ESCAPE VARIABLES AND AVOIDANCE CONDITIONING: TWO EXTINCTION PROCESSES

THESIS FOR THE DEGREE OF

M. A.

MICHIGAN STATE UNIVERSITY

CURTIS ALAN BAGNE

1967

ABSTRACT

ESCAPE VARIABLES AND AVOIDANCE CONDITIONING: TWO EXTINCTION PROCESSES

by Curtis A. Bagne

The role of an escape contingency on behavior under aversive control is not clear. A number of studies suggest that aversive events which are response terminated are less aversive than those from which escape is prevented.

Experiment 1 demonstrated that hooded rats trained to avoid shock in a one-way box under conditions of no escape showed the same resistance to extinction as _S_s allowed to escape during training. These results are not readily interpretable because of a possible effect of method of transferring _S_s from the shock area to the safe area following the aversive US.

In Experiment 2 several treatments were interpolated between the acquisition and extinction phase of avoidance learning. The treatment variables yielded results that can be summarized as follows:

1. Interpolated escapable shock increases resistance to extinction more than the same amount of inescapable shock;
2. Method of transferring _S_s from the shock area to the safe area following inescapable shock has

an effect that could account for the negative results of Experiment 1;

3. In general, resistance to extinction is greater when conditions in the shock and safe areas are similar during interpolated shock than when they are different;
4. In general, resistance to extinction is increased when line of sight from shock to safe areas is blocked.

An analysis of response latencies for trials during extinction suggests that all _S_s can be classified into one of two extinction process groups. Some _S_s consistently respond rapidly until the extinction criterion is reached and extinguish during the first few trials of an extinction session. These _S_s are identified as belonging to the freeze group. The extinction response latencies of _S_s identified as belonging to the relax group respond less rapidly and with greater variability as extinction progresses. These _S_s are likely to extinguish at any time during an extinction session.

Thus, the assumption that number of trials to extinction of an avoidance response constitutes a unitary measure of the effectiveness of certain treatments on the acquisition and extinction on an avoidance response is untenable. In the experimental analysis of avoidance learning it is important to remember that treatment variables may have effects that are process specific.

ESCAPE VARIABLES AND

AVOIDANCE CONDITIONING:

TWO EXTINCTION PROCESSES

By

Curtis A. lan Bagne

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Psychology

1967

D E D I C A T I O N   T O

F A R I D E H

ACKNOWLEDGMENTS

The writer wishes to express special thanks to Dr. M. Ray Denny, chairman of his committee, for his assistance throughout the preparation of this report. Also he wishes to convey thanks to Drs. R. Levine and M. E. Rilling for their helpful criticism and advice.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	iii
LIST OF TABLES	v
LIST OF FIGURES	vi
INTRODUCTION	1
EXPERIMENT 1	3
Subjects	3
Apparatus	3
Procedure	3
Results	4
Discussion	5
EXPERIMENT 2	6
Introduction	6
Subjects	7
Apparatus	7
Procedure	7
Results	10
Discussion	30
SUMMARY	41
BIBLIOGRAPHY	43

LIST OF TABLES

Table		Page
1	Measures of Acquisition - All Groups	10
2	ANOVA: Number of Shocks During Acquisition .	10
3	ANOVA: Total Shock Received During Acquisition	11
4	ANOVA: Total Interpolated Shock	11
5	Trials to Extinction - Individuals by Group	12
6	Sums of Ranks by Group	12
7	Individual Comparisons	13
8	Trials to Extinction - Dichotomized by Extinction Process Group	23
9	Acquisition Comparisons - Freeze and Relax Groups	25
10	ANOVA: Trials to Extinction - Relax Group Only	27
11	Individual Comparisons - Relax Group Only .	28
12	ANOVA: Blind and Conditions in Safe - Relax Group Only	30

LIST OF FIGURES

Figure		Page
1	Mean Response Latencies for $\underline{S}$s in Group ED Plotted by Blocks	16
2a	Mean Response Latencies for Last Block of Extinction Trials	18
2b	Normalized and Standardized Distributions after Dichotomization at the 5 sec. Mark	18
3	Average Extinction Response Latency Patterns for Relax and Freeze $\underline{S}$s Plotted by Treatment Group	19-20
4	Freeze and Relax Extinction Process Groups Contrasted in Terms of (a) Average Mean Response Latencies and (b) Average Response Latency Standard Deviations . .	22
5	Relax and Freeze Groups Compared Trial by Trial in Terms of (a) Average Avoidance Latency, (b) Average Escape Latency and (c) Percentage Avoiding During Acquisition	26

INTRODUCTION

A number of experiments suggest that escapable aversive events are less aversive than those from which escape is prevented. Leitenberg (1967) found that punishment is less effective in suppressing a platform pressing response when _S_s are allowed to escape the aversive stimulus. Studying rats in a shuttle box, Marx and Hellwig (1964) found that when escape from shock is prevented both acquisition and extinction of the avoidance response proceeds more slowly.

Mowrer and Viek (1948) found that a CS preceding inescapable shock more effectively suppressed an eating response than a CS preceding escapable shock. This effect was labled "fear of a sense of helplessness."

A study by Brimer and Kamin (1963) did not replicate this finding. They found that the CS used in shuttle box avoidance training suppressed a previously learned bar-pressing response to the same extent whether or not escape was permitted during avoidance training. These authors conclude that fear of the CS in avoidance conditioning is independent of the _S_'s instrumental behavior.

Studies on the effect of an escape contingency yield apparently conflicting results. Theoretical explanations of the role of the escape contingency are weak. For instance, both the Leitenberg (1967) and the Marx-Hellwig (1964) studies suggest that inescapable shock is more motivating. Mowrer and Viek (1948) suggest that a symbolic response for leaping may lessen fear of shock when escape is permitted. Methodologically, most studies do not adequately match total duration and variability of the aversive US for Ss trained under conditions of escape with Ss trained under conditions where escape is prevented.

In Experiment 1 rats were used in an attempt to determine if the escape variable affects acquisition and extinction of an avoidance response in a one-way box. Experiment 2 explores the effect of conditions in the safe area following escapable shock when line of sight from the shock area to the safe area is either open or when it is blocked. The effect of the method of transferring Ss from shock to safe areas following inescapable shock is also studied.

EXPERIMENT 1

Subjects

The Ss were 10 experimentally naive male hooded rats from the colony maintained by the Psychology Department of Michigan State University. All Ss were 160-190 days of age at the beginning of training.

Apparatus

The basic apparatus was a one-way box with two chambers 18 in. long by 14 in. high by 4 in. wide. The floors were 1/8 in. stainless steel rods 5/8 in. center to center. The shock and safe areas were separated by a barrier 2 1/2 in. high and a manually operated guillotine door that opened a distance of 2 3/4 in. A shock of 1.1 ma. from an Applegate Stimulator was delivered through a Grayson-Stadler scrambler. The CS-US interval and shock duration were controled by Hunter timers. Stop clocks facilitated the control of ITI's and the recording of response latencies.

Procedure

The Ss were randomly divided into two groups of five each. A CS-US interval of 5 sec. was used during acquisition and an ITI of 30 sec. remained constant throughout the experiment. The CS consisted of handling and opening the door between shock and safe areas.

The Ss in the control group were run first and received 12 regular acquisition trials. At the end of these trials, the shock was turned off and extinction trials were begun without interruption. Extinction trials were run in blocks of 50 trials per day until the extinction criterion of two consecutive 60 sec. latencies was reached. At the end of 60 sec. Ss were boosted into the safe area. All latencies were recorded.

The Ss in the experimental group received inescapable shock if they failed to avoid within the CS-US interval of 5 sec. Control and experimental Ss were matched in regard to total shock received and shock variability. Escape was prevented by closing the door between the shock and safe areas at the end of the CS-US interval. Within a second after shock termination, the guillotine door was again opened and Ss were manually boosted over the barrier and into the safe area.

Results

The Ss receiving inescapable shock were shocked less frequently than controls although the difference was not significant ($t = .805$). Matching for total shock was successful as indicated by a t test ($t = .134$). The shock standard deviations for the control and experimental groups were 12.96 sec. and 15.67 sec., respectively.

Experimental and control groups were almost identical in terms of the number of trials to extinction. Experimental Ss extinguished in an average of 42.2 trials ($s = 27.2$).

Control Ss extinguished after an average of 38.6 trials ($s = 27.7$). The difference between the groups is not significant ($t = .207$).

Discussion

The presence of an escape contingency does not affect acquisition or extinction of an avoidance response for rats in a one-way box under the conditions of this experiment. The absence of an effect would be explained if boosting Ss over the barrier between shock and safe areas served the same function as an escape response. This and other variables associated with the role of escape in avoidance conditioning are explored in Experiment 2.

EXPERIMENT 2

Introduction

Experiment 1 revealed that blocking escape from the US during acquisition of an avoidance response had no effect on either acquisition or extinction of that response. But Ss receiving inescapable shock were manually assisted into the safe area shortly after the termination of the US. If this method of transferring Ss from shock to safe areas serves the same function as an escape response, the negative results of Experiment 1 would be explained. A different method of transfer might reveal the effect of an escape contingency.

