Fall 1971

State-Dependent Learning as a Function of the Temporal Relationship between Noncontingent Footshock and Electroconvulsive Shock

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STATE-DEPENDENT LEARNING AS A FUNCTION OF THE TEMPORAL RELATIONSHIP BETWEEN NONCONTINGENT FOOTSHOCK AND ELECTROCONVULSIVE SHOCK

A Thesis

Presented to

the Graduate Faculty

Central Washington State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

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October 1971

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Rats were given a noncontingent footshock followed at various intervals by electroconvulsive shock. Twenty-four hours later they were trained on a non-shock passive avoidance task and tested for retention 72 hours later. When the interval between NCFS and ECS was short the animals showed an amnesia which reduced as the interval was lengthened. An interval of .5 seconds produced the most pronounced amnesia and intervals greater than 10 seconds produced virtually no amnesia. The results were consistent with a state dependent retrieval failure hypothesis.

ACKNOWLEDGEMENTS

The author would like to express his gratitude to Dr. V. Gerald Reed and Dr. Donald E. Guy for their assistance with his thesis. He would like especially to thank Dr. Terry L. DeVietti for his constant assistance and patience during the past two years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Electroconvulsive shock (ECS) has been shown to cause a performance decrement when it is administered within a short period following a learning situation in both appetitive (Pinel, 1969) and avoidance tasks (e.g. Chorover & Schiller, 1965; King, 1965). The most efficient method of producing this decrement has been obtained when a foot-shock (FS) has been used in the training and ECS is given immediately afterward (Chorover & Schiller, 1965). The explanation for this decrement has taken various forms, of which two hypotheses are the consolidation interpretation and the state dependent interpretation.

According to the consolidation hypothesis (McGaugh, 1966), a period of time following a learning trial is necessary for the consolidation (fixation) of the memory trace. When electroconvulsive shock is administered after the learning situation the consolidation process is presumably blocked and a performance decrement occurs when the subject is tested later. As the interval between the learning situation and the administration of ECS is lengthened, the amnestic effect of ECS is reduced due to proportionately greater consolidation (Chorover & Schiller, 1965, 1966; Quartermain, Paolino & Miller, 1965).

According to the state dependency hypothesis (e.g. Nielson, 1968), the observed decrement in performance results because ECS given immediately after the training trial alters the "state" of the organism such that memories cannot be retrieved. Thus, resulting in a performance decrement. However, he argues that there is no interference with memory consolidation, per se. In support of this hypothesis several studies (Kohlnberg & Trabasso, 1968; Pagano, Bush, Martin & Hunt, 1969; Zinkin & Miller, 1967) have shown a recovery of memory after an initial amnesia produced by ECS. The cause of the initial amnesia, i.e., disruption of fixation or retrieval processes, is difficult to interpret because the state dependent hypothesis and the consolidation hypothesis make the same predictions at the 24 hour test when the ECS follows a training trial FS. However, since memory recovered, the effect of the ECS would seem to be due to retrieval failure. DeVietti and Larson (1971) demonstrated that paired NCFS and ECS appear to produce an amnestic effect when tested 24 hours but not 96 hours after NCFS and ECS, even though the NCFS-ECS treatment was not administered in the original training apparatus. The explanation for this phenomenon according to the state dependent hypothesis is that the subjects were not able to retrieve the memory 24 hours after NCFS-ECS

because they were in a different state. However, at the 96 hour test the subjects had returned to their normal state and were therefore able to remember the training. These results would seem difficult to explain by the consolidation hypothesis.

In some of the previous studies (Chorover & Schiller, 1965; King, 1965) the administration of FS is characteristic in the training trial but it becomes confounded with the ECS treatment since the ECS follows the FS so closely and the attenuated performance could have been an effect of the ECS or it could have been the effect of the interaction of the FS and ECS. DeVietti and Larson (1971) have shown that a NCFS-ECS administered 24 hours after training can produce the same effect as the ECS given immediately after the training trial. They also showed that an ECS given 24 hours after the training trial had no effect upon retention, thus suggesting that the NCFS and ECS combination is very important.

The temporal interval between the FS and ECS seems to be of prime importance; when the usual interval, i.e., the time between footshock received during training and administration of ECS, is extended, a reduction in the amnestic effects due to the administration of the ECS results (Chorover & Schiller, 1965). This gradient is usually taken to mean that successively more memory is

fixed prior to disruption by a delayed ECS and is therefore consistent with the consolidation hypothesis of ECS effects. Thus, the existence of the "gradient" is one of the prime effects cited to support the consolidation hypothesis.

