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Classical Conditioning as a Function of the Motivational History of the CS

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Classical Conditioning
as a Function of the
Motivational History of the CS

A Dissertation Presented

By
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Submitted to the Graduate School of the
University of Massachusetts in
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Classical Conditioning
as a Function of the
Motivational History of the CS

A Dissertation

by

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INTRODUCTION

Rescorla and Solomon (1967) reviewed in some detail studies of classical - instrumental transfer which provide a rather extensive body of evidence that there is strong mediating control of instrumental responses by Pavlovian conditioning procedures. They pointed out that conditioned emotional states may serve as either motivators or reinforcers of instrumental responses. One version of two-process theory holds that the sensory feedback from emotional responses that have become conditioned to previously neutral stimuli has both cue and drive properties. Thus the CR is assumed to reflect an underlying general motivational state which mediates subsequent instrumental responding. It is possible that the influence of such a central nervous system state is not limited to the instrumental situation but may affect responding in the classical conditioning situation as well. There has been relatively little evidence, however, that the rate of Pavlovian conditioning and differentiation vary as a function of the motivational and emotional associations of the conditioned stimulus (CS).

Historical Perspective

One approach to the problem of the role of motivational associations of the CS has been made by investigations of the effects of the primary motivational aspects of the conditioned stimulus. Several studies have employed electrical stimulation

of the brain (ESB) as the CS but, like the transfer investigations, have tended to employ a paradigm which is partially Pavlovian and partially instrumental. The possible application of results to a more strictly defined Pavlovian situation, therefore, is necessarily limited.

Mogenson (1964) and Mogenson and Morrison (1962) used electrical stimulation of positively rewarding brain structures in rats as the CS for a shuttle avoidance response. The results suggested that, in addition to reinforcing properties, the ESB had acquired cue functions as well and further that the initially positive stimulation apparently became temporarily aversive after its association with the painful peripheral shock in avoidance training. It was also found that positively rewarding ESB retarded acquisition of the avoidance response compared to a "neutral" peripheral CS. There has also been evidence that the peripheral shock may have both an avoidance and a cue function. Muenzinger (1934) and more recently Fowler and Wischner (1965) have found that presentation of shock after the correct response in a visual discrimination task facilitates performance.

There are several disadvantages, however, of using primary motivating stimuli such as shock and electrical stimulation of the brain in the role of the conditioned stimulus. Both peripheral shock and ESB may sometimes have postural or motor effects which may tend to facilitate or to interfere with the performance of the response(s) under investigation. Intra-cranial stimulation

can also interfere with learning, perhaps by means of spreading cortical depression initiated by the electrical stimulation or by simultaneous excitation of components which normally respond sequentially to sensory input (Mogenson, 1959).

A different approach has been taken by Garcia and his associates (e.g., Garcia, McGowan, and Green, 1969) who have provided evidence that various primary motivational stimuli (e.g., gustatory and olfactory stimuli) do not have equivalent value in different conditioning situations. They have found, for example, that visual and tactual stimuli are ineffective as cues for avoidance of a poison bait while gustatory stimuli are highly effective. Gustatory and olfactory stimuli were also found to be of prime importance in generating preferences and aversions in feeding behavior while the more peripheral cues are not.

Yet another approach to the role of motivational aspects of the CS has been made by those studies investigating the effect of stimuli which acquire incentive-motivational value. Several recent studies have demonstrated that the pairing of a stimulus with a positive reinforcer will lead to enhancement of subsequent instrumental responding which is under the control of that same stimulus (Bower and Grusec, 1964; Trapold, Gross and Lawton, 1968; Trapold and Winokur, 1967; Trapold, Lawton, Dick, and Gross, 1968) and that pairing a stimulus with shock will lead to enhancement of subsequent avoidance responding (Overmier

and Leaf, 1965; Solomon and Turner, 1962).

Many of these studies do not seem to provide a particularly rigorous test of the concept of "transfer," however. They often employ the same apparatus for both Pavlovian and instrumental conditioning and frequently the instrumental response acquired is only an additional link in an operant chain shaped during the "classical conditioning" phase of the experiment. For example, Trapold, Gross, and Lawton (1968) attempted to reverse an appetitive instrumental discrimination by interpolated classical conditioning on the reversal. Rats were first trained on a barpress discrimination in which responding in the presence of S+ delivered food reinforcement but responding in the presence of S- did not. The experimental group was then given "classical conditioning" on the reversal. The S- became CS+ and the S+ became CS-. During CS+ the animals approached the magazine and consumed the food with the bar absent. During the next phase (instrumental reversal) with the bar again present in the same apparatus in the presence of the new S+, the animals made the previously acquired barpress, approached the magazine, and consumed the food. The demonstration of transfer in such a paradigm is limited by the presence of cues common to both classical conditioning and instrumental phases. The existence of such common elements allows the possibility that subsequent behavior in the same situation may be under the control of stimuli (e.g., apparatus cues, etc.) which, while not necessarily

irrelevant, are not of prime interest to the experimenter.

Bindra (1968) has recently presented evidence to support an hypothesis that the facilitation of specific instrumental responses is attributable to a central state created by incentive-motivational stimuli and that the same incentive-motivational stimulus can influence behavior in several different situations. Results of studies by Bacon and Bindra (1967), Hyde and Trapold (1967), Weinrich, Cahoon, Ambrose, and LaPlace (1966) and Bower and Kaufman (1963) all showed transfer from a classical to an instrumental conditioning situation.

A common feature of the above studies is concern with the effects of prior classical conditioning procedures on responding in an instrumental situation. Ashton (1968) conducted an experiment in which rabbits first received operant discrimination training in which a barpress response in the presence of an S^D was followed by a food reinforcer while a response in the presence of an S^A was not. The S^D then became CS+ in a classical conditioning phase and was paired with a shock UCS. The results indicated that these Ss who showed the better operant differentiation had the poorer performance in the differential classical conditioning phase.

With the exception of Ashton's study and aside from investigations, initially by Pavlov and more recently by others (e.g., Davenport, 1966) of second order conditioning and studies by Sokolov concerning the perceptual reflexes associated with

the CS, investigations of the role of the CS in the classical conditioning paradigm have been largely limited to various parametric manipulations of its physical quality. The purpose of the present study was to examine the effects of previous motivational associations of the CSs on classical differential conditioning.