In Experiment 2 a method was used in which a treatment was interpolated between the acquisition and extinction phase of avoidance learning. All experimental Ss received either escapable or inescapable shock. Following inescapable shock Ss were transferred from the shock region to the safe region by one of two different methods. Following shock, Ss were transferred from the shock region to the safe region by one of two different methods. Following shock, Ss of one group were boosted in the same manner as those in Experiment 1. The Ss of the other group were lifted out of the shock area (completely out of the apparatus) and immediately placed in the safe area.

Conditions following escape were also manipulated. Two groups of Ss escaped to a familiar safe area and two groups of Ss escaped to a different, unfamiliar safe area. One group of Ss escaping to a familiar area and one escaping to a different area were trained with a blind that blocked the line of sight from shock to safe areas.

All experimental groups were compared with a control receiving no interpolated shock.

Subjects

The Ss were 56 experimentally naive male hooded rats from the colony maintained by the Psychology Department of Michigan State University. All Ss were 114-192 days of age at the beginning of training.

Apparatus

The apparatus consisted of a one-way box with the same specifications given for Experiment 1.

Procedure

The Ss were divided into seven groups of eight each. Training and testing of all groups was divided into three phases: acquisition, a treatment interpolated between acquisition and extinction, and regular extinction trials.

A shock level of 1.1 ma. was used for all groups during acquisition and interpolated shock. A CS-US interval of 5 sec. was used during acquisition and an ITI of 30 sec. remained constant for all Ss throughout acquisition and extinction. The CS consisted of handling and opening of the guillotine door. All Ss received twelve acquisition trials after 60 sec. of habituation in the apparatus. The walls of the shock and safe areas were covered with white cardboard throughout acquisition and extinction.

Two groups were trained and tested without a blind. The remaining groups were trained and tested with the blind. The blind was a white cardboard attachment to the guillotine door that extended into the safe area in such a way that it blocked the line of sight into the safe area without seriously hindering access.

Groups were differentiated primarily by treatments interpolated between acquisition and extinction. These treatments were separated from both acquisition and extinction for all Ss by 90 sec. of confinement in a holding cage. All experimental groups receive two additional shock trials. The Ss of the four groups receiving escapable shock were placed in the shock area, the door opened and shock turned on simultaneously. One of these groups trained with a blind and one group trained without the blind escaped to the familiar safe area which was very similar to the shock area. One group trained with a blind and one without escaped to an unfamiliar safe area very different from the shock area. On one of the two interpolated trials in which Ss escaped to a different area, the walls and floor of the safe area were covered with black cardboard. Escape after the other interpolated trial was to a black chamber with vertical white stripes and a white cardboard floor. The order in which these conditions were presented was alternated for Ss. Ten seconds on a stool separated the interpolated trials. All Ss remained in the safe area for 30 sec. after interpolated shock.

Two groups of Ss received two inescapable shocks of the same average duration as Ss that were permitted to escape. Escape was prevented by not opening the door between the shock and safe areas. For one group, the door was opened within a second after shock termination and Ss were manually boosted over the barrier into the safe area. For another group, Ss were manually removed from the shock area without opening the door separating the two compartments and placed in the safe area. Timing of these procedures was made as similar as possible to the other interpolated shock groups.

The Ss in the control group received no additional shock but were handled on the same schedule as Ss receiving shock with placement and confinement in a holding cage rather than in the apparatus.

After interpolated treatments all Ss were extinguished with shock and safe areas similar. Extinction trials were run in blocks of 50 per day until the criterion of two consecutive 60 sec. latencies was reached. All response latencies were recorded.

The major treatment variables are summarized and the groups coded for later identification as follows:

Group Code	Acquisition	Interpolated Treatments	Extinction
ES	No blind	Escape to Similar	No blind
ED	No blind	Escape to Different	No blind
BES	Blind present	Escape to Similar	Blind
BED	Blind present	Escape to Different	Blind
BIB	Blind present	Inescapable - Boosted	Blind
BIC	Blind present	Inescapable - Carried	Blind
C	Blind present	No shock	Blind

Results

Table 1 summarizes the acquisition data for all groups. Included are the average number of shocks received during the 12 regular acquisition trails, the average total shock received, and the average amount of shock received during the interpolated trials where escape was permitted.

Table 1. Measures of Acquisition - All Groups

		GROUP						
		ES	ED	BES	BED	BIB	BIC	C
Number of Shocks	$\bar{x}$ =	4.25	6.00	5.63	5.75	5.50	6.50	6.50
	s =	1.91	2.45	2.07	2.38	1.19	2.20	1.85
Total Shock (sec.)	$\bar{x}$ =	13.50	15.84	14.73	16.10	11.80	9.20	16.14
	s =	6.12	4.21	6.25	10.27	9.08	4.43	13.70
Interpolated Shock (sec.)	$\bar{x}$ =	2.10	1.88	1.95	1.55			
	s =	.46	.42	.58	.25			

A one-way analysis of variance was performed on each of these measures of acquisition variables. The results are summarized in Tables 2, 3, and 4.

Table 2. ANOVA: Number of Shocks During Acquisition

Source	SS	df	MS	F
Between	28.11	6	4.68	1.12
Within	204.88	49	4.18	
Total	232.99	55		

Table 3. ANOVA: Total Shock Received During Acquisition

Source	SS	df	MS	F
Between	327.53	6	54.59	.78
Within	3426.89	49	69.94	
Total	3754.42	55		

Table 4. ANOVA: Total Interpolated Shock

Source	SS	df	MS	F
Between	1.29	3	.43	2.22
Within	5.46	28	.19	
Total	6.75	31		

None of the obtained F ratios are significant at the 5% level. The Pearson product moment correlation between number of shocks received during acquisition and number of trials to extinction for all Ss was insignificant ($r = -.017$, $t = -.125$). Similarly, the correlation between total shock received during acquisition and the number of trials to extinction for all Ss was also found to be insignificant ($r = .069$, $t = .508$).

Together these results indicate that group differences in reaching the extinction criterion cannot be reasonably attributed to differential learning during acquisition.

As would be expected, the correlation between number of shocks received and total shock was significant ($r = .337$, $t = 2.943$, $df = 54$, $p < .005$) although the linear relationship is not very strong as indicated by the coefficient of determination ($r^2 = .114$).

Table 5 lists the number of trials to extinction for all Ss by group together with appropriate summary statistics.

Table 5. Trials to Extinction - Individuals by Group

	GROUP						
	ES	ED	BES	BED	BIB	BIC	C
	51	50	43	102	38	0	3
	53	50	51	102	50	0	53
	56	51	54	122	52	0	62
	129	52	154	127	52	0	68
	183	53	338	172	54	16	83
	229	67	362	213	55	48	89
	339	70	468	215	167	51	120
	382	81	480	218	251	125	142
$\bar{x}$ =	177.75	59.25	243.75	158.87	89.87	30.00	77.50
s =	130.49	11.83	189.16	51.55	77.06	44.06	42.44

Cochran's test for homogeniety of variance yielded a $C = .535$ ($k = 7$, $df = 7$, $p < .01$). Some degree of bimodality in the sample distributions was also noted. For these reasons, the extinction data was analyzed by the Kruskal-Wallis one-way analysis of variance by ranks corrected for ties (Siegel, 1956). The effect of treatments was highly significant ($H = 1383.5$, $df = 6$, $p \ll .001$). Table 6 presents the sums of ranks for all groups.

Table 6. Sums of Ranks by Group

GROUP	SUM OF RANKS
ES	301.5
ED	164.5
BES	303.0
BED	330.0
BIB	195.5
BIC	77.5
C	224.0

Individual comparisons were made with the Mann-Whitney U test. All tests are of the two-tailed hypothesis of no difference. The values of U and their associated probabilities are given in Table 7.

The effect of an escape contingency is clearly evident in these comparisons. The multiple comparison between the two groups receiving inescapable shock (both trained with the blind) and the group trained with a blind and escaping to a similar area is significant ($U = 24$, $p < .02$) with Ss escaping being more resistant to extinction (BIB & BIC vs. BES). Individual comparisons also support this conclusion. The Ss trained with a blind and escaping to either similar or different areas are more resistant than Ss receiving inescapable shock and carried to safe (BES vs. BIC; BED vs. BIC). This effect is also present when Ss trained without a blind and escaping to either similar or different areas are compared with Ss receiving inescapable shock and carried to saftey (ES vs. BIC; ED vs. BIC). The Ss trained with a blind and escaping to a different area are more resistant to extinction than Ss receiving inescapable shock and boosted to saftey (BED vs. BIB).

Table 7. Individual Comparisons (Mann-Whitney U Test)

	ED	BES	BED	BIB	BIC	C
ES	$U = 11$ $p < .028$	$U = 29$ $p < .798$	$U = 31$ $p < .960$	$U = 16$ $p < .104$	$U = 3$ $p < .002$	$U = 20$ $p < .234$
ED		$U = 17$ $p < .130$	$U = 0$ $p < .000$	$U = 30$ $p < .878$	$U = 10$ $p < .020$	$U = 16$ $p < .104$
BES			$U = 28$ $p < .720$	$U = 18$ $p < .160$	$U = 5$ $p < .002$	$U = 20$ $p < .234$
BED				$U = 12$ $p < .028$	$U = 3$ $p < .002$	$U = 6$ $p < .004$
BIB					$U = 9$ $p < .014$	$U = 24$ $p < .442$
BIC						$U = 10$ $p < .020$

The Ss boosted into the safe area after inescapable shock are more resistant to extinction than Ss manually removed from the shock area and placed in the safe area (BIB vs. BIC). Boosted Ss do not differ from no shock controls (BIB vs. C). The Ss manually moved after inescapable shock are less resistant to extinction than no shock controls (BIC vs. C).

