more Ss failed to meet the criterion, e.g., 6, 21, and 24 Ss failed to have latencies as long as 10 sec. on the start, alley, and GB sections, respectively.

In order to obtain scores from all 135 Ss on the three sections, a criterion of .50 sec. was employed. The number of trials to a latency equal to or greater than .50 sec. was recorded for each S for each of the three runway sections. The first extinction trial was excluded from statistical treatment. The results of the 3 x 3 analyses of variance performed on these data were essentially the same for all three runway sections. The main effects for both Ng and per cent were significant but the interaction effect did not approach significance. The

summary statistics were, (1) start measure: F = 10.63, 2, 126 df., $P < .001$ for Ng; F = 4.47, 2, 126 df., $P < .025$ for per cent; F = 1.30, 4, 126 df., $P > .20$ for Ng x %, (2) alley measure: F = 7.74, 2, 126 df., $P < .001$ for Ng; F = 4.38, 2, 126 df., $P < .025$ for per cent; F = 1.52, 4, 126 df., $P < .20$ for Ng x %, and (3) GB measure: F = 8.15, 2, 126 df., $P < .001$ for Ng; F = 3.80, 2, 126 df., $P < .025$ for per cent; F = 1.45, 4, 126 df., $P > .20$ for Ng x %.

For all three sections, analyses by t tests showed that the combined 60 and 120 vs. 30 trial and combined 16 and 32 vs. 8 per cent comparisons were significant beyond the 2 per cent level but the ts were 1.0 or less for the 60 vs. 120 trial and 16 vs. 32 per cent comparisons. Because the Ss reached the .50 sec. criterion in relatively few trials (3.64, 5.07, and 5.00 trials for the start, alley and GB sections, respectively), the similarity of these results to those of terminal acquisition is not surprising. The main difference between the terminal acquisition speed and extinction trials data appeared in the per cent sucrose factor. Where the analyses of the start and alley speed measures only suggested a sucrose concentration effect, the trials to criterion analyses resulted in significant concentration effects for all three runway sections.

Extinction, Speed Measure

The procedure of removing the S from the apparatus after a 5 min. latency reading resulted in missing data, e.g., if S were removed from the initial alley position there were no clock readings for the terminal alley or goal measures. Missing data

were infrequent. Out of the possible 2835 scores, only 35 and 26 scores (about 1%) were missing from the alley and goal measures, respectively. At no time was it necessary to compute a median on less than four scores and no S ever exceeded three refusals on one measure. This procedure did not affect speeds because a latency of 5 min. transforms to a zero speed score.

The first extinction trial was not included in the treatment of the data. The remaining 21 trials were blocked into groups of 7 trials for purposes of statistical treatment. The median for each trial block was computed which resulted in three extinction scores for each S. The group means and SDs for each group (N = 15) and the means for each Ng and per cent level (N = 45) for each of the three measures, start, alley, and goal speeds, are presented, respectively, in Tables 2, 3, and 4. Separate 3 x 3 x 3 analyses of variance were performed on each measure where the three factors investigated were Ng, per cent sucrose solution, and the phase of extinction training (first, second, or third trial block). The last factor involved repeated measurement on the same S. The summary tables for the analyses are presented in Table 5. In all t analyses the appropriate MS error from the relevant analysis of variance was used as the estimate of error.

The Ng main effect was significant for all three measures and the subsequent analyses also showed the same pattern across measures. The summary statistics for the combined 120 and 60 vs. 30 trial comparisons for the start, alley, and goal speed measures were, respectively, $t = 5.02$, 126 df., $P < .01$; $t = 3.86$, 126 df.,

TABLE 2

EXTINCTION: GROUP MEAN START SPEED (100/Lat.) AND SD FOR EACH OF THE 9 Ng-% COMBINATIONS (n = 15) AND MEAN FOR EACH Ng AND % LEVEL (n = 45)

Blocks of 7 Extinction Trials	8%		16%		32%		Overall Mean
	Mean	SD	Mean	SD	Mean	SD	
30 Trials							
Block 1	75.13	78.95	120.60	79.30	126.20	82.46	107.31
Block 2	24.53	39.23	49.13	61.13	38.20	55.02	37.29
Block 3	15.93	21.50	41.07	47.42	33.73	48.38	30.24
Overall Mean	38.53		70.27		66.04		58.28
60 Trials							
Block 1	167.20	87.03	204.33	92.14	191.60	87.91	187.71
Block 2	78.07	91.71	103.47	74.28	103.27	100.38	94.93
Block 3	62.53	60.23	22.47	25.91	31.20	60.23	38.73
Overall Mean	102.60		110.09		108.69		107.13
120 Trials							
Block 1	150.87	73.41	205.13	96.66	239.13	71.60	198.38
Block 2	80.33	61.55	109.40	90.92	140.33	95.31	110.02
Block 3	53.93	51.15	34.93	45.42	53.20	59.32	47.36
Overall Mean	95.04		116.49		144.22		118.59
% Level Mean	78.73		98.95		106.32		

TABLE 3

EXTINCTION: GROUP MEAN ALLEY SPEED (100/Lat.) AND SD FOR EACH OF THE 9 Ng-% COMBINATIONS (n = 15) AND MEAN FOR EACH Ng AND % LEVEL (n = 45)