The purpose of this study was to investigate the possibility of producing the gradient by varying the interval between the NCFS and the ECS when the NCFS-ECS combination is not given immediately following the training period.

CHAPTER II

METHOD

First Attempt

The first attempt to produce the state dependent gradient followed the design of the experiment by DeVietti and Larson (1971). The animals were water deprived and were allowed to receive water in a special drinking chamber for fifty-five seconds on two consecutive days. On the third day, the water was unavailable and the subject heard a tone (CS) and received a FS (UCS) to produce a conditioned emotional response (CER). Twenty-four hours later the subject received a NCFS and .5, 10, 60, or 300 seconds later received ECS. Twenty-four hours after the NCFS-ECS the subject was placed back into the drinking chamber and after fifty seconds of drinking (100 licks) the tone was presented and the time it took the animal to begin drinking for another five seconds (10 licks) was recorded. The same procedure was followed 96 hours after the NCFS-ECS treatment. The rational behind this was that if the animal remembered the conditioning on the 24 hour test, he would suppress his drinking, if not, he would continue drinking. At the 96 hour test the same holds true with the exception of those that remembered at 24 hours should have shorter latencies because the first trial would serve as an extinction trial. The problem that became

apparent with this design was that the control animals (NCFS only), i.e., those that did not receive ECS, did not show conditioning. In the DeVietti and Larson study, the 10 lick measure of the control group had a mean lick latency of around 600 seconds. Table 1 shows that the comparable control group had a mean lick latency of around 250 seconds and a great deal of variability was also present. Therefore, it was difficult to interpret the effect of the NCFS-ECS because there was no effective control group for comparison.

Second Attempt

In the second attempt, an effort was made to solve this problem by using the tone as an arousal factor rather than the FS because it was thought that the second FS (NCFS) may have somehow served to disinhibit drink suppression. The method was based on work done by Misanin, Miller & Lewis (1968) in which they used a previously conditioned stimulus to reactivate a memory trace. The procedure was generally the same as the first attempt. The animal was conditioned using the tone and FS, but on the ECS treatment day the animal was placed in the drinking chamber with the water bottle removed, the walls were black and the chamber was illuminated by a red light. The animal was placed in the box and five minutes later heard the tone and received ECS at the appropriate interval afterward. The tone should have had the same effect

TABLE 1

DATA FROM FIRST ATTEMPT

100 licks (in seconds)

Treatment

NCFS-ECS .5			NCFS-ECS 10			NCFS-ECS 60			NCFS-ECS 300			NCFS ONLY		
S	24	96	S	24	96	S	24	96	S	24	96	S	24	96
102	409	107	96	225	80	94	1009	283	91	322	264	100	651	251
107	698	122	99	629	210	101	472	91	93	235	234	108	836	212
109	1168	406	104	176	261	105	873	243	98	153	276	92	688	365
113	2874	1962	110	621	274	106	1039	154	103	1147	184	135	303	100
117	978	253	122	682	236	114	1457	184	118	708	105	116	304	223
132	3289	917	123	475	212	115	488	182	126	465	487	121	885	269
133	143	120	129	2942	249	127	2240	420	131	536	56	130	2062	241
136	2056	231				142	405	126	138	948	114	137	385	189
140	2227	196							143	96	184	139	270	134
144	700	315										97	768	482
												128	466	228
												95	797	439
												141	154	117

TABLE 1 (continued)

10 licks (in seconds)

Treatment														
NCFS-ECS .5			NCFS-ECS 10			NCFS-ECS 60			NCFS-ECS 300			NCFS ONLY		
S	24	96	S	24	96	S	24	96	S	24	96	S	24	96
102	160	175	96	81	44	94	200	90	91	119	65	100	48	68
107	20	74	99	375	14	101	105	17	93	115	33	108	230	80
109	900+	148	104	552	18	105	308	106	98	26	93	92	14	16
113	300+	1188	110	30	149	106	161	56	103	36	15	135	70	301
117	280	267	122	61	217	114	23	174	118	211	31	116	11	131
132	500+	137	123	8	5	115	48	33	126	296	92	121	456	112
133	29	78	129	85	121	127	346	325	131	19	15	130	42	35
136	400+	144				142	543	60	138	10	57	137	121	41
140	157	108							143	87	51	139	77	167
144	238	78										97	882	110
												128	50	14
												95	900+	19
												141	297	59

as the FS to arouse the animal and interact with the ECS. The control animals (CS only) still failed to condition as Table 2 indicates; therefore, no conclusions could be drawn from the data.