Theoretical Perspective

It is commonly assumed that the transfer from the classical to the instrumental paradigm is mediated by the $r_g - s_g$ mechanism. According to this view, a fractional anticipatory consummatory response (r_g) is classically conditioned to situational stimuli during instrumental training. The proprioceptive feedback stimuli (s_g) can either motivate or provide stimulus control over responses occurring in their presence. Transfer presumably occurs when a CS, superimposed on an instrumental response, elicits the same $r_g - s_g$ involved in controlling the instrumental response. This type of mediation does not appear to offer an adequate explanation for the results of studies in which there was transfer across drives. It is not clear, for example, how the fractional anticipatory consummatory response acquired in relation to a positive reinforcer such as food might facilitate the specific responses related to subsequent shock avoidance.

Bindra (1968) has presented a more general neuropsychological model to deal with the effects of drive and incentive motivation on appetitive behavior. Although the model was developed to deal with appetitive motivation in an instrumental paradigm, Bindra has suggested that it may also be applied to the case of aversive motivation as well. Briefly, his model consists of four hypothetical "motivational functions." Drive is assumed to activate consummatory action sites by enhancing neural activity which facilitates species-typical consummatory acts. This activation leads to selective enhancement of sensory input (attention) arising from objects relevant to the consummatory behavior. In addition, certain drive states raise the level of general motor readiness, presumably by means of increased neural activity in the reticular arousal system which enhances the excitability of the motor system as a whole. The conditioned incentive-motivational stimuli, such as a metronome which has been paired with a water reinforcer, acquire properties similar to those possessed by the "natural" incentive-motivational stimuli. These conditioned stimuli then become capable of enhancing neural activity in the appetitive (or aversive) system. These central "emotional" states promote the neural organization of a variety of environmentally oriented response tendencies.

With some slight modification, these same functions might also be applied to the classical conditioning paradigm as well.

Although, drive, in the Pavlovian situation is usually a function of various UCS parameters rather than of antecedent deprivation conditions, it might be assumed to serve the same function of activating certain neural sites, thereby increasing readiness to respond. The responses facilitated by this enhanced neural activity might be expected to be a subset of those involved in the consummatory action of the instrumental situation, depending on the nature of the Pavlovian UCS. The incentive-motivational properties acquired by the CS might also be expected to serve the same function in both classical and instrumental conditioning by activation of motivational systems and facilitation of behavior by means of central emotional states.

Estes (1969) has recently proposed a theory in a somewhat more behavioral framework to account for the effects of drive and incentive motivation which appears to have relevance for the classical as well as instrumental conditioning paradigm. According to the Estes' formulation, the primary function of drives and rewards is to act as stimulus amplifiers. Associated with each of the principle drive systems is a source or generator which provides a certain base rate of amplifier element input under given deprivation or stimulation conditions. Prior to any learning experiences, the amplifier input of a given motivational system is associated with a "family" of S-R units. In the case of hunger, these S-R units are involved in consummatory behavior; in the case of pain, they are associated with escape, attack or

defensive behaviors. Response evocation requires summation of stimuli associated with a given response, either by previous learning or innate organization, and the internally generated amplifier elements. Drive is assumed to increase the base rate of amplifier elements to the appropriate family of responses, providing a basis for summation of amplifier elements with any UCS or CS that may become available in the experimental situation. In the case of a negative motivational system, that associated with shock, for example, the conditioning process is assumed to proceed in the following manner. Generation of amplifier elements is initially controlled only by the painful shock stimulation itself. The input of these amplifier elements provides the basis for summation and facilitates the occurrence of responses in the flight-attack-defense family of behaviors which occur in the presence of the shock. As the result of S-S contiguity, the control of negative amplifier input is transferred from the shock to the stimuli immediately preceding it. This anticipatory occurrence of amplifier input facilitates responding in the presence of the CS alone. A major feature of Estes' theory is that it assumes reward and punishment systems are mutually inhibitory, a viewpoint shared by Stein (1964).

On the basis of Estes' formulation it was expected that rate of conditioning would be fastest when both the CS+ and CS- of a differential conditioning paradigm had been paired with shock before classical differential conditioning and slowest when

both had been pre-paired with food. The former experimental condition should provide the greatest input of negative amplifier elements which would summate with those provided by the noxious UCS in the classical conditioning situation to produce optimal conditioning in terms of total response frequency. In contrast, the latter pre-pairing conditions would provide amplifier input antagonistic to the noxious UCS and might therefore lead to poorer rate of conditioning (lower response frequency). The same predictions can be made from Bindra's theory: pairing the stimuli with shock would lead to activation of the aversive system and might thus facilitate responding while pairing the stimuli with food would lead to activation of the appetitive system and might be expected to attenuate responding. Optimal differentiation might be expected when the CS+ was pre-paired with shock and the CS- with food. In this case, the CS+ would presumably provide a source of negative amplifier elements which should lead to a high probability of responding to that stimulus while the CS- is a source of negative amplifier elements which should inhibit the aversive system associated with the noxious UCS and reduce the probability of responding to CS-. The same predictions may also be derived from Bindra's theory by the same reasoning as above, with the CS+ and CS- leading to activation of mutually inhibitory aversive and appetitive systems respectively.

The purpose of the present study was to investigate the effects of previous emotional and motivational associations of

the CS on differential conditioning of the nictitating membrane response (NMR) of the rabbit. The motivational properties of the CS were manipulated by pairing tonal stimuli with food or shock prior to NMR conditioning.

METHOD

Subjects. Fifty-eight naive Belgian and Dutch rabbits, 120 to 160 days old were used as subjects (Ss). Four animals were discarded, one for failure to consume food pellets during Phase I, two for failure to condition during Phase II, and one because of failure to respond following a 1/4 cc dose of Thorazine on the third day of Phase II conditioning. All Ss were placed on a 23 hour deprivation schedule for the duration of the experiment. They were given free access to food for one hour following each session in both Phase I and Phase II. Ad-lib water was available in the home cages.