Blocks of 7 Extinction Trials	8%		16%		32%		
	Mean	SD	Mean	SD	Mean	SD	Overall Mean
30 Trials							
Block 1	170.07	75.88	223.40	70.04	179.33	88.82	190.93
Block 2	94.07	51.53	104.47	55.91	100.80	61.82	99.78
Block 3	95.73	54.06	66.67	45.84	125.47	70.39	95.96
Overall Mean	119.96		131.51		135.20		128.89
60 Trials							
Block 1	234.07	79.27	270.40	55.78	267.87	86.46	257.44
Block 2	162.73	74.56	146.47	60.91	144.00	105.83	151.07
Block 3	119.13	62.87	90.80	45.41	82.40	41.32	97.44
Overall Mean	171.98		169.22		164.76		168.65
120 Trials							
Block 1	224.40	64.64	225.07	106.93	297.87	90.75	249.11
Block 2	140.07	50.98	132.40	84.71	188.27	92.28	153.58
Block 3	102.60	51.39	95.00	47.15	134.13	58.27	110.58
Overall Mean	155.69		150.82		206.76		171.09
% Level Mean	149.21		150.52		168.90		

TABLE 4

EXTINCTION: GROUP MEAN GOAL SPEED (100/Lat.) AND SD FOR EACH OF THE 9 Ng-% COMBINATIONS (n = 15) AND MEAN FOR EACH Ng AND % LEVEL (n = 45)

Blocks of 7 Extinction Trials	8%		16%		32%		Overall Mean
	Mean	SD	Mean	SD	Mean	SD	
30 Trials							
Block 1	188.53	63.71	231.80	62.03	184.33	59.59	201.56
Block 2	124.33	71.47	145.33	39.20	131.53	48.07	133.73
Block 3	115.60	86.00	118.47	59.09	125.27	52.72	119.78
Overall Mean	142.82		165.20		147.04		151.69
60 Trials							
Block 1	221.00	83.61	255.67	53.12	279.27	62.10	251.98
Block 2	162.87	59.63	152.40	56.46	191.73	52.79	169.00
Block 3	143.87	54.41	130.93	52.14	152.27	50.68	142.36
Overall Mean	175.91		179.67		207.76		187.78
120 Trials							
Block 1	238.47	47.07	219.53	38.59	256.80	82.87	238.27
Block 2	158.07	57.91	175.00	43.14	202.40	79.38	178.49
Block 3	145.87	54.36	138.33	35.93	138.60	59.91	140.93
Overall Mean	180.80		177.62		199.27		185.90
% Level Mean	166.51		174.16		184.69		

TABLE 5

EXTINCTION: SUMMARY TABLES FOR 3 x 3 x 3 ANALYSES OF VARIANCE ON THE START, ALLEY, AND GOAL SPEED (100/Lat.) DATA

		Start Speed			Alley Speed			Goal Speed		
Source	df	MS	F	P	MS	F	P	MS	F	P
Ng[a]	2	138456.50	13.01	<.001	75777.00	7.47	<.001	55712.00	8.58	<.001
%[b]	2	55107.00	2.59	< .10	16372.50	1.61	>.20	11245.00	1.73	<.20
Ng x %	4	6939.25	<1	----	15136.00	1.49	>.20	7446.25	1.15	>.20
Between Ss error	126	10644.33			10137.78			6491.74		
No[c]	2	552780.00	184.46	<.001	627070.50	217.42	<.001	334545.50	137.74	<.001
No x Ng	4	21337.75	7.12	<.001	13852.50	4.80	<.01	3547.50	1.46	>.20
No x %	4	13066.00	4.36	<.005	8162.25	2.83	<.05	2775.75	1.14	>.20
No x Ng x %	8	2289.62	<1	----	5709.62	1.98	<.05	3644.38	1.50	>.20
Within Ss error	252	2996.30			2884.15			2428.78		

[a] Number of rewarded trials during acquisition
[b] Per cent sucrose solution during acquisition
[c] Blocks of 7 extinction trials

$P < .01$; $t = 4.14$, 126 df., $P < .01$. For all measures, the Ng level mean running speed was similar for the 60 and 120 trial levels but reliably slower for the 30 trial level. The findings support the assumption of a positive relationship obtaining between Ng and resistance to extinction.

All three measures yielded nonsignificant Fs for the per cent main effect. The rank order of the means for the three levels was consistent across measures and directly related to resistance to extinction in that per cent level mean running speed was greater for the 32% level than for the 16% level which was greater than the 8% level. The magnitude of the per cent effect approached significance on only the start speed measure ($P < .10$). The trend of these data suggest that the relationship between per cent sucrose solution and resistance to extinction is positive and monotonic.

No evidence was found to indicate that Ng and per cent interact in their influence on extinction behavior. None of the Fs for the Ng x % interaction approached significance.

The effect of the number of unrewarded trials (No) was consistently large reflecting the usual decrement in response speed subsequent to removal of the reward ($P < .001$ for all three measures). Both first order interactions (No x Ng, No x %) were significant for the start and alley measures and both were nonsignificant for the goal measure.