Third Attempt

Since the previous two methods had failed to produce conditioning, a different approach was utilized. If the NCFS-ECS does produce a different state, then it would seem plausible that the state could be induced prior to training as well as after training. The existence of the state could be demonstrated by training the subject after induction of the state and testing for amnestic effects after the state has dissipated. If the subject remembers the training then there is no retrieval problem, but if the animal fails to remember then the state dependent notion is supported. Still using the lick latency task the animals were given a NCFS-ECS treatment 24 hours prior to the CER conditioning which consisted of pairing a tone with a FS. The animals were then tested 96 hours after their treatment. The subjects still failed to condition as evidenced in Table 3 by the NCFS only group, so a new task, not involving a FS as part of the conditioning procedure, was introduced because the problem seemed to center around the shock source in the training apparatus. Otherwise, the same rationale as outlined above in "third attempt" prevailed.

TABLE 2

DATA FROM SECOND ATTEMPT

100 licks (in seconds)

Treatment

CS-ECS .5			CS-ECS 10			CS-ECS 60			CS-ECS 300			CS ONLY		
S	24	96	S	24	96	S	24	96	S	24	96	S	24	96
165	309	364	167	1122	303	166	157	241	170	608	59	172	905	138
180	1338	254	171	135	61	168	766	218	173	172	287	192	73	60
188	115	282	176	865	499	177	823	555	184	63	87	182	564	291
191	1178	470	187	342	198	181	268	56	203	57	236	179	448	284
198	286	72	196	409	71	197	439	302	208	238	73	189	59	43
199	339	4059	202	961	149	195	103	331	205	594	66	183	1090	424
201	2465	330	193	2376	758	190	470	161	175	990	213	200	1193	165
169	1451	470				186	206	53				194	637	236
						185	155	453						

10 licks (in seconds)

165	31	61	167	724	444	166	411	320	170	65	15	172	198	179
180	800+	165	171	707	215	168	1264	612	173	41	300	192	50	13
188	150	56	176	167	264	177	550	174	184	8	14	182	45	140
191	263	457	187	287	397	181	236	66	203	28	115	179	45	16
198	77	8	196	147	111	197	35	8	208	11	140	189	276	305
199	106	18	202	235	213	195	1800+	72	205	4	45	183	698	200
201	900+	762	193	1500+	114	190	72	259	175	964	138	200	40	278
169	667	609				186	765	23				194	31	38
						185	171	42						

TABLE 3

DATA FROM THIRD ATTEMPT (IN SECONDS)

Treatment								
NCFS-ECS .5			NCFS-ECS 10			NCFS-ECS 60		
S	100	10	S	100	10	S	100	10
212	884	168	213	211	393	211	426	32
218	347	319	215	422	231	217	233	96
221	99	286	234	686	1657	223	827	916
225	717	180	236	879	151	227	1161	35
230	935	552	239	183	51	245	1012	6
237	50	238	272	502	678	266	651	80
267	1114	11	274	487	5	275	558	125
269	745	486	282	544	276	276	707	134
278	373	440				277	729	5
279	434	28				284	71	35
281	576	7						

Treatment								
NCFS ONLY			ECS ONLY			NCFS-ECS 300		
S	100	10	S	100	10	S	100	10
209	1693	5	232	49	106	216	146	735
210	4293	25	240	347	148	219	426	132
214	1388	1100+	243	676	1100+	224	2497	1100+
220	1435	123	246	1662	487	233	65	8
222	710	251	247	53	373	242	932	47
226	1498	71	249	92	21	268	655	137
228	1779	216	250	1157	93			
231	918	189	252	68	110			
235	218	189	253	106	354			
271	677	620	254	2423	1600+			
273	820	642	255	291	208			
280	318	14	258	573	63			
283	694	345	259	85	175			
285	1217	15	260	1129	375			
			262	132	323			
			263	1793	474			
			264	1135	1270			
			265	159	324			

Final Attempt

Subjects

The subjects were 127 naive male Long-Evans hooded rats. At the beginning of the experiment, they ranged from 90 to 130 days old. They were individually housed and allowed access to food and water ad lib throughout the experiment.

