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PRECONDITIONING STIMULI INTENSITIES AND THE MAGNITUDE OF SENSORY PRECONDITIONING IN RATS

by

PETER D. McLEAN
B.A., University of Windsor, 1965

A Thesis
Submitted to the Faculty of Graduate Studies
through the Department of Psychology in
Partial Fulfillment of the Requirements
for the Degree of Master of Arts at
University of Windsor

Windsor, Ontario, Canada
1966

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ABSTRACT

Fifty-four rats were used in a factorial study of the magnitude of sensory preconditioning (SPC) as a function of preconditioning stimuli intensities. The method used to measure the strength of SPC was a conditioned emotional response (CER) presented so as to interfere with the animals's performance on another conditioned response, bar-pressing, during critical test periods. The independent variable manipulated was the intensity of the preconditioning stimuli. The preconditioning stimuli had three intensities, and every combination resulted in a different treatment group,. eighteen in all (nine experimental, nine control).

It was found that the Experimental groups gave significantly fewer bar-press responses during the Transfer test than did the Control group. It was concluded that, although SPC had been demonstrated, this interpretation was contingent upon a pronounced sex difference in the second critical ("CS") test. That is, the males were much more sensitive to the SPC procedures than were the females and hence displayed significantly more evidence of the transfer effect.

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The multiple comparisons of the Experimental treatment groups showed that the preconditioning order, tone at low intensity, asynchronously paired with light at high intensity, produced much greater transfer effect than any other intensity combination. This finding is comparable to the results obtained in standard conditioning experiments, in which a weak CS preceding the onset of a strong UCS, generally produces greater strength of response than when the CS and UCS have other intensity values.

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PREFACE

This study was inspired by a pilot study involving sensory preconditioning, undertaken in an undergraduate comparative psychology course.

Dr. Hugh Kirby deserves special acknowledgement for his encouragement and counsel in the development of this study. The author also wishes to express his gratitude to Professor A. A. Smith for his cooperation in providing statistical advice. Similar gratitude must also be extended to Professor V. Cervin and Dr. H. McCurdy for their Counsel.

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CHAPTER I

INTRODUCTION

Pavlov (1927) conditioned a salivation response in a dog to the periodic onset of a light, such that the conditioned stimulus (CS), light, when presented alone would elicit the response. He then presented a second stimulus, tone, in conjunction with the original CS, light, for a number of trials. After this training was completed (pairing light and tone), it was then shown in test trials that the tone alone elicited the salivation response, although with less magnitude than the response evoked by the original CS, light. A variation of this procedure, called Sensory Conditioning, in which the first and second order stimuli were presented together, prior to conditioning proper, was attempted by several experimenters, using human subjects (Prokofiev and Zeliony, 1926; Kelly, 1934; Carson, 1936; Bogoslavski, 1937). After a specified number of pairings of the two stimuli, first order conditioning (light eliciting the salivation response, in the above example) was then established to one of the stimuli. Tests were then

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administered to see if the second order stimulus (tone eliciting the salivation response in the above example) would produce the same conditioned response. These experimenters, however, could draw no reliable conclusions regarding the effectiveness of this procedure since control subjects had not been employed. As a result, it could not be determined whether the effects of stimulus generalization and familiarity with the second order stimulus were contributing to the magnitude of response elicited by the second order stimulus. Hence, no reliable demonstration of Sensory Conditioning had been established.

Brogden (1939), following the reasoning of the sensory conditioning experiment and utilizing more refined procedures, designed an experiment to answer the following question: "... if an organism be given successive experiences of two temporally simultaneous stimuli exciting two sense modalities without evoking any observable response, and if after this contiguous sensory experience, one stimulus be made a conditioned signal for the activity of a given behavioral system by appropriate training, will the other elicit a similar conditioned response without the usual training?" (p. 323).