The data of Tables 2 and 3 suggested that these significant first order interactions might have occurred because the Ss in

the higher levels (32 and 16 per cent, 60 and 120 trials) of both factors were running faster in initial extinction than those in the lower levels (8%, 30 trials) but the three levels of both factors were comparable at terminal extinction. To test this implication, each of the four significant interactions was appropriately separated into a set of four orthogonal comparisons and the SS for each comparison was computed. The picture was the same for each of the interactions. As an example, the interaction effect (1 df.) that accounted for the major portion of the total (4 df.) No x Ng interaction for the start speed measure was the comparison of the combined 120 and 60 vs. 30 trial levels on the differences between combined trial blocks 1 and 2 minus 3. The combined 120 and 60 trial levels had greater differences (greater reduction in speed) than did the 30 trial level. This was the only significant No x Ng (1 df.) comparison for the alley speed measure also. Analogous findings for both of the significant No x % interactions (4 df.) obtained, i.e., the only comparison (1 df.) achieving significance was the one evaluating the reduction in speed from combined trial blocks 1 and 2 to trial block 3 for the combined 16 and 32 vs. 8 per cent comparison. Again the combined higher levels (16 and 32 per cent) experienced a greater drop in response speed over the extinction period than did the lower (8%) level. These interaction or rate of fall results, taken by themselves, appear to show that the lowest levels of the Ng and per cent factors produced greater resistance to extinction, a slower rate of response speed diminution, than the higher levels.

An alternative suggestion makes use of one general extinction curve (Birch, Allison, & House, 1963). The point where a factor level enters this curve is directly related to its Ng or per cent value during acquisition. For example, the Ss in the higher levels tended to run faster at terminal acquisition and had a higher initial point on the extinction curve. As long as the Ng or per cent factors predominate in the control of response speed, the rate of response decrement is similar for all levels, supported by the minimal level x blocks 1 and 2 interaction effect (1 df.) included in the MS residual interactions, Tables 6 and 7. When a factor no longer dominates the control of behavior (i.e., extinguishes) the rate of response decrement changes (last third of extinction for the lowest levels of Ng and per cent) producing an interaction with the higher levels. In short, the suggestion is that the 8% and 30 trial levels reached the point where the extinction curve levels out more rapidly than the higher levels because they entered the curve at initially lower points. This interpretation is consistent with the positive relationship between both Ng and per cent to resistance to extinction found in the acquisition data and extinction main effect data.

Additional support for the above interpretation of the significant first order interactions was found by an examination of the nonsignificant first order interaction results obtained in the goal speed analysis. On the latter measure, one of the two conditions specified as necessary for the interaction, terminal

TABLE 6

SUMMARY TABLES OF THE No x Ng INTERACTION BREAKDOWN FOR THE START AND ALLEY SPEED MEASURES DURING EXTINCTION

		Start Speed		Alley Speed	
Source	df	MS	F	MS	F
No x Ng[a]	1	78528.30	26.20*	48785.25	16.91*
No x Ng Residual	3	2274.23	< 1	2208.25	< 1
MS Error Within Ss	252	2996.80	-	2884.15	-

*P < .001

[a](60- 1&2 — 60-3) + (120- 1&2 — 120-3) — (30- 1&2 — 30-3)

TABLE 7

SUMMARY TABLE OF THE No x % INTERACTION BREAKDOWN FOR THE START AND ALLEY SPEED MEASURES DURING EXTINCTION

		Start Speed		Alley Speed	
Source	df	MS	F	MS	F
No x %[a]	1	45909.49	15.32**	13387.44	4.64*
No x % Residual	3	2118.17	< 1	6420.52	2.23
MS Error Within Ss	252	2996.80	-	2884.15	-

*P < .05

**P < .001

[a] (16-1&2 — 16-3) + (32- 1&2 — 32-3) — (8- 1&2 — 8-3)

acquisition differences and terminal extinction similarity, did not obtain. The condition of terminal acquisition differences held for the Ng factor but the relative difference among groups at terminal extinction was greater for the goal speed measure than it was for the start and alley speed measures. The mean differences for the combined 60 and 120 vs. 30 trial comparison on the third extinction trial block was 21.86 for the goal measure compared to differences of 8.05 and 12.80 for the alley and start measures, respectively. The per cent level means for terminal extinction were quite similar but there was relatively little difference at the end of acquisition (mean differences for the combined 16 and 32 vs. 8 per cent comparison were, respectively, 32.24, 30.17, and 11.48 for the start, alley, and goal measures). Although the lack of terminal acquisition differences obtained, the reader is reminded that the trials to criterion measure, presumably closely related to terminal acquisition performance, showed significant concentration effects.