Apparatus

The apparatus consisted of a conditioning drop box and a NCFS-ECS chamber. The drop box, a modified step-through box (Thompson & Galosy, 1969), was a covered box 30.5 cm. sq. and 40.6 cm. high. The floor was divided in half and hinged on each side to act as a trap door. The floor was 24.1 cm. above the bottom of the box and was supported by a piece of plastic attached to a solenoid so that activation of the solenoid allowed the trap door to open. A 9.69 cm. long and 5 cm. wide platform, level with the floor, extended out from a 7.6 cm. sq. hole in the front of the box. A 6-w. lamp was mounted 22.9 cm. above the platform. The bottom of the watertight box was filled to a depth of 10.2 cm. with water between 2° and 10° C. The apparatus sat on a table 82.5 cm. above the room floor with the platform extending away from the table and the nearest wall in the room. The room was lighted by a single 25-w. red bulb suspended 60 cm.

above the apparatus. A holding cage, 35 cm. sq. and 22.5 cm. high with a 250-w. infrared heat lamp placed 27.5 cm. above one end, was located in an adjacent well-lighted room.

The NCFS-ECS chamber, 20 cm. by 22.5 cm. and 20 cm. high, constructed of Plexiglass with anodized aluminum front and rear walls and a grid floor of stainless steel rods measuring .325 cm. in diameter and spaced .95 cm. apart, was used to deliver the treatments. A polarized NCFS of 1 ma. (60 Hz., 206 v. rms) and two second duration was used. The ECS apparatus was set to deliver a shock of 92 ma. (60 Hz., 1,840 v. rms) for a period of .20 seconds.

Procedure

Two days prior to the experiment, all subjects had #0 Prims snap fasteners attached to their ears, which were used for the administration of ECS. The snaps were attached by puncturing the pinna of the subject's ear and fastening the snap through the puncture.

The experiment was conducted blind, one experimenter randomly assigned the subjects to the various treatments and gave the treatments. Another experimenter conditioned and tested the subjects for retention. The four experimental groups received a NCFS followed at intervals of .5, 10, 60, or 300 seconds by ECS. The control groups consisted of a group that received only the conditioning (C), a group that

received ECS only and the conditioning (E), and a group that received neither ECS, NCFS-ECS, nor conditioning (N).

On the first day of the experiment each subject was hand carried to the NCFS-ECS chamber where the first experimenter attached a modified clip to the snap in the subject's ear and placed him in the chamber. Two minutes later, the subject received one of the following conditions: nothing, ECS, or NCFS-ECS depending upon which group the subject had been assigned, and was then returned to the home cage.

Twenty-four hours post-treatment the subjects were trained in the drop box. They were hand carried by the second experimenter to the drop box and placed on the platform. When the subject entered the box, i.e. when the base of his tail and both back feet had entered the box, he was dropped into the water, with the exception of those subjects in group N which were allowed to remain on the floor of the box for two seconds. The subjects were then removed and taken to the holding cage where they stayed for approximately five minutes after which they were returned to their home cage. The step through latency (STL) for each subject was recorded to the nearest second. If the subject remained on the platform for 180 seconds he was removed and returned to his home cage and discarded from the experiment. Ninety-six hours post-treatment, each subject was tested for retention of the conditioning. The procedure for the retention test

was the same as the training procedure except the subjects were not dropped and the holding cage was not used. On the test day a cut-off criterion of 600 seconds was used.

CHAPTER III

RESULTS

Some of the subjects were discarded from the experiment as summarized in Table 4. The reasons were: 1) the subject did not get conditioned, i.e., the subject remained on the platform for more than 180 seconds and did not enter the drop box on the conditioning day (n=15), 2) animals that backed through the entrance to the box on either the conditioning or the test day (n=13), 3) those that were physically unfit after the treatment (n=4), 4) those that were statistically deviant from the rest of their group, i.e. their STL was greater than two standard deviations from the mean of their specific treatment group on either the conditioning or the testing day (n=6), and 5) procedural differences due to apparatus malfunction (n=12).