When conditions in the safe area are different and a blind is present, escapable interpolated shock increases the resistance to extinction of Ss compared with no shock controls (BED vs. C). When the blind is not present or when the conditions in the shock and safe areas are similar, escapable interpolated shock has no effect when compared with controls (ED vs. C; ES vs. C; BES vs. C).

Different conditions in the safe area after escape from interpolated shock decrease resistance to extinction only when the blind is not present (ES vs. ED; BES vs. BED). The blind has no effect when conditions in the shock and safe areas are similar but increases the resistance to extinction when conditions are different (ES vs. BES; ED vs. BED).

Behavioral observations suggested the presence of two extinction processes. Some Ss appeared fearful at the time the extinction criterion was reached. Others appeared relaxed. Freezing evidenced fear; exploration and grooming evidenced relaxation. The Ss of the first kind responded rapidly until they froze during the criterion trials. The Ss that extinguished in this way will be identified as belonging to the "freeze" group. Other Ss showed a pattern of gradually increasing response latencies until criterion was reached. These will be labled as belonging to the "relax" group. Response latencies during extinction were analyzed to see if the two patterns could be detected more precisely.

The extinction response latencies of all Ss were divided into successive blocks each containing 20% of the extinction trials for that S. The last block was further subdivided into two blocks of 10% each. The criterion trials as well as all individual 60 sec. "latencies" were excluded from this analysis because after 60 sec. in the shock area Ss were manually assisted into the safe area. Also, 5 Ss were excluded from this analysis because they extinguished in less than 5 trials. These 5 Ss froze early in extinction and are included in the "freeze" group on the basis of behavioral observations alone.

The mean and standard deviation of each block of extinction response latencies was calculated. The mean for each block was plotted for each S by group. Two rather distinct patterns of response latencies during extinction emerged. These were most clearly observed in group ED and are presented in Figure 1.

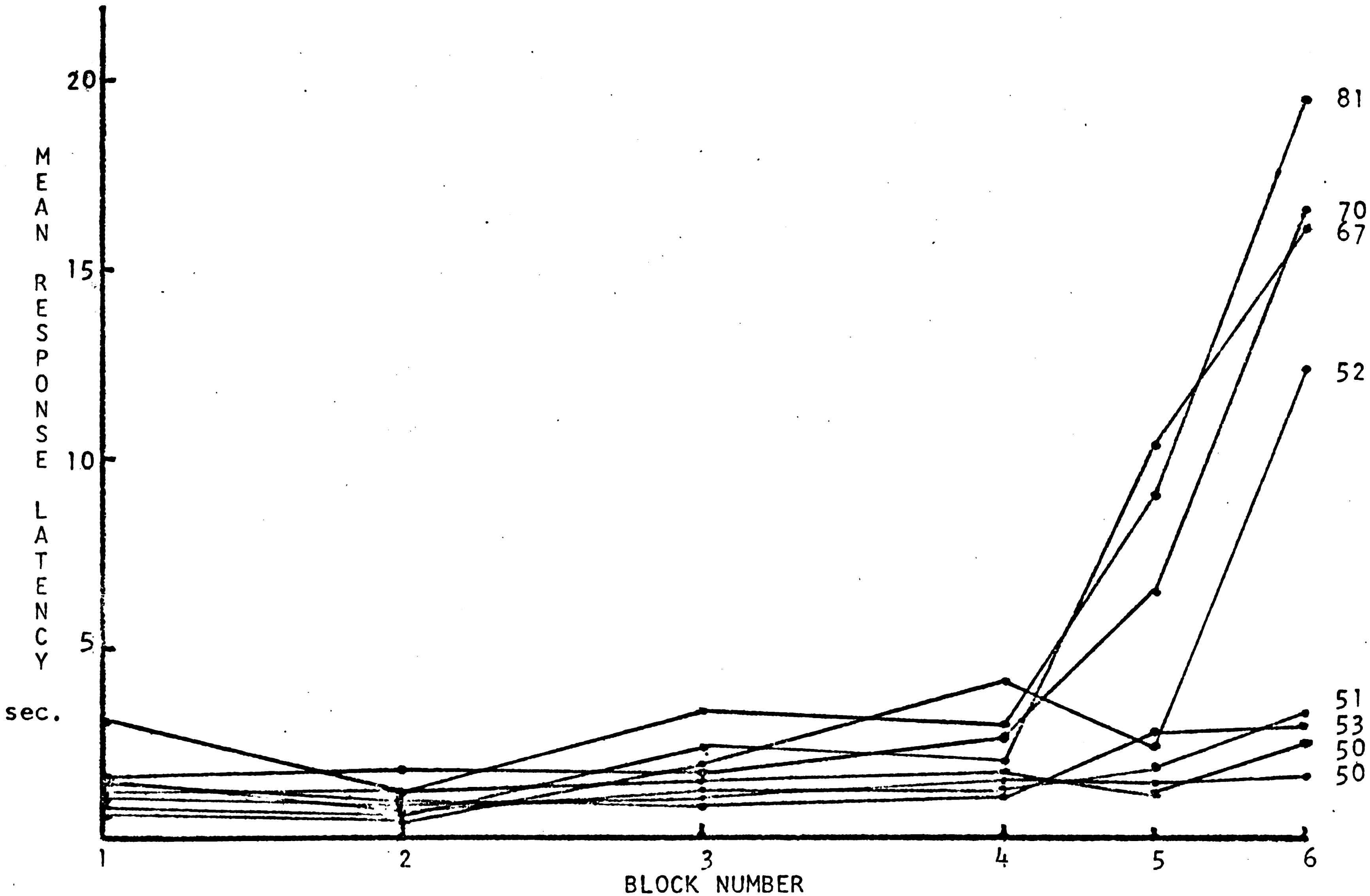

Figure 1. Mean Response Latencies for Ss in Group ED Plotted by Blocks. Trials to extinction are indicated at the end of each line.

Figure 2(a) is a bar graph of the means of the last block (10%) of the extinction response latencies for all Ss. This graph is sufficiently bimodal to warrant further exploration for evidence of two extinction processes.

All Ss were dichotomized into two groups on the basis of the mean latency of the last block of extinction trials. Those which, on the average, responded in less than 5 sec. (the CS-US interval) tended to show a freeze pattern during extinction and were classified as belonging to the freeze group. The Ss which averaged more than 5 sec. tended to relax during extinction and were so classified.

The distribution of means for the freeze group has a mean equal to 2.53 and standard deviation equal to 1.12. The values of these statistics for the relax group are 14.56 and 5.24, respectively. These distributions are normalized, standardized and plotted in proper relationship to each other in Fibure 2(b).

This dichotomization was applied to Ss in each experimental and the control group. The average means for the freeze and relax groups are plotted block by block for all groups in Figure 3. The contrast between freeze and relax extinction process groups for all experimental and the control group support the dichotomization. (One S is not included in this and the next figure. This S's average response latencies for the first, second and third extinction sessions are .87 sec., 10.0 sec., and 2.0 sec., respectively.)