In this classic experiment, eight dogs were placed

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in a sound-proofed and light-shielded experimental chamber. The experimental dogs were presented with the sound of a bell and the flash of a light in combination for two seconds. Twenty of these stimulus combinations were given daily for ten successive days. The eight dogs were then randomly distributed to one of two groups. Left forelimb flexion, with shock as the unconditioned stimulus (UCS), was conditioned to bell in one group (group BE). The bell sounded for two seconds and was followed immediately by the shock which continued for 1/10 of a second. The second group (group LE) was conditioned to the left forelimb flexion response in the same manner except the conditioned stimulus (CS) was light. Conditioning proceeded at the rate of 20 trials per day until the CS (either light or bell) evoked the leg-flexion response, thereby avoiding the shock. Then, after the conditioned flexion response reached 100 per cent (20 shock-avoidance flexion responses in one test period) in the BE group (conditioned to Bell), it was given 20 trials of Light alone each day until it no longer produced the flexion response. Group LE (conditioned to Light), on the other hand, was given 20 trials of Bell alone until the flexion response was extinguished.

Two control groups, consisting of four dogs each,

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were employed in order to test for stimulus generalization. One group, BC, was trained in the same manner as the BE group in the shock-avoidance leg-flexion response. The day after the successful completion of this response (100 per cent avoidance), light was presented alone for 20 trials per day until the avoidance response was extinguished. Similarly, the other control group, LC, was trained to avoid shock by making the leg-flexion response, except the conditioned stimulus in this case was light. After training, group LC was presented with bell alone for 20 trials per day until the avoidance response was extinguished.

The results revealed that both experimental groups (BE and LE) made a significant number of leg-flexion responses to the stimulus not directly associated with the shock, whereas neither control group (BC and LB) did. Brogden concluded that the flexion response, elicited by the stimulus not associated with shock, must be due to the prior association of light and bell. He inferred that the experimental Ss, by virtue of the initial continuous presentation of the two preconditioning stimuli, had formed some kind of "bond" or "link" between the two, whereas the control groups, which had had no such pairings, made no such association.

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Brogden called this learning phenomenon "Sensory Preconditioning".

The sensory preconditioning (SPC) paradigm consists of the following three phases: (1) repeated contiguous, unreinforced presentation of stimuli, (e.g. light and tone); (2) establishing a response to one of these stimuli (e.g. light); and (3) testing for the transfer of the response to the other stimulus, (tone).

Since Brogden's initial study, there have been several others reported in the literature that will be reviewed here. Although there have been several SPC experiments conducted, using human subjects, it is felt that cross-species differences such as the human's capacity for verbal response mediation, may make direct comparisons misleading. Therefore, only animal studies will be discussed (for a more thorough review of the relevant human and animal literature, see Seidel, 1958; Kirby, 1963).

Partial Review of the SPC Animal Studies

Of the twenty studies of SPC so far reported, half of them have used animal subjects. The five studies reviewed here have been selected as the most informative and representative. Only one animal study of the ten reported in the

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literature failed to provide positive evidence for SPC. This study will be reviewed first.

Reid (1952) conducted an experiment to show that the SPC effect, originally reported by Brogden, may have been due to a faulty control procedure. More specifically, he speculated that as the control subjects (Ss) in Brogden's original study had had no experience with the transfer test stimulus in the preconditioning phase, as compared to the experimental Ss, the transfer effect may have been due to differences in familiarity with the transfer test stimulus, favouring the experimental group, and thus biased the results. His experiment included this control procedure; i.e., he exposed the control Ss to the transfer test stimulus during preconditioning training.

Reid distributed sixteen pigeons to four groups (two experimental groups and two control groups of four Ss each). In phase one, the experimental Ss received 200 paired presentations of light and buzzer for 1½ sec. duration each (see Table I). In the second phase, half of the experimental Ss, (group BE) were trained to make a pecking response to criterion (pecking for a food reward on 24 of 25 trials within 5 sec. of the termination of the buzzer CS). The

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other half of the experimental subjects (group LE), were trained identically except the CS was light, rather than buzzer. In the third, or test phase, administered immediately after the training criterion had been reached, the transfer test stimulus (buzzer for the LE group and light for the BE group) was presented 25 times under the same conditions as in training, except no reinforcement was given. The design of the experiment is shown in Table 1.