The breakdown of the number of subjects dropped according to groups was three from group N, nine from .5, eight from both the 10 and 300 second groups, seven from the 60 second, five from the ECS only group, and ten from group C. This left 77 subjects with 11 subjects in groups N, C, and E. Twelve subjects were in both the NCFS-ECS 10 and 60 second groups, and the NCFS-ECS .5 and 300 second groups had ten subjects each. The STL were transformed into logarithms in order to meet the assumption of homogeneity of variance

TABLE 4

DATA FROM DISCARDED SUBJECTS

Treatment Group	Reason Discarded														
	No Conditioning			Backed Through			Procedural Differences			Statistically Deviant			Physically Unfit		
	S	Cond.	Test	S	Cond.	Test	S	Cond.	Test	S	Cond.	Test	S	Cond.	Test
.5				27	6	398	71	4	600+						
				32	5	63	97	1	---						
				63	2	386	113	3	522						
				153	1	104	138	1	5						
							143	2	600+						
10	50	180+		134	1	539	101	1	520				82	36	---
	58	180+													
	81	180+													
	91	180+													
	103	180+													
60	41	180+		135	5	20				85	18	600+	24	---	---
	72	180+											28	---	---
	93	180+													
300	87	180+		44	175	600+	66	2	600+	68	28	600+			
				53	3	62	99	1	18	90	1	1			
							151	2	600+						
N	56	180+								26	179	220			
	109	180+													
C	34	180+		61	12	131	84	1	2	77	2	16			
	42	180+		83	21	25				114	1	27			
	98	180+		86	6	132									
	57	180+													
E				47	4	179	79	5	351				43	3	600+
				144	6	27									

(Kirk, 1968) and a repeated measures analysis of variance was computed to explore the differences among treatments, time of testing (training vs. 96 hour test) and the interaction of treatments and time of testing.

Table 5 shows the results of the analysis. A significant difference was found between training and test day ($F=362.01$, $df=1/70$, $p<.001$) indicating that the STL's on the day of training were significantly less than the STL's for the test day and that the conditioning was effective. A difference was also found among the treatments ($F=6.71$, $df=6/70$, $p<.001$). The interaction of Treatments X Test day was also found to be significant ($F=11.96$, $df=6/70$, $p<.001$), indicating a need for the test of simple main effects as described by Kirk (1968). This analysis (Table 6) showed that there were no significant differences among the treatment groups during training. Thus, differential treatment did not effect the initial STL. The analysis also indicated that all groups had reliably longer STL's on the testing day as compared with the training day with the exception of treatment N.

A Tukey's HSD was computed on the mean STL's for the retention test day in order to find where the differences were among the treatment groups. The results of this analysis are summarized in Table 7. Basically, the outcome of this analysis showed that the N group had significantly

TABLE 5

SUMMARY OF ANALYSIS OF VARIANCE

Source	SS	df	MS	F
Treatments	149,398.07	6	24,899.68	6.71*
Ss/Treat	259,497.19	70	3,707.10	
Test	945,849.10	1	945,849.10	362.01*
Treat X Test	187,412.65	6	31,235.44	11.96*
Test X Ss/Tr	182,891.75	70	2,612.74	

*p < .001.

TABLE 6

SUMMARY OF SIMPLE MAIN EFFECTS

Source	SS	df	MS	F
Treat at Train	34,005.90	6	5,667.65	1.79
Treat at Test	302,804.82	6	50,467.47	15.97*
Pooled Error	442,388.94	140	3,159.92	
Test at .05	66,816.80	1	66,816.80	25.57*
Test at 10	150,892.04	1	150,892.04	57.75*
Test at 60	278,641.50	1	278,641.50	106.65*
Test at 300	270,746.45	1	270,746.45	103.63*
Test at ECS	139,522.91	1	139,522.91	53.40*
Test at C	226,040.91	1	226,040.91	86.51*
Test at N	601.14	1	601.14	.23
Test X Ss/Tr	182,891.75	70	2,612.74	

*p < .001.

TABLE 7

MULTIPLE COMPARISONS OF $\bar{X}$ LOG STL FOR THE TEST DAY USING TUKEY'S HSD

	Treatment						
	N	.5	10	ECS	60	300	C
$\bar{X}$ log STL	.8209	1.5920	1.9475	2.3909	2.4558	2.5800	2.7536
.8209		.77*	1.13**	1.57**	1.63**	1.76**	1.93**
1.5920			.36	.80*	.86*	.99*	1.16**
1.9475				.44	.51	.63	.81*
2.3909					.06	.19	.36
2.4558						.12	.30
2.5800							.17
2.7536							

*$p < .05$.