Phase I, Apparatus. The pre-conditioning chamber consisted of a plexiglas Skinner box 24 in. long by 20 in. high by 15 in. wide with two audio speakers in the rear wall to deliver masking noise and the tonal stimuli. The front contained a food magazine 4 in. wide, 3 1/2 in. long, and 1 1/4 in. deep. The floor of the chamber consisted of 1/4 in. stainless steel rods 3/4 in. apart (center to center). A Scientific Prototype Model D-100 feeder delivered a single Noyes alfalfa pellet 4.8 mm. by 4.9 mm. by 97 mg. on food reinforced trials. A Grason Stadler Model E1064GS

shock generator delivered an AC shock of 2 sec. duration to the grid floor on shock reinforced trials.

House lighting was provided by a 15 watt incandescent light source suspended centrally above the test chamber. Tonal stimuli 75 db SPL at the center of the chamber were supplied by two Hewlett-Packard signal generators. A continuous white noise 70 db SPL masked extraneous auditory stimuli throughout each session.

Phase I, Procedure. All animals were given two days of magazine training for approximately 10 - 20 min. each day. On the day prior to Phase I training, the feet and the hair around the right eye were shaved with animal clippers. A length of 00 Ethilon monofilament nylon was sutured through the nictitating membrane of S's right eye and tied with a double squared knot. In order to minimize the possibility of injury to the animals, a 1/2 ml. dose of Nembutal (50 mg./ml.) was administered intravenously prior to the surgical preparation.

Six animals were assigned to each of nine cells of a 3 x 3 factorial design:

		History of CS- (400 Hz)		
		Food	Nothing	Shock
History of CS+ (1000 Hz)	Food	FF	FN	FS
	Nothing	NF	NN	NS
	Shock	SF	SN	SS

Magazine training served also as a "screening" procedure. In general, animals who were slower in acquiring approach behavior to the magazine were assigned to groups NN, NS, SN, or SS, although these groups did contain several "good approachers" as well. For Ss in group FF, both tones were paired with food. For Ss in group FN, the 1000 Hz tone was paired with food and the 400 Hz tone was presented alone; in group FS the 1000 Hz tone was followed by food and the 400 Hz tone by shock, etc. Subjects were given four days of training with 30 CS+ and 30 CS- trials per session presented in a random order such that there were no more than three trials of the same type in succession.

The intertrial interval varied randomly from 20 to 40 sec. with an average of 30 sec. CS duration was 10 sec. and the interstimulus interval was 5 sec. The shock intensity was .5-mA, 1.0-mA, 1.6-mA, and 2-mA respectively on each of the four days of Phase I training.

Phase II, Apparatus. Four Ss were run concurrently in a 4-drawer, sound-proofed filing cabinet. The stimulating and recording components of all drawers were identical. Each drawer was illuminated by two 6 watt house lights situated in the front portion of the drawer. Three speakers, also in the front portion of the drawer, delivered the tonal stimuli and masking noise. An 18 in. by 7 in. by 4.5 in. plexiglas box with adjustable front stock and adjustable back plate was used to restrain S (cf. Gormezano, 1966). Movements of the nictitating

membrane were monitored by a rotary Minitorque potentiometer (Giannini Model no. 85153) mounted on S's head. The shaft of the potentiometer was connected to the nylon suture by means of a small metal hook and a piece of silk thread. Amplification and recording were done on a 4-channel Grass 5D ink-writing oscillograph at a paper speed of 100 mm./sec. Event markers recorded onset and termination of CS and UCS.

Phase II, Procedure. Subjects were given four days of differential conditioning. A 400 Hz tone was used as CS- and a 1000 Hz tone as CS+. CS duration was 400 msec. The UCS was a 2-mA AC shock of 50 msec. duration delivered through two wound clip electrodes embedded one posterior and one inferior to the right eye. The interstimulus interval was 350 msec. The inter-trial interval was randomly varied from 20 to 40 sec. with an average of 30 sec. Sixty CS+ and 60 CS- trials were presented each day for 4 days in a random sequence such that there were no more than two trials of the same type in succession. On the fifth day, all Ss were given 100 extinction trials, half to CS+ and half to CS- in the same random sequence that was employed in acquisition.

Two rabbits, one in group SN and one in group FN, both smaller than average and therefore not adequately restrained by the plexiglas boxes, tended to disrupt the conditioning sessions by their attempts to escape from the restraining boxes. On Day 3 both animals were given a 1/4 ml. intraperitoneal injection of

Thorazine (25 mg./ml.) in an attempt to quiet them. The SN sub-ject was given a 1/2 ml. injection on Day 4 for the same reason. The drug did not appear to diminish the conditioned responding of the SN animal. Responding by the FN animal was disrupted for slightly less than three trial blocks but subsequently recovered.

RESULTS

Phase I. The only overt response required by the experimental conditions of Phase I was the consumption of the food pellet by Ss in groups FF, FN, FS, NF, and SF. Record was kept of the failure of Ss in these groups to consume pellets in the interval between presentation of the pellet and the onset of the next trial. The percentage of food pellets consumed by animals in each of these groups on each of the four days of Phase I training is presented in Appendix 1. There was an increase in the number of pellets consumed by all groups over days from an average of 73.22% on Day 1 to an average of 95.33% on Day 4. By the end of the four-day training period of Phase I, no animal failed to consume less than 76% of the food pellets presented and only 5 animals failed to consume less than 90% of the pellets.

Phase II, Trial of First CR. An analysis of variance was performed using the trial number of the first CR as the dependent measure. The first CR occurred significantly later in those groups in which CS+ had been presented alone than when it had been paired with either food or shock during Phase I, $F(2,45) =$

3.21, $p < .05$. The mean trial number of the first CR was 108.7 in groups in which food had been paired with CS+, 115.3 in groups in which shock had been paired with CS+ and 164.3 in groups in which CS+ had been presented alone. The trial number of the first CR for each animal is included in Appendix 2.

Phase II, Total Percentage of CRs. Table 1 presents the mean total percentage of CRs (pooled over CS+ and CS-) for each

 Insert Table 1 about here

of the nine groups on each day of conditioning. It was hypothesized that group SS should show the fastest rate of conditioning in terms of total response frequency and group FF the slowest. On Day 1 group SS did yield a significantly greater percentage of responses than group FF, $t(10) = 2.45$, $p < .05$, but neither of these groups differed significantly from the control group NN. In addition, the extreme scores on Day 1 were obtained, not from groups SS and FF, but rather from group FN (23.61%) and group SN (.28%). No significant difference was found between group FN and NN or between group SN and NN. F ratios based on the CR frequency data for each day are summarized in Appendix 3. Table 2 presents the results of independent t tests performed on differences among various of the group means. In view of the directionality of the hypotheses being tested, one-tailed values were used to assess significance.