The second order interaction (Ng x % x No) was significant for the alley measure while it did not approach significance for the other two measures. The comparison (1 df.) which accounted for the significant portion (F = 11.15, 1, 252 df.) of the total interaction variance (4 df.) and left a nonsignificant residual (Table 8) was the 32 vs. 16 per cent comparison for the combined trial blocks 1 and 2 minus 3 differences for the combined 60 and 120 vs. 30 trial group. The difference between combined trial blocks (1 + 2) and (3) was greater for the 16% group than for the

TABLE 8

SUMMARY TABLE OF THE No x Ng x % INTERACTION BREAKDOWN FOR THE ALLEY SPEED MEASURE DURING EXTINCTION

Source	df	MS	F
No x Ng x %[a]	1	32155.05	11.15*
No x Ng x % Residual	7	1931.71	< 1
MS Error Within Ss	252	2884.15	-

*P < .005

[a] [(60-16-1&2 — 60-16-3) — (60-32-1&2 — 60-32-3) + (120-16-1&2 — 120-16-3) — (120-32-1&2 — 120-32-3)] — [(30-16-1&2 — 30-16-3) — (30-32-1&2 — 30-32-3)]

32% group at the 30 trial level but for the combined 60 and 120 trial levels the differences for the 32% and 16% Ss were similar. This interaction was primarily due to the relatively abnormal pattern of extinction behavior exhibited by the 30-32% group. By the end of the first extinction trial block (7 trials), the 30-32% group was comparable to the 30-8% group indicating relatively rapid extinction; but the former group then showed enough increase in response strength from trial block 2 to trial block 3 to show an overall mean extinction speed greater than either the 30-16% or 30-8% groups.

CHAPTER IV

DISCUSSION

The pattern of results that emerged from the three speed measures was consistent and showed a close relationship between performance at terminal acquisition and resistance to extinction (Ro). Both the number of rewarded acquisition trials (Ng) and amount of reward, represented by per cent sucrose solution, were positively related to terminal acquisition speeds and Ro. The Ng factor exerted more control on performance, in general, than the sucrose concentration or the Ng x % interaction. Although per cent sucrose was a significant factor on the trials to criterion analysis, its effect on the running speed measures, while consistent, only approached significance. The Ng x % interaction was very small in both extinction and terminal acquisition.

The obtained positive relationships both replicate and conflict with previous findings. The position taken here is that the relation holding between Ro and amount of reward or Ng may vary as a function of many variables. As Kimble (1961) has pointed out in a discussion of the "enormous complexity" of the literature concerning extinction,

> Another reason for the impression of complexity is that variables controlling extinction seem to interact in ways which limit the generality of statements about extinction. (p. 323)

The hope, then, is that at least some of the apparent conflict can be reasonably attributed to interstudy differences in variables effective in the control of extinction performance.

Among the recent reviews of theories relevant to extinction phenomena are Kimble (1961), Amsel (1962), and Lawrence and Festinger (1962). For purposes of exposition, the orientation and vocabulary of Amsel (1958, 1962), Birch (1961), and Spence (1956, 1960) will be adopted. This approach conceives of performance under conditions of experimental extinction to be controlled primarily by two motivational processes, (1) a positive motivational process (rg-sg) associated with the anticipation of reward (K), and (2) a negative motivational process (rf-sf) associated with the anticipation of frustration occasioned by the removal of reward during experimental extinction. During acquisition, the build-up of frustration potential is directly related to the build up of rg-sg and both are directly related to Ng and K. While the relationship between Ro and rg-sg is positive, Ro is specified to be negatively related to rf-sf. Given these two processes and one of them (rg-sg) developing at a faster rate than the other, the relationship expected between Ro and K or Ng is some function of the relative magnitude of the two processes. Where extinction performance is controlled primarily by the strength of rg-sg, the relationship expected between Ro and K or Ng is positive; but where groups are comparable in rg-sg and different in magnitude of elicitable frustration, negative relationships should obtain. Over several, well-separated levels of the Ng or K factors, the theory provides for the occurrence of curvilinear (inverted U) relationships to Ro. Where studies have differed

in variables (experimental or procedural) related to the development of these two motivational processes and/or to their rate of antedation, differences (apparent conflict) in the reported relationships can be expected.

North and Stimmel (1960) interpreted their finding of greater Ro after 45 trials compared with 90 or 135 trials in conjunction with that of Lawrence and Miller (1947), 16 trials producing more Ro than 8, to reflect a "nonmonotonic" relation between Ng and Ro. Ison's reported finding of a negative relationship holding over a range of 10-100 trials appears to conflict. Two reported findings have bearing on this. The first is runway length. Amsel, Ernhart, and Galbrecht (1961), in a study which involved runways of different lengths obtained results that suggested, "... that the magnitude of frustration is, up to a point at least, directly related to the duration of an instrumental response which is frustratively non-rewarded" (p. 184). The alley lengths, excluding start box (SB), for the North and Stimmel study was 50 3/4 in., and for the Ison study, 90 in. Also, Ison used a .4 gm. food reward; North and Stimmel used 1 unit of a commercial breakfast food, "Sugar Jets". The greater runway length, and, presumably, greater reward of the Ison study could have operated in a manner to move the apex of a curvilinear function to an earlier trial number. Second, Ison's apparatus was black throughout while North and Stimmel left the SB portion of their apparatus unpainted. The results of Finger's (1942) study (no brightness cue) in combination

with those of Lawrence and Miller (brightness cue present) indicated that the relationship over the lower levels of Ng will be positive or negative depending on the presence or absence of brightness cues clearly delineating the SB from GB. The absence of a brightness cue in Ison's study in combination with the effect of a lengthy runway could have contributed to the reported inverse relationship which included small values of the Ng factor. The suggestion here is that a positive Ro to Ng relation might have obtained for small values of Ng under conditions of a brightness cue and/or a shorter runway.