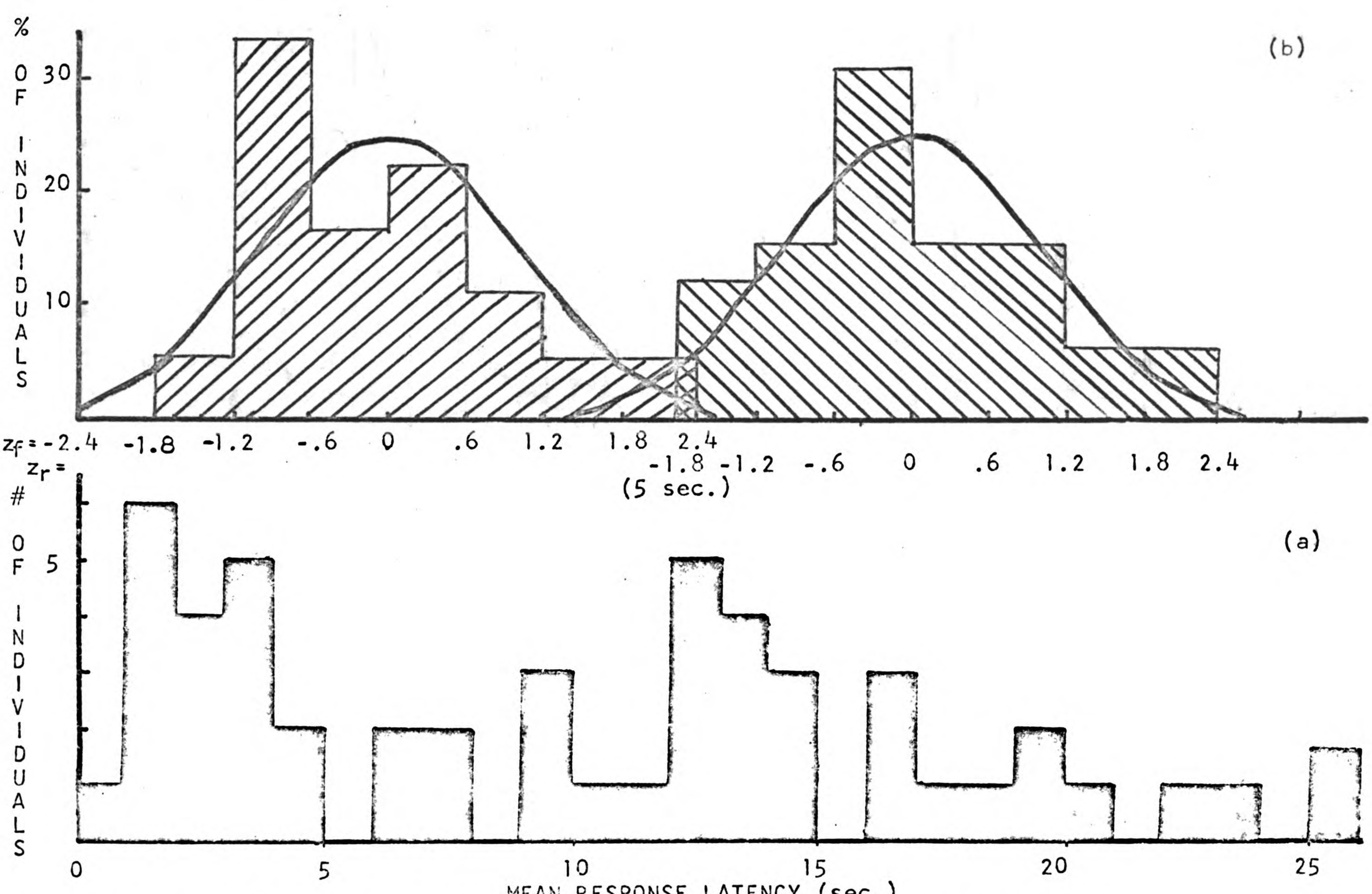

Figure 2. (a) Mean Response Latencies for Last Block of Extinction Trials
(b) Normalized and Standardized Distribution after Dichotomization at the 5 sec. Mark.

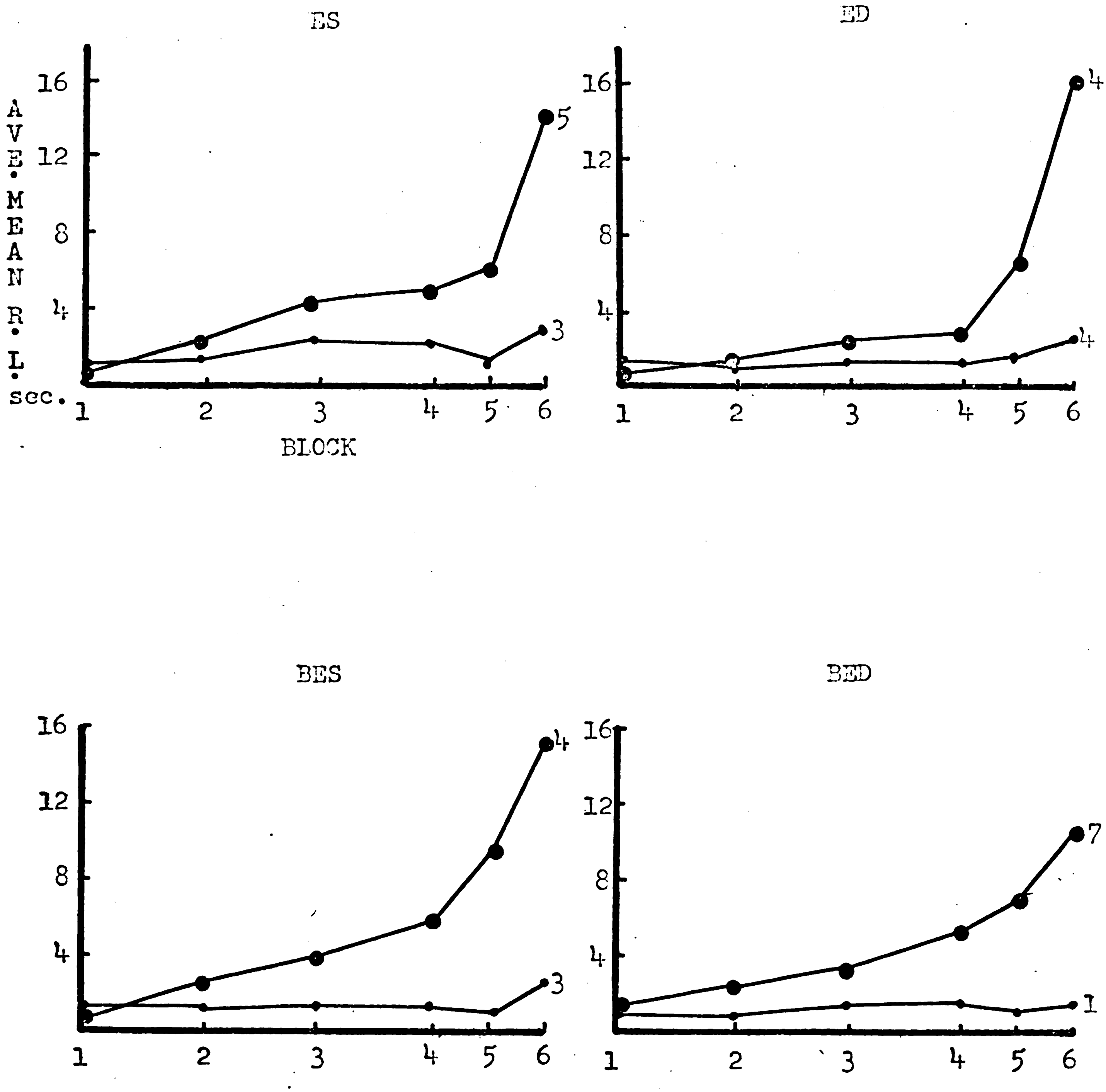

Figure 3. Average Extinction Response Latency Patterns for Relax and Freeze Ss Plotted by Treatment Group. The upper curve always represents relax Ss. Number at end of each plot gives the number of Ss upon which pattern is based.