Table 1
Total Percentage of CRs for
Each Day of Conditioning

		Day 1				Day 2				
		History of CS-				History of CS-				
		F	N	S	\bar{X}	F	N	S	\bar{X}	
History of CS+	F	.42	23.61	9.72	11.25	F	29.58	77.50	66.25	57.78
	N	8.33	15.56	1.25	8.38	N	21.81	72.36	20.00	38.06
	S	9.31	.28	14.31	7.97	S	52.50	48.89	58.75	53.38
	\bar{X}	6.02	13.15	8.43		\bar{X}	34.63	66.25	48.33	
		Day 3				Day 4				
		History of CS-				History of CS-				
		F	N	S	\bar{X}	F	N	S	\bar{X}	
History of CS+	F	80.83	81.11	68.06	76.67	F	88.47	66.25	81.53	78.75
	N	59.72	72.22	72.78	68.24	N	74.03	83.61	88.75	82.13
	S	84.58	85.14	79.44	83.06	S	75.00	76.94	86.11	79.35
	\bar{X}	75.05	79.49	73.43		\bar{X}	79.17	75.60	85.46	

 Insert Table 2 about here

On Day 1 32 of the 54 SS gave no CRs at all. Because of this low level of responding, differences among the group means on Day 1 are at best only suggestive of underlying directional trends.

By Day 2 all but 5 animals were responding and differences among the Day 2 means are therefore likely to be more reliable. A significantly greater percentage of CRs was obtained from groups in which CS+ had been paired with either food or shock (+F & +S) than from groups in which CS+ had been presented alone (+N), $t(52) = 1.83$, $p < .05$. Inspection of the Day 2 data in Table 1 revealed that overall level of responding was lower when CS- had been paired with food or shock prior to conditioning than when it was presented alone, $F(2,45) = 5.25$, $p < .01$. The direction of this difference was especially pronounced in the groups in which CS+ had been presented alone, less so when CS+ had been paired with food and completely absent when CS+ had been paired with shock. On Day 2 group FF yielded significantly fewer CRs (% CR pooled over CS+ and CS-) than the control group NN, $t(10) = 2.48$, $p < .05$. Comparisons of group SS with FF and of SS with NN were not significant.

Phase II, Differentiation. Figure 1 shows differentiation (percentage of CRs to CS+ minus percentage of CRs to CS-) pooled over days as a function of history of CS+.

Table 2
Summary of t tests

<u>Comparison</u>	<u>t</u>	<u>df</u>	<u>p</u> (one-tailed)
Day 1			
% CR			
SS vs FF	2.45	10	<.05
FF vs NN	1.66	10	>.05
SS vs NN	.12	10	>.05
FN vs NN	.64	10	>.05
SN vs NN	1.67	10	>.05
Day 2			
% CR			
FF vs NN	2.48	10	<.05
SS vs FF	1.59	10	>.05
SS vs NN	.63	10	>.05
+N vs (+F & +S)	1.83	52	<.05
NN vs (NF & NS)	3.45	16	<.005
Differentiation (% CR to CS+ minus % CR to CS-)			
Pooled Over Days			
+S vs +F	.14	34	>.05
+F vs +N	1.73	34	<.05
+S vs +N	1.94	34	<.026
+N vs (+F & +S)	2.12	52	<.05
SF vs NN	1.90	10	<.05

Table 2
Summary of t tests (cont'd)

<u>Comparison</u>	<u>t</u>	<u>df</u>	<u>p</u> (one-tailed)
Differentiation (% CR to CS+ minus % CR to CS-)			
Day 1			
+F vs +S	.02	34	>.05
+F vs +N	1.07	34	>.05
+S vs +N	.99	34	>.05
+N vs (+F & +S)	1.09	52	>.05
<hr/>			
Differentiation (% CR to CS+ minus % CR to CS-)			
Day 2			
+F vs +S	1.04	34	>.05
+F vs +N	1.38	34	>.05
+S vs +N	2.67	34	<.025
+N vs (+F & +S)	2.23	52	<.025

 Insert Fig. 1 about here

Figure 1 indicates that differentiation was significantly poorer when CS+ had been presented alone during Phase I, $t(52) = 2.12$, $p < .05$. Results of independent t test comparisons of groups +F with +N, of +S with +N and of +N with (+F & +S) combined are included in Table 2. Highly reliable differentiation between CS+ and CS- was obtained (See Appendix 3). Figure 2 presents the mean percentage of CRs to each of the stimuli for each group pooled over the days of acquisition. Greatest mean difference in

 Insert Fig. 2 about here

percentage of CRs to CS+ and CS- was obtained from group SF. Comparison of this group with the control group NN yielded $t(10) = 1.90$, $p < .05$. Smallest mean difference was obtained from group NS. A comparison of this group with the control group failed to achieve significance.

Table 3 presents the mean difference score (percentage of CRs to CS+ minus percentage of CRs to CS-) for each group on each day of conditioning. Although the mean difference on Day 1 was

 Insert Table 3 about here

slightly larger in those groups in which CS+ had been paired with food or shock during Phase I, as compared to those groups in which the CS+ had been presented alone, t tests indicated that