Wagner (1962), using a 50 in. alley (post pre-SB), found a 16 trial group to have less Ro than a 60 trial group when the level of K was .08 gm. The conjecture here is that had Wagner had a third, higher level of Ng, e.g., 135 trials, the positive relationship reported could have changed to a curvilinear one. (When the reward was 1.0 gm., the 16 and 60 trial groups were similar to Ro but no Ng x K interaction was mentioned.)

While Theios found no reliable differences in extinction performance between groups which had received either 100 or 170 acquisition trials, the small difference found (Group 170 required 3 more trials to an extinction criterion) is consistent with placing the two points on the descending side of a curvilinear function. That such a placement is reasonable is supported both by runway length (87 in. post SB) and level of reward (one "Frostyos" pellet).

Although none of the intrastudy data presented have demonstrated directly that the relationship between Ng and Ro is curvilinear, such a hypothesis manages to survive the studies reviewed. Further, Amsel (1962) has reported some unpublished data (Reynolds, Richter, & Carlock, 1960) which he interpreted as direct support for the hypothesis (a 66 trial group had less Ro than either 6, 12, or 30 trial groups).

The present study found no evidence to suggest a curvilinear relationship. The short runway used (41 1/2 in. post SB) could have prolonged, relatively, the positive phase of a curvilinear function. While Amsel found little evidence for a frustrative nonreward effect after 75 trials on a 24 in. alley portion of a runway, one would expect the increase in length and Ng to have produced some frustration. In the same vein, the procedure of opening the SB door upon obtaining an orienting response from the S, used in this study, differs from the more general procedure of imposing some constant, minimum time interval between placement and opening of the SB door. Since the former procedure shortened the duration of instrumental responding, less frustration should result from it, other variables held constant.

Another factor which may have contributed to the positive K-Ro relationship found was the reward used in this study. Several studies (Goodrich & Zaretsky, 1962; Goodrich, 1962; Dufort & Kimble, 1956; Rosen, 1961; but cf. Collier & Marx, 1959) which involved a shift in sucrose concentration failed to find the "depression effect" reported in studies involved

with a shift of food reward (Crespi, 1942; Zeaman, 1949; Spence, 1956; Ehrendfreund & Badia, 1962). Dufort and Kimble suggested that extinction may be viewed as the limiting case of a downward shift in reward. Following this suggestion and assuming that the depression effect is dependent upon frustration (GB and anticipatory) resulting from the shift to a lower reward, the differential shift effects of sucrose and food are compatible with the notion that, (1) the magnitude of frustration occasioned by a downward shift of reward is less for sucrose solutions, and/or (2) the antedation of the frustration effect is slower for solutions of sucrose. Either (1) and/or (2) could, presumably, prolong the positive portion of the relationship for sucrose solutions relative to food. Research directly bearing on this is apparently not available, i.e., intrastudy comparisons of food, solid sucrose, and solutions of sucrose. The fact that a goal response to solid reward has more components capable of antedation may be an important factor here.

While the effects of consummatory response and amount of reward factors have, in general, been confounded in food reward studies (Spence, 1956) sucrose is better suited for the separation of these factors (Gutman, 1953). The theoretical approach used as a framework for this discussion has arisen, almost exclusively, from animal experimental work involving a food reward. The approach leans heavily on the idea that the goal response becomes classically conditioned to stimuli, external and internal, present at the moment of reward consummation. The fractional components,

represented by rg-sg and rf-sf, are conceived to antedate the goal box over trials and provide a basis for motivating the instrumental approach response. Factors which influence the classical conditioning process, e.g., strength of the UCS, number of CS-UCS pairings, etc., are expected to affect the strength of the fractional, antedating goal responses. By holding the effects of sucrose concentration constant and varying such factors as the number of laps, laps/unit time, etc., the expectation would be, in general, a positive correlation between, e.g., the number of laps or classical conditioning "trials" and instrumental approach speed. Recent studies have failed to find much support for this expectation. After reviewing some of this literature, Knarr and Collier (1962) conclude, "that variations in consummatory activity are neither necessary nor even sufficient conditions for producing variations in acquisition and performance" (p. 587). Although this conclusion may have to be qualified for very large values of various factors, e.g., Ng, Td, etc., it is compatible with the notion that the build up of rg-sg, and thus frustration potential, may be slower under conditions of sucrose reward as compared with food.

It should be emphasized that the Knarr-Collier conclusion may be limited by considerations other than increases in the range of the usual experimental variables. One such consideration of possible importance is the prior history of the subject with a particular reward. Wetzel (1959) contains a brief

review of studies which have investigated the effects of short term experience with sucrose on subsequent performance. While measurable short term effects have been reported, the speculation here refers to long term experience, namely, animals naive to solid food from birth might perform for food reward in much the same fashion that sucrose naive Ss perform for sucrose.