**$p < .01$.

shorter STL's than all other groups. The ECS only and C groups were statistically equal indicating that ECS alone produced no state dependency effect. The NCFS-ECS .5 group was equal to the NCFS-ECS 10 second group and showed reliably more amnesia than all the others. The NCFS-ECS .5 and 10 second groups also had reliably shorter STL's than group C. These differences indicate that the NCFS-ECS .5 and 10 second groups did not remember their conditioning as well as the C group but still retained some memory relative to group N. It can be seen from Figure 1 that the mean STL's on the test day became increasingly longer as the interval between the NCFS and the ECS increased, showing the "gradient" that is often found.

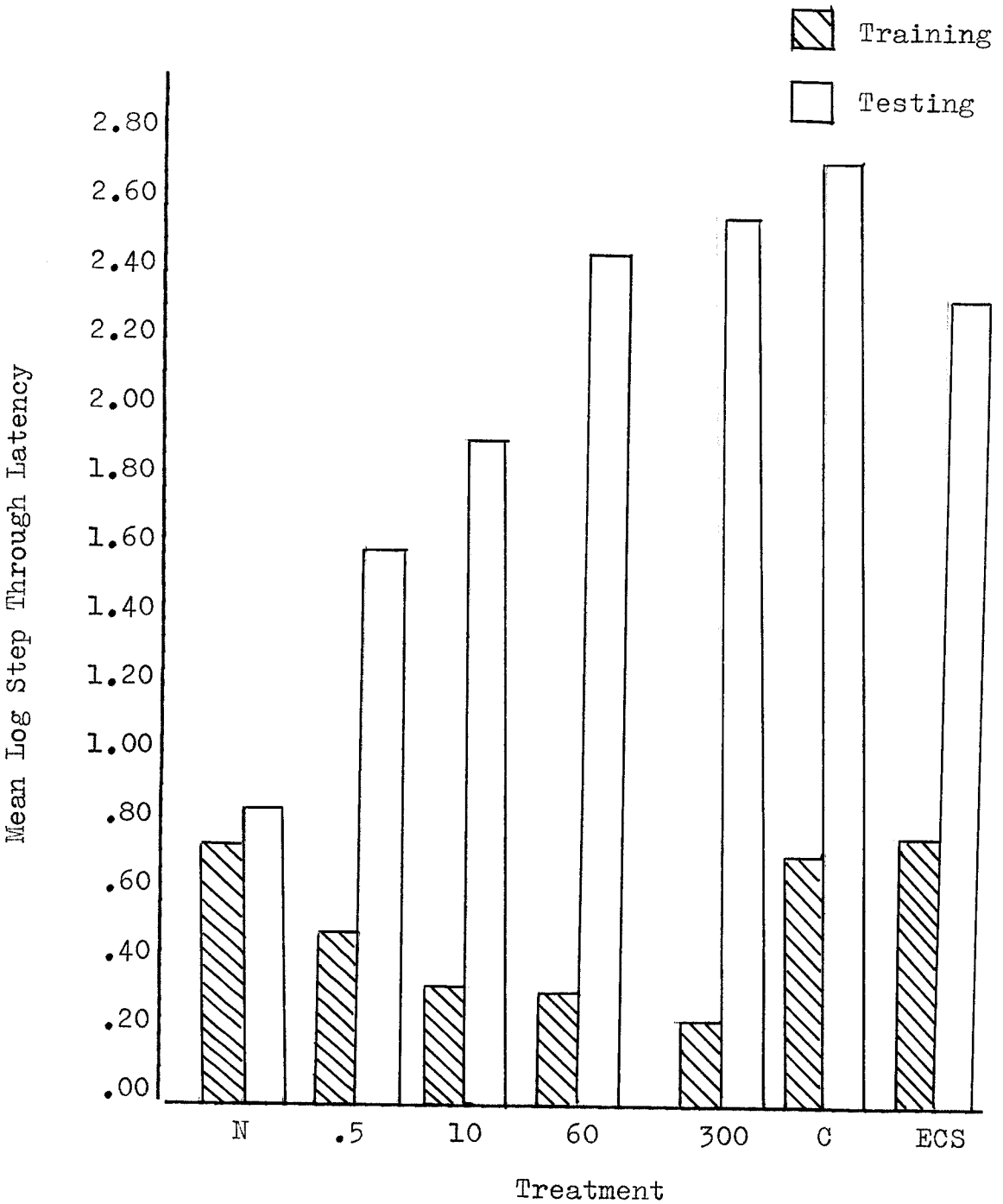

Figure 1

Mean log step through latencies for the seven treatments at training (24 hours post treatment) and testing (96 hours post treatment).