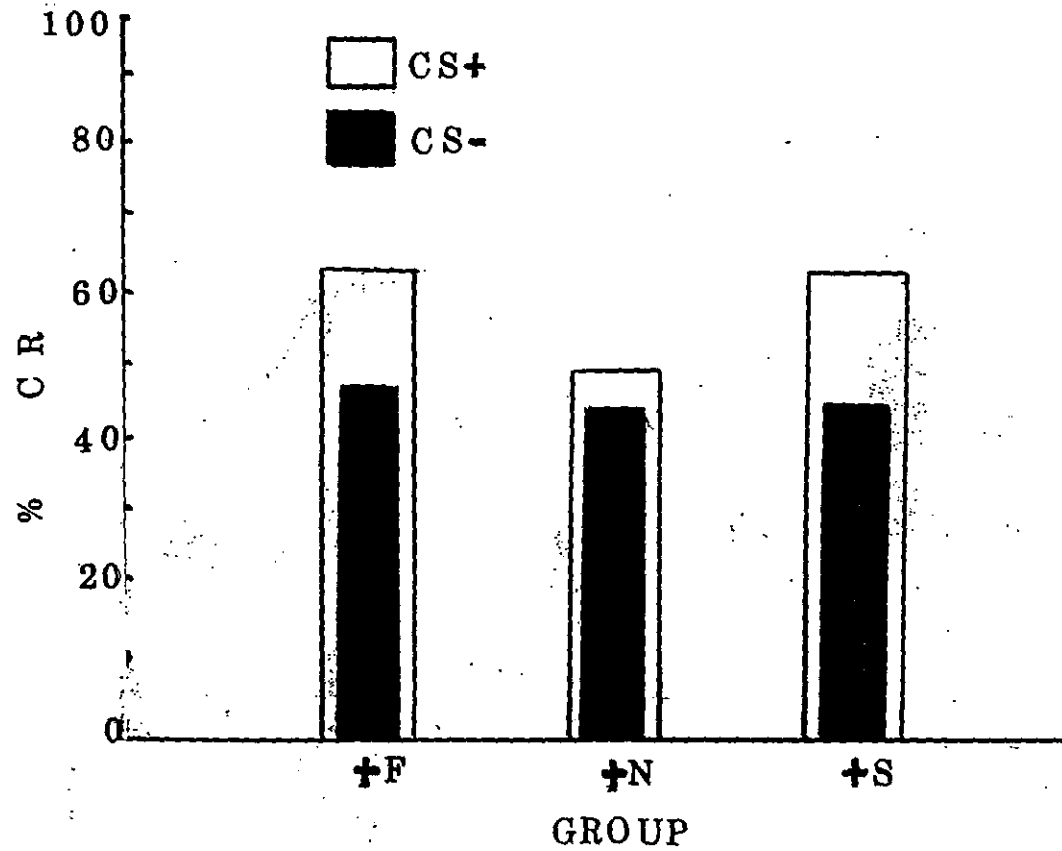


Figure 1

Differentiation Pooled Over Days

as a Function of History of CS+

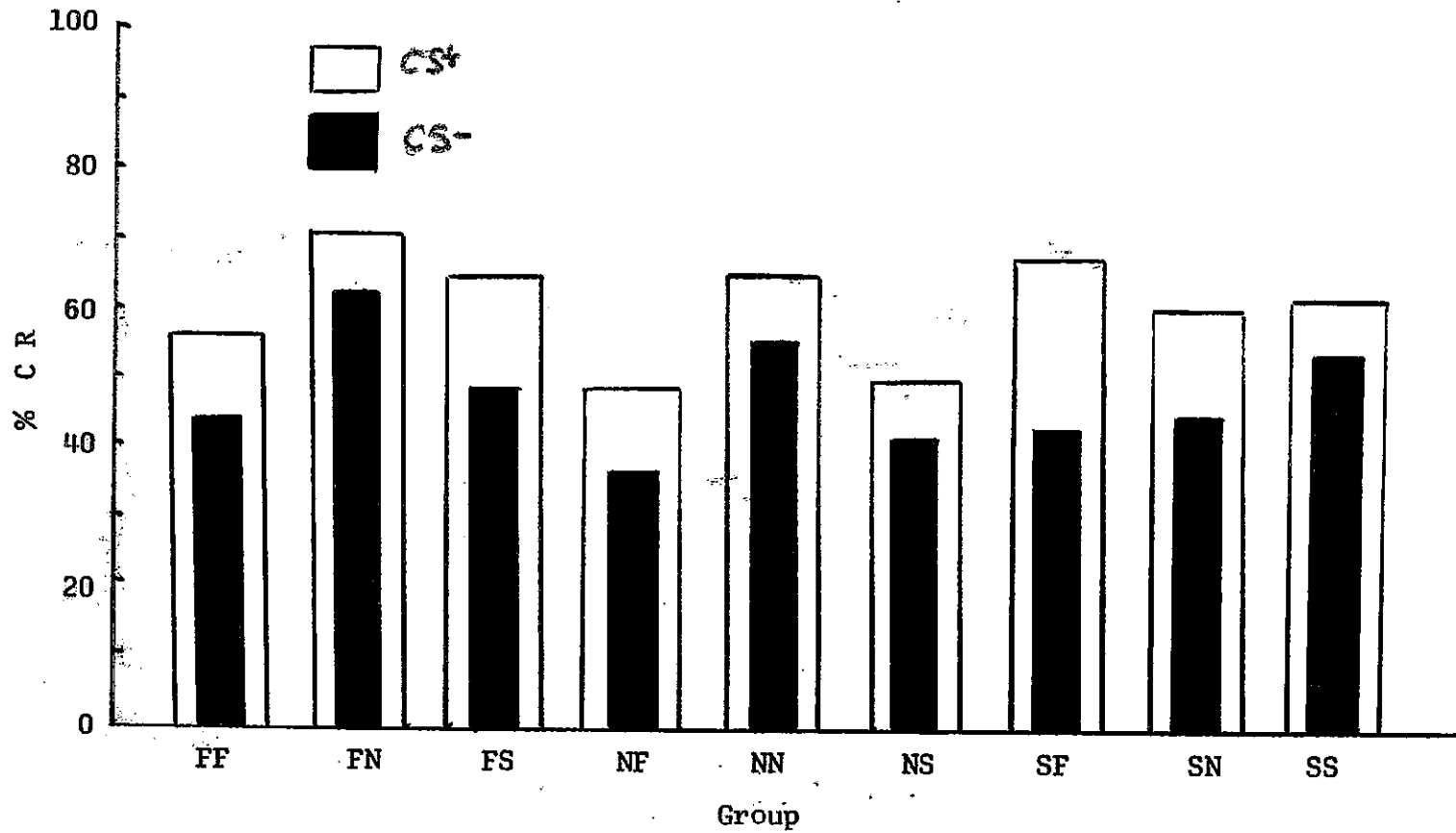


Figure 2

Mean Percentage CRs to CS+ & CS-

Pooled Over Days

Table 3
 Mean Difference Scores for
 Each Day of Conditioning

		Day 1				Day 2				
		History of CS-				History of CS-				
		F	N	S	\bar{X}	F	N	S	\bar{X}	
History of CS+	F	.28	13.34	.83	4.86	F	21.11	16.84	12.50	16.81
	N	0.00	5.28	1.39	2.22	N	5.83	5.28	14.44	8.52
	S	10.83	.56	3.33	4.91	S	38.33	24.72	10.28	24.44
	\bar{X}	3.70	6.39	1.85		\bar{X}	21.76	15.61	12.41	
		Day 3				Day 4				
		History of CS-				History of CS-				
		F	N	S	\bar{X}	F	N	S	\bar{X}	
History of CS+	F	13.33	16.67	35.33	21.78	F	15.83	30.00	27.22	24.35
	N	9.45	12.78	9.17	10.47	N	24.94	15.00	4.74	14.89
	S	20.83	13.61	21.11	18.52	S	35.56	22.83	18.83	25.57
	\bar{X}	14.54	14.35	21.87		\bar{X}	25.17	22.61	16.76	