Knarr and Collier notwithstanding, the working hypothesis here is that the effects found under food reward may be found under sucrose rewards by substantially increasing the level of the factors investigated. Some support for this stems from a study (Clifford, 1963) conducted concurrently with the present one and on the same apparatus. The important differences between the present study and Clifford's were that Clifford encompassed a broader range of the Ng factor, used female rats, employed a greater food deprivation (Td), and interpolated a latent extinction manipulation between acquisition and experimental extinction. During acquisition, all subjects were rewarded with a 33% sucrose solution reward for 24, 48, 84, 132, or 192 trials. A curvilinear relation was found between Ng and Ro with an apex somewhere between the 84 and 132 trial marks. Birch's suggestion (1961) that increases in drive might also increase the frustrative nonreward effect (supported by Ehrendfreund and Badia) coupled with an interstudy suggestion that sucrose might have greater reward value for females than males (Crespi, Zeaman, and the present study found no correlation between weight and running speed; Young and Shuford (1954)

found satiated females to run faster to sucrose than satiated males) would seem to indicate that the positive relations found in the present study would have continued beyond the point of slope change found by Clifford. Before leaving the drive factor, it should be mentioned in passing that while studies can vary in Td, the amount of extra-experimental food given S can vary while holding Td relatively constant, e.g., Hulse gave his animals 7.5 gm., the present study provided for a 15 g. ration, and Wagner allowed 30 min. access to food. Returning to the sucrose studies on hand, the main point is that given enough trials, Td, etc., the expected curvilinear relation between Ro and Ng has been found under the conditions of a sucrose solution reward.

Changing the focus to the K factor, Armus (1959) viewed his study as an extrapolation of Zeaman's along the Ng dimension. Where Zeaman (and Lawrence and Miller) reported a positive relation between K and Ro for rats given a small (less than 20) number of acquisition trials, Armus found a negative relation for rats given 75 trials. Armus' suggestion was that the relationship between K and Ro is dependent on the number of acquisition trials. Hulse (1958) reported that after 30 acquisition trials, a .08 gm. group required more trials to an extinction criterion than a 1.0 gm. group. The negative relationship obtained after only 30 trials may be reasonable in that the post SB runway length (60. in. vs. 54 in.) and spread of reward levels (factors of 12.5 to 10) were greater in the Hulse

than the Armus study. Wagner replicated Hulse's finding with rats given an average of 38 trials (collapsed 16 and 60 trial groups). By inspection of the graphs presented by Wagner, it is clear that the difference between K levels for the 60 trial groups was greater than that of the 16 trial groups. This is in keeping with the suggestion by Armus.

In short, the relationship between K and Ro appears to depend on the level of Ng, positive for low levels of Ng and negative for higher levels. No reliable Ng x K interactions have been reported in support of this, nor has anyone reported a curvilinear Ro-K relationship for a particular Ng level. The latter would not seem to be precluded by the literature at hand.

Shifting from food to sucrose reward, the only other study (Marx and Brownstein), which also assessed the effect of differential sucrose reward upon extinction performance, replicated the present study in results based on speed measures. No significant concentration effect was found for terminal acquisition or extinction for groups of Ss given 73 trials with a sucrose solution reward of 8%, 16%, 32%, or 64%. The tendency was for the 8% group to run more slowly in both acquisition and initial extinction.

Two other results from the Marx and Brownstein study are worth noting if only to emphasize the aforementioned complexity encountered with sucrose reward. The first is that there was a systematic decline and recovery in performance during

acquisition with the order of decline and recovery perfectly and positively correlated with sucrose concentration (Ss had had prior licking experience with 32% sucrose and water). This phenomenon was attributed to, "a loss of incentive value per se, rather than mediated by the physiological factors known to operate over longer intake intervals" (p. 188). The second result indicating the complexity was that measures of Ro other than speed showed consistently but not reliably, a curvilinear relationship between K and Ro. The striking thing is that the U was not inverted.

As with the studies investigating the relationship between Ng and Ro, there appears to be differences in the K-Ro relation dependent upon whether food or sucrose reward was used. The studies which involved a sucrose reward found a positive relation for levels of Ng comparable to those of food studies which reported a negative relation. This apparent conflict is attributed, in part, to a prolongation of the Ng range where positive relations hold. The prolongation is ascribed to certain possible ramifications of sucrose reward as previously outlined.

As intimated earlier, in spite of the importance placed on fractional anticipatory responses, the lack of a literature, indicating that with solid food reward, magnitude of reward effects are dependent upon correspondingly different goal responses, leaves such an emphasis essentially gratuitous. The relevant literature on studies which involved a liquid reward,

primarily, sucrose solution, saachrine solution (Hulse & Bacon, 1962; Snyder, 1962; but cf. the work of Sheffield and coworkers, e.g., Sheffield, Roby, & Campbell, 1954) and water (e.g., Kling, 1956) have indicated little relationship between consummatory response factors and running speed but positive relationships between amount and/or concentration factors and running speed. The paucity of direct support in addition to a growing literature of negative results suggests the possibility that models in the Hull-Spence tradition may have to relate the mediational constructs (rg, rf, etc.) to behavioral events more central than the clearly peripheral ones now employed.