CHAPTER IV

DISCUSSION

The gradient shown in this study is similar to the gradients shown in previous studies (Chorover & Schiller, 1965; King, 1965) in that the interval between a FS (in this case a NCFS) and ECS is important in affecting the degree of amnesia obtained. In previous studies the interpretation of ECS effects in terms of the consolidation position has been based heavily upon this gradient. The gradient has been assumed to be evidence that the fixation of memory has been disrupted when the ECS follows a training trial; the longer the interval between training and ECS the more memory consolidated. In the present study since NCFS and ECS were given 24 hours prior to conditioning and no ECS followed training, the results cannot be explained in terms of memory consolidation. It would appear that memory retrieval, rather than consolidation, was temporarily blocked and that the amnesic gradient in this, as well as the previous studies, is a function of the interval between footshock and ECS rather than between learning and ECS.

Apparently the interaction of the NCFS and ECS caused a state which persisted for approximately 96 hours. When an animal was trained during this period and required to recall the training after the state had dissipated memory retrieval

failure resulted, as is particularly evidenced by the NCFS-ECS .5 second group. As the interval between the NCFS and ECS increased a lesser state change was induced so that memory retrieval occurred relatively well when tested later in the normal state. Apparently intervals as long as 60-300 seconds induced state changes that were not detectably different from the normal state. Thus these subjects showed memory retrieval essentially the same as subjects which received conditioning only.

This study also indicates that ECS alone is not sufficient to cause the amnesia reported in other studies (Chorover & Schiller, 1965; King, 1965). The ECS only group is comparable to group C which received only the conditioning. Thus, it was the interaction of the NCFS and ECS that caused the amnesia. Thompson and Neely (1970) have shown that memories stored during an ECS state are dissociated from the normal state when tested within minutes of the ECS treatment, but they used the ECS after a training trial FS with which the ECS interacted to produce the state. There seems to be a need for some arousing stimulus to interact with the ECS to produce a state change. This calls for some reevaluation of the effects of ECS alone. Mayse and DeVietti (1971) have shown that ECS alone does not produced a dissociation effect, but 24 hours after a FS and ECS a dissociation was produced which was as effective as a high dose of pentobarbital.

The order of the treatments and testing in this experiment was different from the order usually involved in ECS research. This study used a treatment (NCFS-ECS) followed by training and finally testing 96 hours after the treatment. The more conventional order needs to be explored also. That is, the animals should be trained and 24 hours later given the treatment (NCFS-ECS) and tested both at 24 and 96 hours post-treatment. If this method showed the gradient also it would provide further evidence that the amnesia observed after a training trial FS and ECS may not be due to fixation failure, but rather, may simply reflect retrieval failure.

CHAPTER V

SUMMARY

Nielson (1968) proposed the state dependent hypothesis to account for the effects of ECS on memory, where an initial amnesia was observed followed by a recovery of memory. The present study explored the hypothesis further.

Rats were given a NCFS followed at various intervals by an ECS to produce varying degrees of state change. Twenty-four hours later they were trained on a one trial non-shock passive avoidance task. Ninety-six hours after the NCFS-ECS treatment, they were tested for retention. At this time according to the state dependency hypothesis, they should have returned to their normal state.

The results indicated that the longer the NCFS-ECS interval the more retention of the training occurred. This indicates that the temporal relationship between FS and ECS is critical in the production of a state change. The longer the interval, the less a state change was produced. Behaviorally, a retention gradient was obtained that appears identical to that obtained when ECS follows a training trial FS by various intervals, suggesting that the results of these studies may also simply reflect memory retrieval

failures rather than interruptions of memory consolidation.

REFERENCES

Chorover, S. L., & Schiller, P. H. Short-term retrograde amnesia in rats. Journal of Comparative and Physiological Psychology, 1965, 59, 73-78.