these differences were not significant. Contrary to expectation, the greatest mean difference in percentage of CRs to CS+ and CS- was not obtained from group SF but rather from group FN.

Differences among the means on Day 1 are likely to be somewhat unreliable because of the overall low level of responding.

On Day 2 the greatest mean difference in percentage of CRs to CS+ and CS- was obtained from those groups in which shock had been paired with CS+ during Phase I (+S) and the smallest mean difference from groups in which CS+ had been presented alone (+N). A comparison of the mean differences between +N and combined groups (+F and +S) yielded $t(52) = 2.23$, $p < .05$. The greatest degree of differentiation was obtained from group SF. A comparison of this group with the control group NN yielded $t(10) = 3.44$, $p < .01$. However, pairing CS+ with shock and CS- with food during Phase I (SF) did not enhance differentiation any more than did the procedure of pairing the CS+ with shock and presenting the CS- alone (SN).

Analysis of variance on the data from Day 3 and Day 4 indicated that there were no significant main effects as a function of history of CS+ or of history of CS-, nor did these variables interact significantly. Percentage of CRs to CS+ and CS- for each \underline{S} for each day of conditioning is presented in Appendix 4.

Phase II, Extinction. Analysis of variance on the extinction data revealed that there was a significantly greater percentage

of CRs to CS+ than to CS- (67.22% vs 43.93%), $F(1,45) = 83.56$, $p < .01$. There were no main effects as a function of either history of CS+ or of CS- nor did the two interact significantly. Percentage of CRs to CS+ and CS- for each S is included in Appendix 4.

Phase II, Latency. Table 4 presents the mean latency in msec. to CS+ and to CS- for each group pooled over the four days of acquisition and for each group during extinction. Table 4

 Insert Table 4 about here

shows that latencies of CRs to CS- were consistently longer than were latencies of CRs to CS+. During acquisition mean latency for CRs to CS+ was 219 msec. and to CS- 233 msec. During extinction, mean latency was 202 msec. to CS+ and 218 msec. to CS-.

DISCUSSION

The major findings of the present study were the following:

a. Pairing a tone with either food or shock prior to differential conditioning led to greater level of total responding and better differentiation than prior presentation of that tone alone.

b. The first CR occurred significantly sooner when the CS+ had been paired with either food or shock prior to conditioning than when that tone had been presented alone.

c. As predicted by Estes' theory, Ss in group SS did give

Table 4
Mean Latency in Msec.

		Acquisition				
		History of CS-				
		F	N	S	\bar{X}	
History of CS+	F	+	214	209	213	212
		-	255	225	226	235
	N	+	229	212	229	223
		-	240	215	244	233
	S	+	229	219	217	222
		-	254	233	234	240
	\bar{X}	+	224	213	220	
		-	250	224	235	
			Extinction			
			History of CS-			
			F	N	S	\bar{X}
	History of CS+	F	+	201	190	225
-			222	204	227	218
N		+	205	198	193	198
		-	232	206	204	214
S		+	195	190	220	202
		-	219	205	240	221
\bar{X}		+	200	193	213	
		-	224	205	224	

significantly more responses on the first day of acquisition than did Ss in group FF, but contrary to prediction, these groups did not yield the extreme scores on Day 1. The level of responding of the control group NN on Day 1 was significantly higher than that of group FF but did not differ significantly from the level of responding of group SS. Also, as predicted from Estes' theory, the greatest mean difference in percentage of responses to CS+ and CS- was obtained from group SF. Differentiation in this group was no better, however, than in the group in which the CS- had been presented alone (SN).

There was little conclusive evidence that the particular motivational sign of the CS, whether rewarding or aversive, had a major effect on either the rate of conditioning or on differentiation in the present experimental situation. According to Estes' theoretical position, pre-pairing both stimuli of a differential classical conditioning situation with shock prior to conditioning might be expected to provide the maximum input of negative amplifier elements. Summation of these amplifier elements with those provided by the noxious UCS of the conditioning situation should presumably lead to optimal performance. This was clearly not the case. Animals which had experienced these conditions did not show the greatest level of responding on Day 1 nor did they require, on the average, fewer trials before the appearance of the first conditioned response.

Pre-pairing both of the stimuli with food prior to conditioning did lead to a low level of initial responding relative to the control group. The lowest percentage of responses on Day 1, however, was found in group SN. According to both Estes' (1969) and Bindra's (1968) theoretical positions, conditions in group SN, that is CS+ prepaired with shock, should have facilitated acquisition of conditioned responses.

Pre-pairing food with CS- appeared to depress overall responding somewhat. The direction of this difference was present in the percentage of responses pooled over days but was significant only on Day 2. In addition, the data from Day 2 indicated that responding was also attenuated when the CS- had been pre-paired with shock, a condition which might be expected to have facilitated responding.

Rather than supporting the opposing systems type of theory espoused by Estes and Bindra, the important features of this data can be better understood in terms of an acquired distinctiveness notion (Lawrence, 1949) whereby biologically important events (e.g., food or foot shock) paired with cues enhances transfer. When the CS+ signalled another stimulus during Phase I, that is, signalled food or shock, the first CR occurred sooner, the overall percentage of responses to CS+ and CS- was greater and differentiation was better than when the CS+ had been presented alone. Conversely, when the CS- had signalled another stimulus, responding was attenuated but differentiation did not

appear to be affected. It appeared that the previous history of CS+ was the more important factor in subsequent conditioning and differentiation.