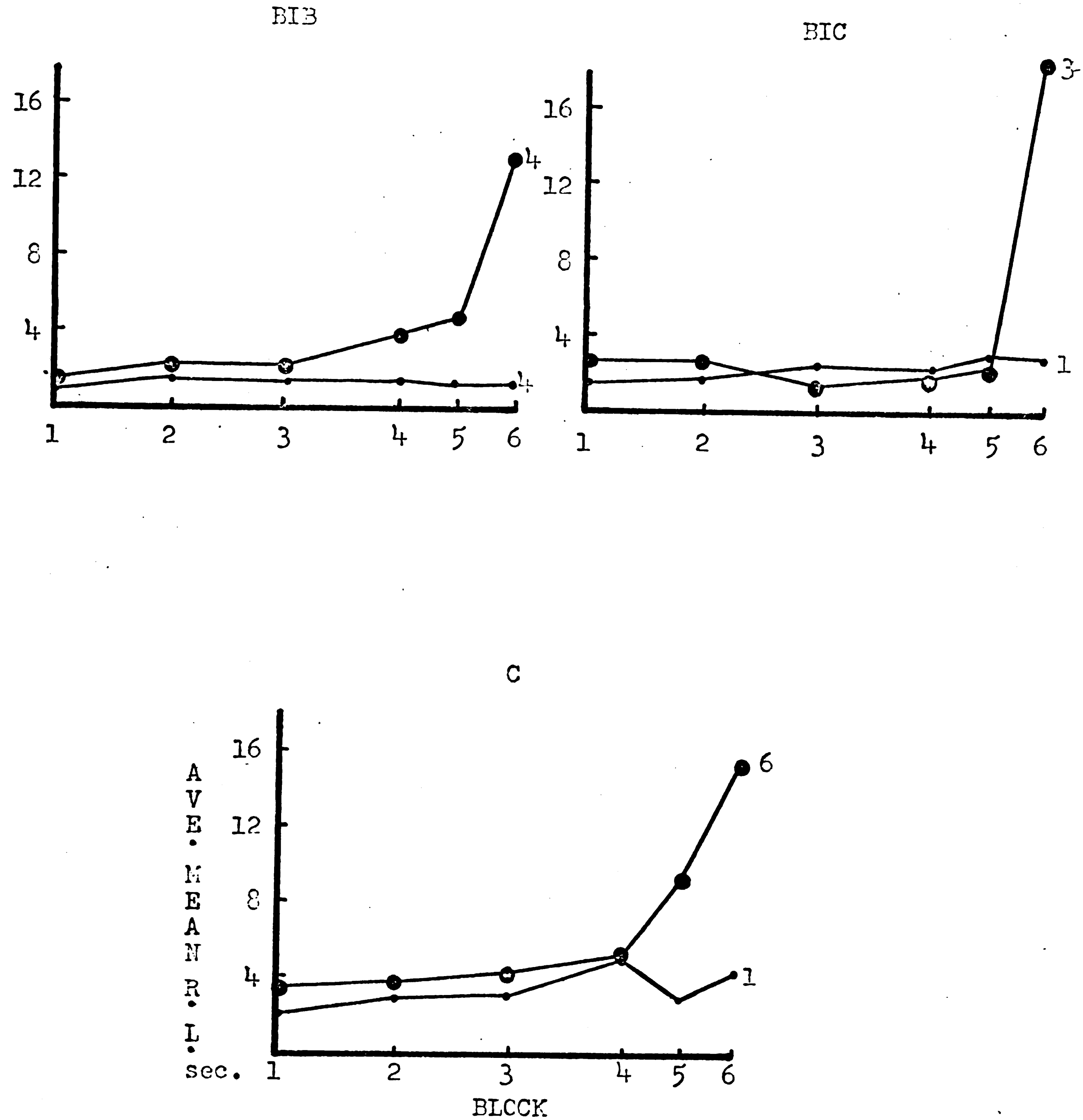

Figure 3. Continued

Figure 4 contrasts the pattern of response latencies of 17 Ss demonstrating the freeze pattern with 33 Ss demonstrating the relax pattern. Performance for the first 20% of the extinction trials is almost identical for both groups. But the differences between the two groups increase greatly as extinction progresses. The two groups differ significantly beginning with the second block of trials ($t = 2.35$, $p < .05$) and the significance of the differences increases as extinction progresses. The dichotomization between groups was based only upon the last block (10%) of the extinction latencies; a significant difference between the two process groups for the last block is guaranteed. But the significant differences for blocks 2, 3, 4, and 5 give independent support for the dichotomization of extinction processes.

A similar dichotomization could be made on the basis of standard deviations. The standard deviations of the last block of extinction trials also yield a bimodal distribution when plotted as the means were plotted in Figure 2(a). The trough between the modes is at approximately $s = 3$. A dichotomization based upon standard deviations would change the classification of 2 Ss as compared with a dichotomization based upon means. These two bases of dichotomization are only moderately independent because of a tendency for positive skewness in the latency distributions. Figure 4(b) parallels Figure 4(a) except that average standard deviations are plotted rather than means. Both figures are based upon the same Ss dichotomized in the same way. Taken together

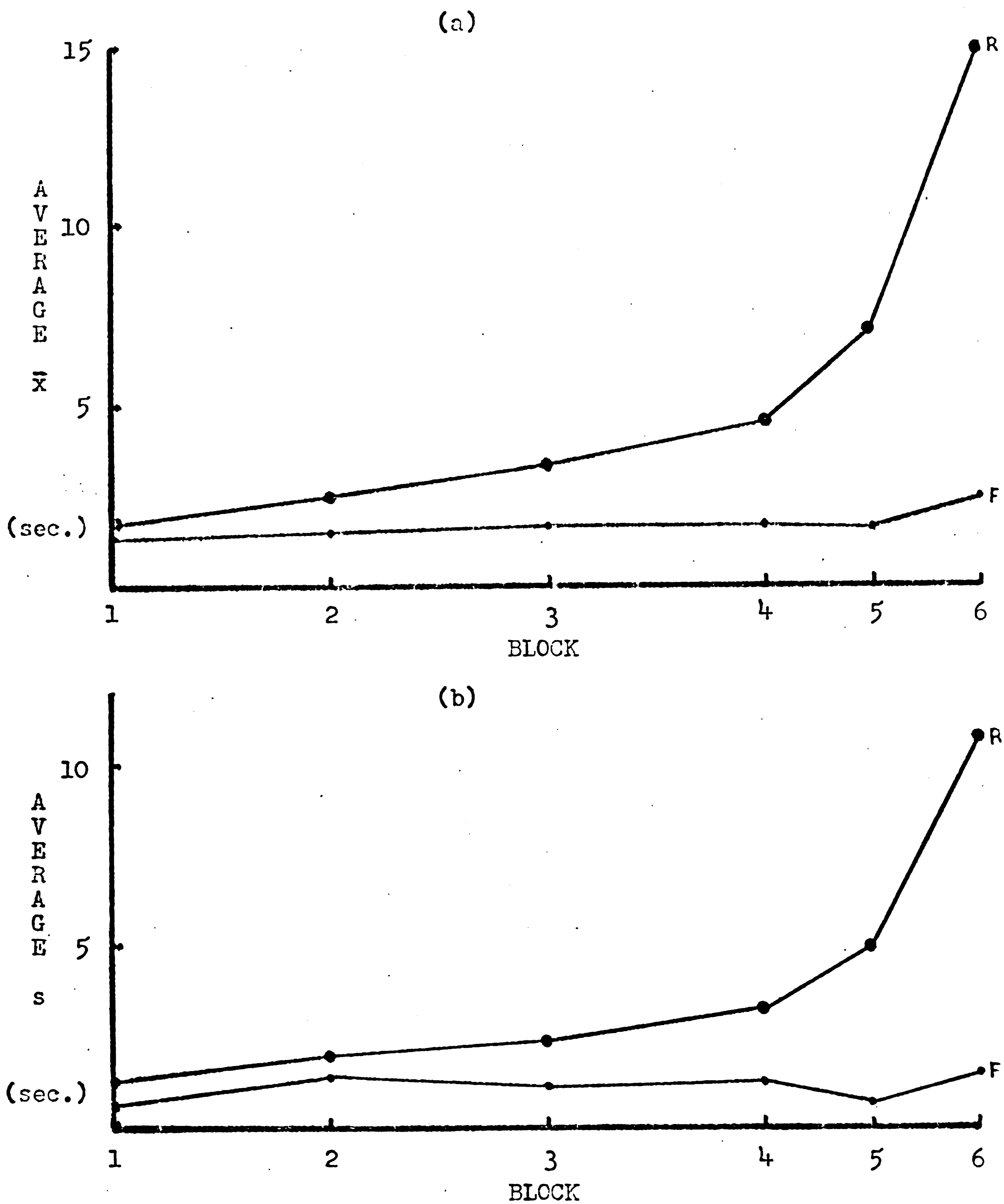

Figure 4. Freeze and Relax Extinction Process Groups Contrasted in Terms of (a) Average Mean Response Latencies and (b) Average Response Latency Standard Deviations. The upper curve in both graphs is based upon 33 relax Ss totaling 5614 response latencies. The lower curves are based upon 17 freeze Ss totaling 929 response latencies.

these figures reveal two rather distinct patterns of extinction response latencies. Some Ss respond rapidly with little variability until the extinction criterion is reached. The latencies of Ss in the relax group increase and become more variable as extinction progresses.

The correlation between the standard deviations and the means of all blocks of extinction trials for all Ss is highly significant ($r = .71$, $t = 17.3$, $p \ll .001$).

This evidence for two extinction processes provides the rationale for a re-analysis of the data dichotomized by process groups. Table 8 presents the extinction data for each group of the experiment dichotomized by process.

Table 8. Trials to Extinction - Dichotomized by Extinction Process Group

	GROUP						
	ES	ED	BES	BED	BIB	BIC	C
Freeze Group	51 53 56	50 50 51 53	43 51 54 154	102	50 52 52 54	0 0 0 0 51	3 53
Relax Group	129 183 229 339 382	52 67 70 81	338 362 468 480	102 122 127 172 213 215 218	38 55 167 251	17 48 125	62 68 83 89 120 142
$n =$	5	4	4	7	4	3	6
$\bar{x} =$	252.40	67.50	412.00	167.00	127.75	63.33	94.00
$s =$	105.93	11.96	72.42	49.83	100.13	55.61	30.90

Examination of the extinction data yields further support for the dichotomy between process groups. All 23 Ss belonging to the freeze group extinguished within six trials of the beginning of an extinction session. Only four of the 33 Ss relaxing during extinction met the criterion within six trials of the beginning of an extinction session. Chi-square for this double dichotomy contingency table is highly significant ($x^2 = 41.9$, $p \ll .001$). The Ss that freeze extinguish early in an extinction session. (Extinction for S that extinguished after 43 trials was interrupted by an electrical power failure during the 41st trial but was continued as normal on the next day.)

The Ss in the freeze group extinguish more rapidly than those in the relax group as evidenced by an over all Mann-Whitney U test ($U = 84$, $p < .001$).

The acquisition data for both process groups were searched for differences. Student's t tests were made on eight measures designed to detect differences between the freeze and relax groups during acquisition. They are:

a) Number of escape responses (shocks) made during the 12 acquisition trials;

b) Total amount of shock received during regular acquisition;

c) Average shock per escape;

d) Number of escapes in last 6 acquisition trials;

e) Trial number of first avoidance;

f) Trial number of last escape;

g) Number of reversals - a reversal defined as an escape after an avoidance or an avoidance after an escape;

h) Longest shock.