In light of this possibility, it would seem remis not to mention one more aspect of sucrose and speculations concerning it. In addition to the liquid-solid aspect of reward, there is another aspect made apparent by a sucrose reward, the nutrient-taste aspect. After a brief review of relevant material, Kimble states, "Thus, there is reason to believe that it actually is the taste of sugar which provides it with its reinforcing power" (p. 251). After trying to incorporate taste under the rubric of secondary reward, again in the Hull-Spence tradition, he states, "It is equally conceivable, however, that the taste of saacharine is primarily reinforcing and that the secondary reinforcement component is very small" (p. 253). The point to be made is that it is equally conceivable that sensory factors (as opposed to nutrient factors) provide the only basis for reward effects (Young, 1955) and the use

of solid food reward, crude in many respects when compared to solutions, has masked this fact. The number of grams of solid rewards should, accordingly, be investigated in light of their sensory components such as solvency in saliva, momentary satiation factors, sensory adaptation and fatigue factors, drive state, etc. Such an approach has encouraged the use of techniques available for evaluating the sensory aspects of reward such as the psychophysical methods (e.g., Campbell, 1958) and direct recording of neural activity in taste receptors and their afferent nerves (Pfaffmann, 1960). The use of solid rewards is not characteristic of this emphasis but at least one attempt has been reported (Hutt, 1954).

In summary, the point was made that a number of theories are available which are broad enough to contain the data reviewed in this discussion. For greater ease of organization and exposition, an attempt was made to incorporate a restricted set of findings, those directly bearing on the K- and Ng-Ro relationship, within the theoretical vocabulary of Amsel, Spence and Birch. The restriction was liberalized to bring in data indirectly related to the relationships in question to emphasize certain complexities relative to the question of what provides the basis for reward effects. Enough material was introduced to make the point, almost ubiquitous with psychological research, that a definitive interpretation of the present results would be premature at this time.

However, this much can be said. Although the results of the present study can be made compatible with theories (e.g., Amsel, Lawrence and Festinger) which provide for (1) nonmonotonic relationships between Ro and amount of reward or Ng, and (2) interaction effects between amount of reward and Ng during extinction, the obtained monotonic relationships, along with little or no suggestion of a Ng x amount of reward interaction, may not be construed as support for such theories.

CHAPTER V

SUMMARY

Performance in a straight runway during terminal acquisition and 22 extinction trials was studied for 135 rats as a function of two variables combined factorially: (2) two drops of either 8, 16, or 32 per cent sucrose reward, and (b) 30, 60, or 120 acquisition trials. Fifteen Ss were assigned to each of the nine independent treatment combinations. The Ss were maintained on 15 gm. of food per day and began experimental sessions approximately 20 hrs. hungry. The minimum intertrial was 8 min. with water available, ad lib., during the interval. Start, alley and goal latencies were recorded and transformed to speed scores (100/latency) for analysis.

Terminal acquisition performance was positively related to both the number of acquisition trials and sucrose concentration but the latter only approached significance. The interaction effect was small and nonsignificant.

Resistance to extinction (mean speed) was positively related to the number of prior rewarded trials and to the sucrose concentration, the latter again failing to achieve significance. The interaction between the number of acquisition trials and concentration was very small. First order interactions were found between both of the experimental variables and blocks of extinction trials. These were interpreted as consistent with the reported positive relationships

and to have resulted from initial differences, transferred from terminal acquisition, in conjunction with terminal comparabilities brought about by the effect of nonreward. The number of trials to a latency criterion of .50 sec. was positively related to both the number of acquisition trials and concentration variables. On the basis of some strong and generally consistent trends found in the speed data which were supported by significant results on the trials to criterion measure, the positive relationship between sucrose concentration and terminal acquisiton performance or resistance to extinction was accepted as genuine.

The results were discussed in relation to recent studies which have (1) found other than positive relations, and/or (2) been used to support theories predicting nonmonotonic relationships under conditions similar to the present study. An attempt was made to integrate the pertinent literature, including the present study, within the framework of one of these theories.

BIBLIOGRAPHY

Amsel, A. The role of frustrative nonreward in noncontinuous reward situations. Psychol. Bull., 1958, 55, 102-119.

Amsel, A. Frustrative nonreward in partial reinforcement and discrimination learning: Some recent history and a theoretical extension. Psychol. Rev., 1962, 69, 306-328.

Amsel, A., Ernhart, C. B., & Galbrecht, C. R. Magnitude of frustration effect and strength of antedating goal factors. Psychol. Rep., 1961, 8, 183-186.

Armus, H. L. Effect of magnitude of reinforcement on acquisition and extinction of a running response. J. exp. Psychol., 1959, 58, 61-63.

Birch, D. A motivational interpretation of extinction. In M. R. Jones (Ed.). Nebraska symposium on motivation. Lincoln: University of Nebraska Press, 1961.

Birch, D., Allison, J., & House, R. F. Extinction performance following discrimination training. J. exp. Psychol., 1963, 65, 148-155.

Campbell, B. A. Absolute and relative sucrose preference thresholds for hungry and satiated rats. J. comp. physiol. Psychol., 1958, 51, 795-800.