It is surprising that the opposing motivational properties of the food and shock, positive in the case of food and negative in the case of shock, had no differential effects in the present situation. It is as though performance in the classical conditioning situation were a function of one, non-specific generalized drive or activation system rather than a result of the interaction of two opposing systems, one positive and one negative, as suggested by Both Estes and Bindra.

Such a view is not inconsistent with the major postulate of the version of two-process theory espoused by Rescorla and Solomon, that is, that Pavlovian conditioning of a central nervous system state mediates instrumental behavior. Rescorla and Solomon's (1967) analysis of two-process theory was based on studies in which transfer was obtained between a Pavlovian conditioning situation and subsequent instrumental training. Although two-process theory does not preclude the possibility of other types of inter-situational transfer, Rescorla and Solomon did not consider such paradigms in their classificatory schema. The present study as well as that of Ashton (1968) provides evidence for transfer in a classical appetitive - classical aversive case.

The results of the present study differ from Ashton's findings. In that study, negative transfer was obtained in that those animals which showed the best differentiation in the operant phase of training yielded the poorest differentiation in the subsequent classical conditioning situation. In contrast, in the present study performance was enhanced when CS+ had been paired with food rather than attenuated. Ashton's procedure required the animals to perform an operant barpressing response in order to obtain a food reinforcer while in the present study, no such response was necessary to produce a food pellet.

Various methodological techniques might be employed to enhance transfer in the present case. It is possible that the additional drive stimuli provided by the proprioceptive feedback from operant responses such as barpressing to produce food and/or to escape shock might act in such a way as to enhance discrimination between the motivational properties of the food and shock. Much can also be done with the order of presentation of the training conditions of Phase I and Phase II, for example, alternating sessions rather than presenting them in succession.

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Appendix 1
 Percentage of Food Pellets
 Consumed During Phase I

<u>Group</u>	<u>S</u>	<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>	<u>Day 4</u>
FF	1	38.33	66.67	65.00	76.67
	2	96.67	98.33	100.00	100.00
	3	83.33	100.00	100.00	100.00
	4	95.00	100.00	100.00	100.00
	5	83.33	96.67	98.33	100.00
	6	<u>75.00</u>	<u>100.00</u>	<u>98.33</u>	<u>100.00</u>
	X	74.44	93.61	93.61	96.11
FN	1	40.00	63.33	100.00	100.00
	2	73.33	96.67	100.00	100.00
	3	93.33	100.00	100.00	96.67
	4	83.33	100.00	93.33	100.00
	5	50.00	90.00	76.67	76.67
	6	<u>80.00</u>	<u>96.67</u>	<u>100.00</u>	<u>100.00</u>
	X	70.00	91.11	95.00	95.56
FS	1	3.33	73.33	83.33	90.00
	2	100.00	100.00	96.67	100.00
	3	96.67	100.00	100.00	100.00
	4	96.67	100.00	96.67	100.00
	5	93.33	100.00	100.00	86.67
	6	<u>96.67</u>	<u>100.00</u>	<u>100.00</u>	<u>93.33</u>
	X	81.11	95.56	96.11	95.00
NF	1	13.33	90.00	96.67	100.00
	2	36.37	80.00	86.67	93.33
	3	46.67	43.33	83.33	83.33
	4	50.55	96.67	96.67	93.33
	5	96.67	100.00	100.00	100.00
	6	<u>66.67</u>	<u>76.67</u>	<u>93.33</u>	<u>90.00</u>
	X	51.67	81.11	92.78	93.33
SF	1	80.00	83.33	93.33	86.67
	2	73.33	96.67	100.00	100.00
	3	86.67	96.67	100.00	96.67
	4	90.00	90.00	100.00	96.67
	5	100.00	100.00	100.00	100.00
	6	<u>73.33</u>	<u>100.00</u>	<u>96.67</u>	<u>100.00</u>
	X	83.89	94.45	97.78	96.67
	X	73.22	91.17	95.06	95.33

Appendix 2

Trial Number of First CR

		History of CS-			\bar{X}
		F	N	S	
History of CS+	F	143	48	158	108.67
		279	131	123	
		61	62	13	
		153	74	48	
		185	149	143	
		<u>30</u>	<u>29</u>	<u>129</u>	
		$\bar{X}=142$	$\bar{X}=82$	$\bar{X}=102$	
	N	36	115	153	164.33
		329	11	102	
		164	83	162	
167		339	265		
260		131	181		
	<u>194</u>	<u>77</u>	<u>189</u>		
	$\bar{X}=192$	$\bar{X}=126$	$\bar{X}=175$		
S	92	131	77	115.33	
	121	159	56		
	198	161	31		
	108	98	55		
	92	138	188		
	<u>47</u>	<u>149</u>	<u>175</u>		
	$\bar{X}=110$	$\bar{X}=139$	$\bar{X}=97$		
\bar{X}	148.00	115.67	124.67		

Appendix 3
 Summary of F Ratios Based On
 Percentage CR Data¹

<u>Source of Variation</u>	<u>df</u>	<u>Day 1</u>	<u>Day 2</u>	<u>Day 3</u>	<u>Day 4</u>
History of CS+ (A)	2	.22	2.24	1.73	.22
History of CS- (B)	2	.91	5.25*	.31	1.68
CS+ vs CS- (R)	1	12.77**	40.05**	32.09**	51.49**
A x B	4	2.28	2.72*	.47	1.64
A x R	2	.51	3.17	1.20	.71
B x R	2	1.44	1.17	.77	1.00
A x B x R	4	3.33*	1.43	.65	1.40

<u>Source of Variation</u>	<u>df</u>	<u>Pooled Over Days</u>	<u>Extinction</u>
History of CS+ (A)	2	1.18	.99
History of CS- (B)	2	1.87	.87
CS+ vs CS- (R)	1	60.73**	83.56**
A x B	4	1.08	2.00
A x R	2	1.94	.86
B x R	2	.32	1.04
A x B x R	4	.90	.24

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

¹ These F ratios were taken from a larger design that included as sources of variation Day and Trial Block effects which were not of particular interest.