The results of these measures are presented in Table 9. As a final check for differences during acquisition the graphs in Figure 5 are presented for inspection. Groups representing the two extinction processes are compared in terms of the average avoidance latency during acquisition, trial by trial, average escape latency, trial by trial, and percentage avoiding, trial by trial.

Table 9. Acquisition Comparisons - Freeze and Relax Groups

Measure	GROUP: Freeze		GROUP: Relax
Number of Escapes	$\bar{x}$ = 5.61 s = 1.95	t = .455	$\bar{x}$ = 5.82 s = 2.16
Total Shock	$\bar{x}$ = 14.83 s = 9.32	t = .701	$\bar{x}$ = 13.25 s = 7.52
Average Shock per Escape	$\bar{x}$ = 2.77 s = 1.55	t = .255	$\bar{x}$ = 2.44 s = 1.45
Number of Escapes in Last Six Acquisition Trials	$\bar{x}$ = 1.17 s = 1.23	t = .105	$\bar{x}$ = 1.21 s = 1.45
Trial Number of First Avoidance	$\bar{x}$ = 3.52 s = 2.64	t = 2.359*	$\bar{x}$ = 5.27 s = 2.82
Trial Number of Last Escape	$\bar{x}$ = 7.48 s = 2.57	t = .652	$\bar{x}$ = 7.06 s = 2.56
Number of Reversals	$\bar{x}$ = 2.96 s = 1.77	t = 1.455	$\bar{x}$ = 2.33 s = 1.45
Longest Shock	$\bar{x}$ = 8.08 s = 5.86	t = .683	$\bar{x}$ = 7.03 s = 5.52

*$p < .05$

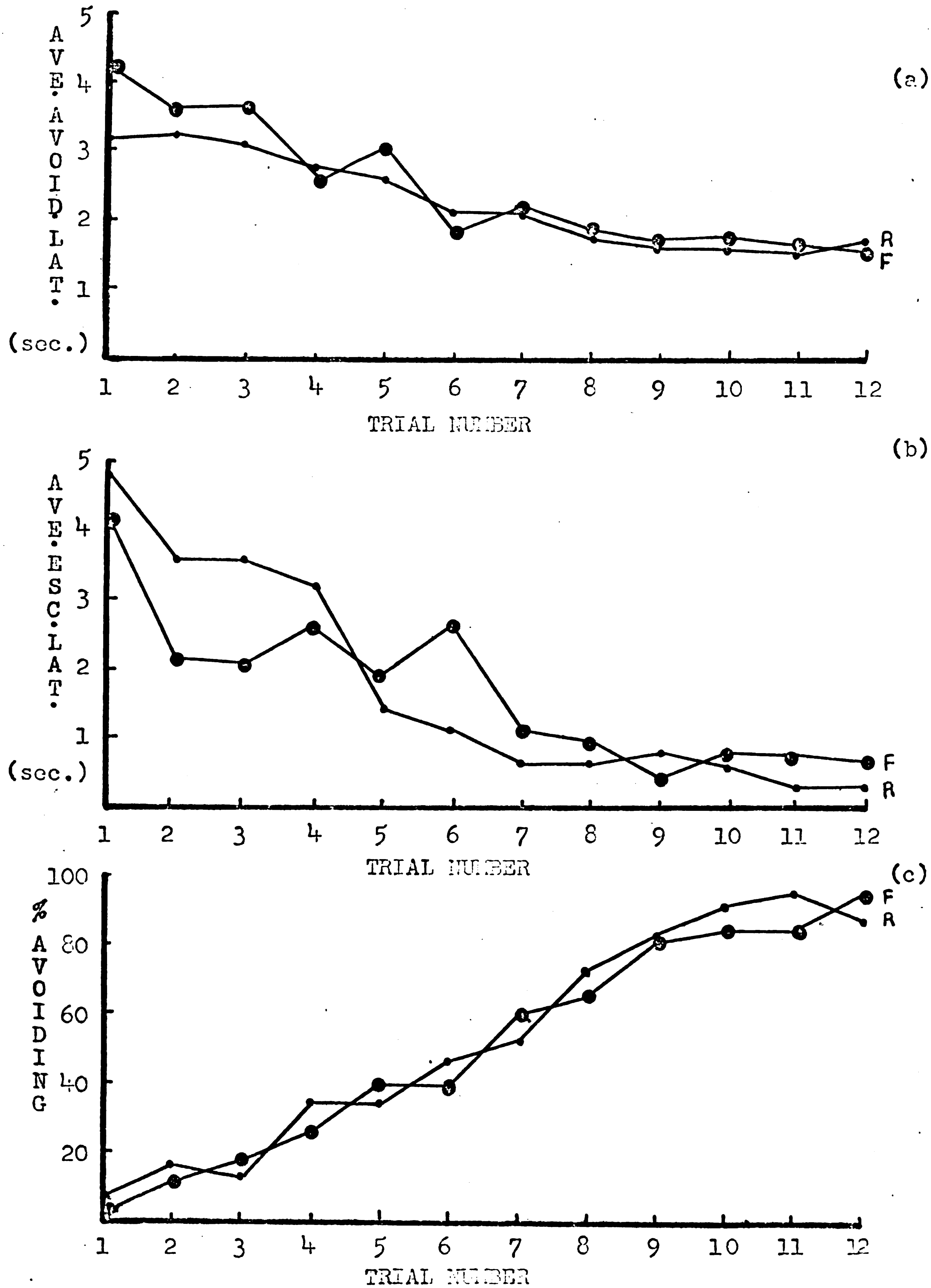

Figure 5.. Relax and Freeze Groups Compared Trial by Trial in Terms of (a) Average Avoidance Latency, (b) Average Escape Latency and (c) Percentage Avoiding During Acquisition.

No over-all measure of learning detects a reliable difference between the acquisition behavior of Ss that freeze and Ss that relax during extinction. The Ss that freeze make their first avoidance sooner although they do not make more avoidances during acquisition. The Ss in the freeze group also tend to take longer to escape on trials 2 and 3 ($t = 1.95$, $p < .10$ and $t = 1.69$, $p < .10$, respectively).

When only Ss in the relax group are considered, the variances of the experimental and control groups are sufficiently homogeneous to justify a parametric analysis ($C = .338$, $p > .05$). Table 10 presents the results of a one-way analysis of variance for the six experimental groups and the control group. The effect of treatments for the group relaxing during extinction is highly significant ($F = 14.30$, $df = 6/26$, $p < .01$).

Table 10. ANOVA: Trials to Extinction - Relax Group Only

SOURCE	SS	df	MS	F
Between	386221.90	6	64370.32	14.299*
Within	117037.62	26	4501.45	
Total	503259.52	32		

$^{*}F_{.99}(6,26) = 3.59$

Individual comparisons were made with the Tukey (a) procedure (Winer, 1962). The differences between the means of all groups and their significance are presented in Table 11. Certain theoretically meaningful multiple comparisons were also made.

Table 11. Individual Comparisons - Relax Group Only

Group	BIC	ED	C	BIB	BED	ES	BES
Mean	63.33	67.50	94.00	127.75	167.00	252.40	412.00
BIC		4.17	30.67	64.42	103.67	189.07**	348.67**
ED			26.50	60.25	99.50	184.90**	344.50**
C				33.75	73.00	158.40*	318.00**
BIB					39.25	124.65	284.25**
BED						85.40	245.00**
ES							160.00*

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

The following conclusions are based upon comparisons of groups of Ss that relax during extinction.

The multiple comparison between the two groups receiving inescapable shock and the group trained under similar conditions but receiving escapable shock is significant ($p < .01$) with escapable shock increasing resistance to extinction (BIC & BIB vs. BES). The Ss trained with a blind and escaping to a similar area are far more resistant to extinction than an S receiving inescapable shock (BES vs. BIB; BES vs. BIC). This effect is less pronounced when the blind is not present (ES vs. BIB; ES vs. BIC).

Method of getting Ss from the shock area to the safe area after inescapable shock has no effect on resistance to extinction (BIB vs. BIC). Neither of these groups differed from the control (BIC vs. C; BIB vs. C).

Conditions in the safe area after escape from interpolated shock have an effect on resistance to extinction. The Ss escaping to a safe area similar to the shock area are more resistant to extinction than those escaping to a different safe area (ES & BES vs. ED & BED). Both groups escaping to a similar safe area are more resistant to extinction than a control group that received no additional shock after regular acquisition (ES vs. C; BED vs. C). The Ss escaping to a different area without a blind are far less resistant to extinction than those escaping to a similar area with a blind (ED vs. BES).

There is a tendency for the presence of the blind to increase resistance to extinction but the over-all effect does not reach significance in this analysis (ES & ED vs. BES & BED). The blind increases resistance to extinction when Ss escape to a similar chamber (ES vs. BES). When they escape to a different chamber, the effect is not significant even though the groups do not overlap and are separated by 21 trials (ED vs. BED).

In order to explore the variables of blind and safe area conditions still further, a two-way analysis of variance was performed on these groups alone using the harmonic mean (Winer, 1962). The results of this analysis are presented in Table 12.