Clifford, L. T. Experimental extinction following different amounts of continuously rewarded training and latent extinction. Unpublished doctoral dissertation, Univer. of Michigan, 1963.

Collier, G. & Marx, M. H. Changes in performance as a function of shifts in the magnitude of reinforcement. J. exp. Psychol., 1959, 57, 305-309.

Crespi, L. P. Quantitative variation of incentive and performance in the white rat. Amer. J. Psychol., 1942, 55, 467-517.

Dufort, R. H. & Kimble, G. A. Changes in response strength with changes in amount of reinforcement. J. exp. Psychol., 1956, 51, 185-191.

Ehrenfreund, D. & Badia, P. Response strength as a function of drive level and pre- and postshift incentive magnitude. J. exp. Psychol., 1962, 63, 468-471.

Finger, F. W. The effect of varying conditions of reinforcement upon a simple running response. J. exp. Psychol., 1942, 30, 53-68.

Goodrich, K. P. Supplementary report: Running speed as a function of sucrose concentration in a prior free-drinking period. Psychol. Rep., 1962, 11, 528-530.

Goodrich, K. P. & Zaretsky, H. Running speed as a function of concentration of sucrose incentive during pretraining. Psychol. Rep., 1962, 11, 463-468.

Gutman, N. Operant conditioning, extinction, and periodic reinforcement in relation to concentration of sucrose used as reinforcing agent. J. exp. Psychol., 1953, 46, 213-224.

Hulse, S. H., Jr. Amount and percentage of reinforcement and duration of goal confinement in conditioning and extinction. J. exp. Psychol., 1958, 56, 48-57.

Hulse, S. H. & Bacon, W. E. Supplementary report: Partial reinforcement and amount of reinforcement as determinants of instrumental licking rates. J. exp. Psychol., 1962, 63, 214-215.

Hutt, P. J. Rate of bar pressing as a function of quality and quantity of food reward. J. comp. physiol. Psychol., 1954, 47, 235-239.

Ison, J. R. Experimental extinction as a function of number of reinforcements. J. exp. Psychol., 1962, 64, 314-317.

Kimble, G. K. Hilgard and Marquis' conditioning and learning. New York: Appleton-Century-Crofts, Inc., 1961.

Kling, J. W. Speed of running as a function of goal-box behavior. J. comp. physiol. Psychol., 1956, 49, 474-476.

Knarr, F. A. & Collier, G. Taste and consummatory activity in amount and gradient of reinforcement functions. J. exp. Psychol., 1962, 63, 579-588.

Lawrence, D. H. & Miller, N. E. A positive relationship between reinforcement and resistance to extinction produced by removing a source of confusion from a technique that had produced opposite results. J. exp. Psychol., 1947, 37, 494-509.

Lawrence, D. H. & Festinger, L. Deterrents and reinforcement - the psychology of insufficient reward. Stanford, Calif.: Stanford University Press, 1962.

Marx, M. H. & Brownstein, A. J. Effects of incentive magnitude on running speeds without competing responses in acquisition and extinction. J. exp. Psychol., 1963, 65, 182-189.

North, A. J. & Stimmel, D. T. Extinction of an instrumental response following a large number of reinforcements. Psychol. Rep., 1960, 6, 227-234.

Pfaffmann, C. The pleasures of sensation. Psychol. Rev., 1960, 67, 253-268.

Reynolds, W. F., Richter, M. L., & Carlock, J. Resistance to extinction as a function of reward magnitude and number of training trials. Paper read at Psychonomic Society, Chicago, 1960.

Rosen, J. Magnitude of reinforcement and time of deprivation in instrumental reward learning. J. gen. Psychol., 1961, 64, 205-212.

Sheffield, F. D., Roby, T. B., & Campbell, B. A. Drive reduction versus consummatory behavior as determinants of reinforcement. J. comp. physiol. Psychol., 1954, 47, 349-354.

Spence, K. W. Behavior theory and conditioning. New Haven: Yale University Press, 1956.

Spence, K. W. Behavioral theory and learning. Englewood Cliffs: Prentice-Hall, 1960.

Snyder, H. L. Saccharine concentration and deprivation as determinants of instrumental and consummatory response strengths. J. exp. Psychol., 1962, 63, 610-615.

Theios, J. The partial reinforcement effect sustained through blocks of continuous reinforcement. J. exp. Psychol., 1962, 64, 1-6.

Wagner, A. R. Effects of amount and percentage of reinforcement and number of acquisition trials on conditioning and extinction. J. exp. Psychol., 1961, 62, 234-242.

Wetzel, R. J. The effect of experience with a taste reward. J. comp. physiol. Psychol., 1959, 52, 267-271.

Young, P. T. The role of hedonic processes in motivation. In M. R. Jones (Ed.). Nebraska symposium on motivation. Lincoln: University of Nebraska Press, 1955.

Young, P. T. & Shuford, E. H., Jr. Intensity, duration, and repetition of hedonic processes as related to acquisition of motives. J. comp. physiol. Psychol., 1954, 47, 298-305.

Zeaman, D. Response latency as a function of the amount of reinforcement. J. exp. Psychol., 1949, 39, 466-483.