Chorover, S. L., & Schiller, P. H. Re-examination of prolonged retrograde amnesia in one-trial learning. Journal of Comparative and Physiological Psychology, 1966, 61, 34-41.

DeVietti, T. L., & Larson, R. C. ECS effects: Evidence supporting state-dependent learning in rats. Journal of Comparative and Physiological Psychology, 1971, 74, 407-415.

King, R. A. Consolidation of the neural trace in memory: Investigation with one-trial avoidance conditioning and ECS. Journal of Comparative and Physiological Psychology, 1965, 59, 283-284.

Kirk, R. E. Experimental design: Procedures for the behavioral sciences. Belmont, Calif.: Brooks/Cole Publishing Co., 1968.

Kohlenberg, R., & Trabasso, T. Recovery of a conditioned emotional response after one or two electroconvulsive shocks. Journal of Comparative and Physiological Psychology, 1968, 65, 270-273.

Mayse, J. F., & DeVietti, T. L. A comparison of state dependent learning induced by electroconvulsive shock and pentobarbital. Physiology and Behavior, (in press).

McGaugh, J. L. Time-dependent processes in memory storage. Science, 1966, 153, 1351-1358.

Misanin, J. R., Miller, R. R., & Lewis, D. J. Retrograde amnesia produced by electroconvulsive shock after reactivation of a consolidated memory trace. Science, 1968, 160, 554-555.

Nielson, H. C. Evidence that electroconvulsive shock alters memory retrieval rather than memory consolidation. Experimental Neurology, 1968, 20, 3-20.

Pagano, R. R., Bush, D. F., Martin, G., & Hunt, E. B. Duration of retrograde amnesia as a function of electroconvulsive shock intensity. Physiology & Behavior, 1969, 4, 98-105.

Pinel, J. P. J. A short gradient of ECS-produced amnesia in an appetitive situation. Journal of Comparative and Physiological Psychology, 1969, 68, 650-655.

Quartermain, D., Paolino, R. M., & Miller, N. E. A brief temporal gradient of retrograde amnesia independent of situational change. Science, 1965, 149, 1116-1118.

Thompson, C. I., & Neely, J. E. Dissociated learning in rats produced by electroconvulsive shock. Physiology & Behavior, 1970, 5, 783-786.

Thompson, R. W., & Galesy, R. A. A one-time non-shock passive avoidance task for rats. Behavior Research Methods and Instrumentation, 1969, 6, 227.

Zinkin, S., & Miller, A. L. Recovery of memory after amnesia induced by electroconvulsive shock. Science, 1967, 155, 102-103.

APPENDIX

APPENDIX

STEP THROUGH LATENCIES IN SECONDS

Treatment

NCFS-ECS .5			NCFS-ECS 10			NCFS-ECS 60			NCFS-ECS 300		
S	Train	Test	S	Train	Test	S	Train	Test	S	Train	Test
31	4	22	25	5	600+	46	2	600+	29	2	600+
33	10	15	37	5	18	51	2	137	30	3	600+
52	3	600+	49	2	24	54	4	600+	55	2	600+
64	4	600+	70	2	190	69	1	600+	40	2	6
80	1	1	74	3	600+	73	1	58	123	1	600+
1	2	7	75	2	8	88	2	600+	141	7	600+
14	4	9	102	1	600+	92	3	38	145	1	600+
110	6	600+	104	2	190	94	1	600+	152	1	600+
111	1	3	135	2	6	95	2	600+	154	2	600+
146	1	600+	140	3	600+	117	3	600+	159	1	600+
			155	3	4	131	1	54			
			158	3	600+	132	7	600+			

APPENDIX (continued)

Treatment								
N			C			ECS		
S	Train	Test	S	Train	Test	S	Train	Test
23	6	6	35	9	600+	38	130	600+
36	14	11	39	2	600+	48	10	512
45	2	8	76	45	600+	65	5	600+
59	7	11	89	1	600+	67	2	600+
60	5	4	100	4	600+	78	90	600+
62	9	5	112	8	600+	105	1	22
96	7	3	136	46	600+	107	1	600+
106	2	4	137	2	600+	148	6	203
118	8	88	139	3	600+	149	4	13
142	12	9	156	2	312	150	11	600+
147	1	1	160	7	600+	157	2	142