Appendix 4

Mean Percentage CRs to CS+ and CS-

for Each Subject

Group	S	Day 1		Day 2		Day 3		Day 4		Extinction	
		CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
FF	1	0.00	1.67	36.67	10.00	91.67	80.00	91.67	85.00	84.00	76.00
	2	0.00	0.00	21.67	3.33	96.67	88.33	98.33	75.00	58.00	26.00
	3	0.00	0.00	63.33	3.33	90.00	65.00	98.33	50.00	58.00	22.00
	4	0.00	0.00	0.00	0.00	56.67	31.67	98.33	93.33	78.00	40.00
	5	3.33	0.00	63.33	41.67	91.67	88.33	96.67	93.33	92.00	78.00
	6	0.00	0.00	56.67	56.67	98.33	91.67	95.00	86.67	86.00	72.00
FN	1	51.67	30.00	95.00	98.33	93.33	98.33	100.00	96.67	88.00	86.00
	2	0.00	0.00	51.67	46.67	75.00	71.67	33.33	8.33	74.00	58.00
	3	40.00	36.67	100.00	93.00	98.33	93.33	95.00	85.00	74.00	66.00
	4	31.67	1.67	96.67	93.33	83.33	55.00	83.33	71.67	82.00	46.00
	5	0.00	0.00	73.33	3.33	91.67	25.00	83.33	16.67	94.00	24.00
	6	55.00	44.00	96.67	81.67	95.00	93.33	90.00	26.67	56.00	30.00
FS	1	0.00	0.00	60.00	6.67	100.00	28.33	96.67	50.00	82.00	32.00
	2	0.00	0.00	96.67	98.33	96.67	95.00	98.33	96.67	62.00	52.00
	3	0.00	0.00	11.67	3.33	60.00	41.67	93.33	68.33	68.00	24.00
	4	0.00	0.00	80.00	73.33	91.67	66.67	95.00	90.00	6.00	0.00
	5	0.00	0.00	86.67	86.67	68.33	41.67	90.00	80.00	52.00	20.00
	6	60.00	55.00	100.00	91.67	98.33	28.33	98.33	23.33	18.00	4.00
NF	1	50.00	50.00	83.33	81.67	80.00	78.33	75.00	63.33	62.00	38.00
	2	0.00	0.00	0.00	0.00	3.33	0.00	95.00	85.00	88.00	88.00
	3	0.00	0.00	1.67	0.00	40.00	16.67	85.00	61.67	38.00	24.00
	4	0.00	0.00	41.67	31.67	91.67	91.67	91.67	93.33	74.00	78.00
	5	0.00	0.00	0.00	0.00	76.67	58.33	93.33	53.33	84.00	20.00
	6	0.00	0.00	21.67	0.00	95.00	85.00	98.33	35.00	88.00	30.00

Appendix 4

Mean Percentage CRs to CS+ and CS-

for Each Subject (cont'd)

<u>Group</u>	<u>S</u>	Day 1		Day 2		Day 3		Day 4		Extinction	
		CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
NN	1	66.67	48.33	96.67	86.67	93.33	33.33	91.67	41.67	90.00	58.00
	2	3.33	1.67	85.00	76.67	96.67	100.00	100.00	100.00	72.00	60.00
	3	15.00	5.00	91.67	91.67	91.67	95.00	98.33	100.00	100.00	96.00
	4	0.00	0.00	0.00	0.00	8.33	0.00	78.33	71.67	30.00	44.00
	5	0.00	0.00	83.33	71.67	85.00	75.00	80.00	51.67	38.00	22.22
	6	23.33	21.67	91.67	93.33	96.67	91.67	98.33	91.67	44.00	38.00
NS	1	0.00	0.00	55.00	46.67	91.67	90.00	95.00	96.67	94.00	92.00
	2	11.67	3.33	68.33	16.67	91.67	43.33	91.67	68.33	56.00	18.00
	3	0.00	0.00	0.00	0.00	11.67	18.33	80.00	68.33	34.00	22.00
	4	0.00	0.00	11.67	3.33	86.67	83.33	91.67	90.00	84.00	62.00
	5	0.00	0.00	20.00	6.67	96.67	83.33	95.00	96.67	94.00	64.00
	6	0.00	0.00	8.33	3.33	83.33	83.33	93.33	98.33	92.00	86.00
SF	1	5.00	1.67	63.33	56.67	98.33	88.33	90.00	63.33	60.00	54.00
	2	0.00	0.00	41.67	11.67	93.33	83.33	80.00	53.33	46.00	22.00
	3	0.00	0.00	33.33	11.67	80.00	76.67	96.67	100.00	78.00	38.00
	4	6.67	0.00	95.00	36.67	100.00	43.33	100.00	66.67	98.00	50.00
	5	60.00	20.00	96.67	50.00	98.33	58.33	93.33	36.67	32.00	6.00
	6	11.67	1.67	100.00	33.33	100.00	95.00	96.67	23.33	42.00	4.00
SN	1	0.00	0.00	68.33	56.67	100.00	93.33	95.00	98.33	40.00	22.00
	2	0.00	0.00	45.00	13.33	98.33	91.67	63.33	1.67	76.00	64.00
	3	3.33	0.00	43.33	25.00	85.00	81.67	98.33	96.67	70.00	60.00
	4	0.00	0.00	60.00	40.00	95.00	96.67	96.67	71.67	82.00	78.00
	5	0.00	0.00	81.67	71.67	95.00	85.00	85.00	78.33	82.00	56.00
	6	0.00	0.00	68.33	11.67	76.67	20.00	83.33	35.00	54.00	8.00

Appendix 4

Mean Percentage CRs to CS+ and CS-

for Each Subject (cont'd)

<u>Group</u>	<u>S</u>	Day 1		Day 2		Day 3		Day 4		Extinction	
		CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-	CS+	CS-
	1	15.00	0.00	76.67	35.00	83.33	55.00	100.00	66.67	64.00	40.00
	2	23.33	18.33	100.00	98.33	90.00	26.67	95.00	85.00	62.00	24.00
SS	3	18.33	26.67	68.33	75.00	96.67	96.67	83.33	73.33	42.00	22.00
	4	38.33	30.00	96.67	98.33	96.67	96.67	96.67	71.67	82.00	78.00
	5	0.00	0.00	40.00	15.00	90.00	93.33	98.33	81.67	64.00	48.00
	6	0.00	0.00	1.67	0.00	83.33	45.00	95.00	68.33	92.00	56.00