Table 12. ANOVA: Blind and Conditions in Safe - Relax Group Only

Source	SS	df	MS	F
Conditions in Safe	219466.64	1	219466.64	46.24*
Blind	79720.21	1	79720.21	16.79*
Conditions X Blind	903.00	1	903.00	.19
Error	75948.20	16	4746.76	
Total	376038.05	19		

$^*F_{.99}(1,16) = 8.53$

The variables of condition in safe area after interpolated shock and presence or absence of a blind are highly significant. Interaction between the variables is negligible.

All individual comparisons are significant beyond the .01 level except one comparison (ES vs. BED) which is significant at the .05 level. These comparisons indicate that conditions in the safe area are a more important variable than the presence of a blind and that the effects of treatments are additive.

Discussion

The design of this experiment rests upon an assumption; namely, that number of trials to extinction constitutes a unitary measure of the effectiveness of certain treatments on the acquisition and extinction of an avoidance response. Thorough analysis of extinction response latencies suggests that this assumption is unwarranted.

A dichotomization of Ss based upon the last block (10%) of extinction response latencies identifies significant differences in the mean response latencies of blocks 2, 3, 4 and 5. A moderately independent measure, response variability, yields an almost identical pattern of differences between the dichotomized groups. The Ss in the freeze group are almost sure to extinguish during the first few trials of an extinction session. The Ss in the relax group extinguish any time during an extinction session. The Ss that freeze extinguish faster. Thus, there is good evidence for two different extinction processes.

These different extinction processes are probably influenced by different variables and by the same variables in different ways. These results indicate that when a prediction is being made about the effect of a treatment on the resistance to extinction of an avoidance response it is important to specify the extinction process involved. For example, it would be inappropriate to test an hypothesis about relaxation during extinction with Ss that freeze during extinction. Yet the hypothesis may receive firm support when only Ss from the relax group are considered.

These data suggest that need for isolating and controling the variables that determine which extinction process will be operative for a given S or at least a provision in the design of an experiment to treat the freeze and relax groups separately.

At least one S in each experimental and the control group showed the freeze pattern during extinction. This suggests that no specific aspect of the treatment conditions can be identified as the determinant of which extinction process will be operative for a given S. No systematic differences marked the pre-experimental history of Ss. Thus, genetic variables are suggested.

The suggestion of two extinction processes is not disparate with published findings on genetic differences in emotional reactivity, the effect of reactivity on avoidance performance, the facilitating effect of electroconvulsive shock on avoidance performance, and the Kamin effect.

Emotionally reactive and emotionally non-reactive strains of rats have been bred on the basis of defecation scores on a version of Hall's open-field test (Broadhurst, 1960). Bignami (1965) has been successful in selectively breeding rats specifically for high and low rates of avoidance conditioning.

Owen (1963), using Ss from the strains developed by Broadhurst found that non-reactives learned avoidance more efficiently as measured by the number of trials needed to extinguish. Joffe (1964) found this effect to continue over a long period of time. Broadhurst and Levine (1963) also tested rats of these two strains in an avoidance situation. The Ss of the reactive strain showed superior conditioning of emotional responses, as measured by frequency of defecation, but learned to avoid less efficiently than non-reactives. These researchers suggested that freezing to shock and the CS interferes with efficient avoidance responding - especially for reactives.

While studying performance decrement at high levels of motivation Kaplan, Kaplan and Walker (1960) observed wide individual differences in the behavior of rats in a T maze with a grid floor. Fixated behavior was associated with high emotionality.

Reynierse, Zerbolio and Denny (1964) studied the decrease in avoidance responding with continued training. Two groups were observed - decrementers and non-decrementers. Decrementers showed an increased tendency to freeze after continued training in a fear arousing situation.

Genetic differences in emotionality are well established. Reactive Ss do more poorly in an avoidance learning situation - a decrement frequently associated with freezing or some type of fixated behavior.

Electroconvulsive shock has been found to facilitate shuttle box performance (Vanderwolf, 1963). Vanderwolf suggests that a series of convulsions damages the neural system underlying freezing behavior facilitating the acquisition of avoidance responding. Evidence supporting the mechanism is cited.

Delprato (1966) found that Ss receiving 16 electroconvulsive shocks were inferior in inhibiting a previously learned avoidance response. Again, the effect was explained in terms of impairment of a neural mechanism underlying freezing behavior.

Cassaday (1966) found that this effect was not caused by the fear arousing properties of ECS. Rats which received ECS 10 sec. after grid shock learned an avoidance response more efficiently than Ss which received only grid shock or only ECS.

Out of 23 Ss constituting the freeze process group of the experiment here reported, 16 froze at the beginning of the second extinction session - approximately 24 hours after training. The timing of the appearance of the freeze reaction needs to be explained.

Relearning of a partially learned avoidance response has been found to be a U shaped function of intertraining interval. This phenomenon has been labled the "Kamin effect" and has been reliably observed (Kamin, 1957; Denny, 1958; Denny, 1962).

Brush (1964a) studied the joint effects of intertrial and intercession interval upon relearning a partially learned avoidance response with particular emphasis on the first 10 relearning trials. He found maximum interference for Ss trained with a 30 sec. ITI after an intercession interval of 24 hours - exactly the conditions of this experiment.

In another series of experiments, Brush (1964b) found that the fear component of original training is the necessary and sufficient condition to produce the U shaped function of the Kamin effect.

The Kamin effect, the effect of ECS on avoidance performance, freezing and emotionality have all invited explanations in terms of the autonomic nervous system. Brush (1963) suggests that a parasympathetic over-reaction follows fear conditioning and that this renders a S ill-equiped to relearn the avoidance response when the over-reaction is at a peak. He also cites evidence on the relationship of fear conditioning, parasympathetic over-reaction and ulcer formation to support the suggestion.

Using injections of adrenaline, a placebo and chloropromazine to obtain descending levels of sympathetic activation, Singer (1963) measured manifestations of fright in a fear and a non-fear situation. The reliable ($r = .92$) measures of fear effectively discriminated the fear from non-fear situations. Singer concluded that amount of emotional behavior is a direct function of the degree of sympathetic activity.

Doyle and Yule (1959) studied freezing behavior and grooming activities in relation to emotionality. Freezing was found to be a valid measure of emotionality in the rat but no correlation was found between grooming activities and emotionality.

The extensive studies by Gellhorn (1957) on the autonomic system of the cat help connect these diverse strands of evidence into an explanation of the appearance and timing of freezing behavior during the extinction of an avoidance response. Gellhorn observed two types of after-effects following stimulation of the sympathetic nervous system.

First, there may be a persistence of sympathetic discharge which reaches a peak after the cessation of stimulation. Second, and most important here, a sudden change from sympathetic to parasympathetic discharge may be observed after sympathetic stimulation. This "parasympathetic after-discharge, referred to as successive autonomic induction, increases with increased effectiveness of the preceding sympathetic stimulation..." (p. 72). Also, Gellhorn found that the "law of reciprocal innervation remains valid in states of a reflexly altered imbalance of the autonomic system" (p. 262) although sympathetic activity may dominate one organ system or set of sturctures while simultaneous parasympathetic activity dominates another. In these studies, stimulation of the sciatic nerve was frequently used to induce the parasympathetic reflex. This fact may clarify the relationship between freezing and parasympathetic activity.

It thus appears that animals which freeze during extinction are emotionally reactive. These Ss apparently made a stronger sympathetic response to training and showed a greater parasympathetic rebound during extinction. Such a rebound became evident in the form of freezing behavior at the beginning of an extinction session.

These ideas are readily testable. The Kamin effect should be more pronounced for emotionally reactive Ss and should be reduced or eliminated by electroconvulsive shock.

Experiment 1 demonstrated that the presence of an escape contingency had no effect on the acquisition or extinction of an avoidance response. But the effect of the escape variable is clearly evident in Experiment 2 even before freeze and relax groups are separated. Here, Ss permitted to escape interpolated shock are more resistant to extinction. These results appear contradictory, but the experimental situations are also different.

In Experiment 1 escape was consistently prevented during acquisition. In Experiment 2, two inescapable shock trials followed regular acquisition. In both cases, escape was blocked. But only Ss in Experiment 2 were blocked from escape after, presumably, learning the escape response. The interpolated shock treatment represents a change in conditions that could facilitate the discrimination of the acquisition and extinction phases of training and thus speed extinction.

The Ss of the relax group receiving inescapable interpolated shock do not differ in resistance to extinction when compared with no shock controls. When escape is prevented, additional shock does not strengthen the avoidance response. When Ss of the freeze group are included in this comparison additional shock has no effect on boosted Ss. But additional shock decreases resistance to extinction of Ss carried into the safe area. It is noteworthy that all four Ss freezing during the first extinction trial are from this group. It is suggested that additional inescapable shock increases fear without strengthing the avoidance response.

The Ss boosted to safety after inescapable shock are more resistant to extinction than Ss carried to safety. The significance of this difference is due mainly to the four carried-Ss that froze during the very first extinction trial. When only relax-Ss are considered, this comparison does not yield a significant difference, but the four boosted-Ss did require, on the average, twice as many trials to extinguish as the three carried-Ss. Thus, these findings seem to suggest that the failure to find a significant effect from the escape variable in Experiment 1 can, in part at least, be explained in terms of the method of transferring Ss to the safe area following inescapable shock.

Conditions in the safe area following interpolated shock have an effect on resistance to extinction which is even more evident when only Ss that relax during extinction are compared. Escape to an area similar to the shock area and familiar from previous training consistently produces greater resistance to extinction than escape to a different area. When only Ss that relax are considered, interpolated shock increases resistance to extinction only when escape is to an area similar to the shock area. Since this effect was demonstrated even when line of sight from shock to safe areas was blocked, it seems necessary to offer an explanation in terms of what happens to Ss while in the safe area.

At first sight, these results appear to be inconsistent with those obtained by Denny, Koons and Mason (1959) and

Knapp (1965). Both of these studies report more rapid extinction of an avoidance response when shock and safe areas are similar than when these areas are different. This effect is explained by the authors in terms of elicitation theory (Denny & Adelman, 1955). According to this theory, relaxation provides the main competing response for extinguishing avoidance. The results of the studies mentioned above are explained if it is assumed that relaxation, which occurs in the safe area, chains back more rapidly when shock and safe areas are similar than when they are different. Relaxation in the shock area interferes with avoidance responding. This theoretical position receives additional empirical support (Weisman, Denny, Platt & Zerbolio, 1966; Denny & Weisman, 1964).

In the present study, extinction was prolonged when shock and safe areas were similar. It thus appears that fear generalizing from the shock area to the safe area interferes with the development of the relaxation needed to extinguish the avoidance response. Comparison of the different experimental situations in these studies makes this interpretation reasonable. Conditions in both the Denny, Koons and Mason (1959) study and the Knapp (1965) study favor the development of moderate fear and considerable relaxation when compared with the conditions of the present study. The Ss in the present study received more shocks during acquisition and had far less time to relax in the safe area.

It is suggested that two processes may be operative in avoidance conditioning when similarity of shock and safe areas is a variable. Relaxation, associated with cues in the safe area, may chain back to speed extinction. And fear, associated with cues in the shock area, may generalize to the safe area and retard extinction. Both processes depend on relaxation even though they have an opposite effect on rate of extinction of an avoidance response. The learning situation determines which process predominates.

It could also be suggested that escape to a different area interpolated between acquisition and extinction would facilitate the discrimination of the two phases of learning and speed extinction.

The presence of a blind tended to increase resistance to extinction. This effect can be expected if the opportunity to observe distinctive aspects of the safe area facilitates the back-chaining of relaxation. It is also possible that the effect of the blind may be a reflection of a fearful rat's preference for a restricted area. Several Ss repeatedly placed their heads under the blind after escape and were difficult to remove from the apparatus. The Ss frequently pressed their heads into a corner of the apparatus especially during the early stages of training and extinction.

SUMMARY

The role of an escape contingency on behavior under aversive control is not clear. A number of studies suggest that aversive events which are response terminated are less aversive than those from which escape is prevented.

Experiment 1 demonstrated that hooded rats trained to avoid shock in a one-way box under conditions of no escape showed the same resistance to extinction as Ss allowed to escape during training. These results are not readily interpretable because of a possible effect of method of transferring Ss from the shock area to the safe area following the aversive US.

In Experiment 2 several treatments were interpolated between the acquisition and extinction phase of avoidance learning. The treatment variables yielded results that can be summarized as follows:

1. Interpolated escapable shock increases resistance to extinction more than the same amount of inescapable shock;
2. Method of transferring Ss from the shock area to the safe area following inescapable shock has an effect that could account for the negative results of Experiment 1;

3. In general, resistance to extinction is greater when conditions in the shock and the safe areas are similar during interpolated shock than when they are different;

4. In general, resistance to extinction is increased when line of sight from shock to safe areas is blocked.

An analysis of response latencies for trials during extinction suggests that all Ss can be classified into one of two extinction process groups. Some Ss consistently respond rapidly until the extinction criterion is reached and extinguish during the first few trials of an extinction session. These Ss are identified as belonging to the freeze group. The extinction response latencies of Ss identified as belonging to the relax group respond less rapidly and with greater variability as extinction progresses. These Ss are likely to extinguish at any time during an extinction session.

Thus, the assumption that number of trials to extinction of an avoidance response constitutes a unitary measure of the effectiveness of certain treatments on the acquisition and extinction of that response is untenable. In the experimental analysis of avoidance learning it is important to remember that treatment variables may have effects that are process specific.

BIBLIOGRAPHY

Bignami, G. Selection for high rates and low rates of avoidance conditioning in the rat. Anim. Behav., 1965, 13, 221-227.

Brimer, C. J., & Kamin, L. J. Fear of the CS in avoidance training and fear from a sense of helplessness. Canad. J. Psychol., 1963, 17, 188-193.

Broadhurst, P. L. Experiments in psychogenetics: Application of biometrical genetics to the inheritance of behaviour. In H. J. Eysenck (Ed.), Experiments in Personality, Vol. 1: Psychogenetics and Psychopharmacology. London: Routledge & Kegan Paul, 1960, 1-102.

Broadhurst, P. L., & Levine, S. Behavioral consistency in strains of rats selectively bred for emotional elimination. Brit. J. Psychol., 1963, 54, 121-125.

Brush, R. F., Myer, J. S., & Palmer, M. E. Effects of kind of prior training and intersession interval upon subsequent avoidance learning. J. comp. physiol. Psychol., 1963, 56, 539-454.

Brush, R. F., Myer, J. S., & Palmer, M. E. Joint effects of intertrial and intersession interval upon avoidance learning. Psychol. Rep., 1964, 14, 31-37.

Brush, R. F. Avoidance learning as a function of time after fear conditioning and unsignalled shock. Psychon. Sci., 1964, 1, 405-406.

Casseday, J. H. Retroactive facilitative effects of ECS on learning an avoidance response in a two-choice situation. Psychon. Sci., 1966, 4, 19-20.

Delprato, Dennis J. Effects of electroconvulsive shock on inhibition of an active avoidance responsive. Psychon. Sci., 1966, 4, 15-16.

Denny, M. R., & Adelman, H. M. Elicitation theory: I. An analysis of two typical learning situations. Psychol. Rev., 1955, 62, 290-296.

Denny, M. R. The "Kamin Effect" in avoidance conditioning. Amer. Psychologist, 1958, 13, 419. (Abstract)

Denny, M. R., Koons, P. B., & Mason, J. E. Extinction of avoidance as a function of the escape situation. _J. comp. physiol. Psychol._, 1959, _52_, 212-216.

Denny, M. R., & Ditchman, R. E. The locus of maximal "Kamin Effect" in rats. _J. comp. physiol. Psychol._, 1962, _55_, 1069-1070.

Denny, M. R. & Weisman, R. G. Avoidance behavior as a function of length of nonshock confinement. _J. comp. physiol. Psychol._, 1964, _58_, 252-257.

Doyle, G., & Yule, E. P. Grooming activities and freezing behaviour in relation to emotionality in albino rats. _Anim. Behav._, 1959, _7_, 12-18.

Gellhorn, E. _Autonomic Imbalance and the Hypothalamus._ London: Oxford University Press, 1957.

Joffe, J. M. Avoidance learning and failure to learn in two strains of rats selectively bred for emotionality. _Psychon. Sci._, 1964, _1_, 185-186.

Kamin, L. J. The retention of an incompletely learned avoidance response. _J. comp. physiol. Psychol._, 1957, _50_, 457-460.

Kaplan, R., Kaplan, S., & Walker, E. L. Individual differences in learning as a function of shock level. _J. exp. Psychol._, 1960, _60_, 404-407.

Knapp, R. K. Acquisition and extinction of avoidance with similar and different shock and escape situations. _J. comp. physiol. Psychol._, 1965, _60_, 272-273.

Leitenberg, H. Punishment training with and without an escape contingency. _J. exp. Psychol._, 1967, _74_, 393-399.

Marx, M. H., & Hellwig, L. R. Acquisition and extinction of avoidance conditioning without escape responses. _J. comp. physiol. Psychol._, 1964, _58_, 451-452.

Mowrer, O. H., & Viek, P. An experimental analogue of fear from a sense of helplessness. _J. abnorm. soc. Psychol._, 1948, _43_, 193-200.

Owen, S. The effect on avoidance response extinction in rats of CS continuation and emotional constitution. _J. genet. Psychol._, 1963, _103_, 147-151.

Reynierse, J. H., Zerbolio, D. J., & Denny, M. R. Avoidance decrement: Replication and further analysis. _Psychon. Sci._, 1964, _1_, 401-402.

Siegel, S. _Nonparametric statistics for the behavioral sciences._ New York: McGraw-Hill, 1956.

Singer, J. E. Sympathetic activation, drugs, and fear. _J. comp. physiol. Psychol._, 1963, _56_, 612-615.

Vanderwolf, C. H. Improved shuttle-box performance following electroconvulsive shock. _J. comp. physiol. Psychol._, 1963, _56_, 983-986.

Weisman, R. G., Denny, M. R., Platt, S. A., & Zerbolio, D. J., Jr. The facilitation of extinction by a stimulus associated with long nonshock confinement periods. _J. comp. physiol. Psychol._, 1966, _62_, 26-30.

Winer, B. J. _Statistical principles of experimental design._ New York: McGraw-Hill, 1962.