Table 1

Stimulus Conditions
(Reid, 1952, p.25)

Phase	Buzzer Control	Light Control	Buzzer Experimental	Light Experimental
I Pre-training	L	B	(B+L)	(B+L)
II Training	B	L	B	L
III Test	L	B	L	B

The two control groups (BC and LC) had the same treatment throughout the three phases as had their respective experimental comparison group (see Table 1 above), except that in the first phase, only one of the two preconditioning stimuli (light for the BC group and tone for the LC group) was presented.

The results provided no evidence for any effect of

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the contiguous presentation of stimuli given to the experimental groups. It was concluded that these negative findings indicated the unsatisfactory nature of Brogden's (1939) original experimental design (i.e., lack of control for stimulus generalization).

Howarth (1960), in another study of the SPC phenomenon, tested the effect of both the temporal separation and the contiguous pairing of the preconditioning stimuli, utilizing the control procedures suggested by Reid. Thirty animals were distributed to three groups of ten Ss each. Group I, the temporally concurrent group, received 500 paired presentations of light and sound in one, 125-minute period. Group II, the temporally spaced group, received 500 separate presentations of light and sound which were never concurrent (7.5 sec. between presentations). Group III, the control group, received no stimulus presentations during the first phase; however, they were placed in the experimental apparatus for the same period of time as the other two groups (125 mins.). Immediately after the preconditioning phase, all groups were trained to avoid shock by jumping a hurdle within 2 sec., following the onset of the CS, light. The criterion for learning was 10 successive avoidance responses. In the third, or test phase, sound was substituted

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for light as the CS, and the amount of transfer effect was measured by training the animal to the same learning criterion as in phase II. Howarth's results indicate that the temporally concurrent group (Group I) showed the preconditioning effect, whereas the temporally spaced and the control groups (Groups II and III, respectively), did not. It was concluded that SPC had been demonstrated and that Reid's criticism was unjustified.

Silver and Meyer (1954) conducted the first animal SPC study within a learning theory framework (for a discussion of the theoretical interpretation of the SPC experiment, see below). Their experiment was derived from an interpretation of the SPC experiment as a type of mediated stimulus generalization. The authors reasoned that the presentation of paired preconditioning stimuli in the preconditioning phase is likened to classical conditioning. Each stimulus is considered to be an unconditioned stimulus (UCS) for a response that is not directly observed, and each is potentially a CS for a second response, similar to the one elicited by the other stimulus. After preconditioning, a response, which resembles the entire complex, follows presentation of either stimulus.

They further reasoned that if an instrumental re-

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sponse is subsequently conditioned to one of these stimuli, several invariant stimuli are present. These include the stimulus itself, stimuli derived from its UCR, and stimuli derived from its CR. Since the latter stimuli are presumably similar to those produced by the UCR to the other preconditioning stimulus, the presentation of this stimulus could be expected, in critical tests, to yield positive transfer.

Silver and Meyer randomly assigned 120 rats to six groups, three control and three experimental, of 20 Ss each. The first control group received no preliminary training. The second control group was exposed to a pseudo-conditioning series of 3000 buzzer presentations during a period of 4 hr. 20 min. The third, another pseudo-conditioning control group, was presented with light instead of a buzzer for 3000 presentations. All three control groups were then divided into sub-groups of ten animals each. Half of these animals were then conditioned to run to light and tested for transfer to buzzer, and half were conditioned initially to buzzer and tested for transfer to light.

The first experimental group was given preliminary training which consisted of 3000 simultaneous presentations of buzzer and light (called simultaneous preconditioning).

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After this training, half of the rats of this group were conditioned to run to light and tested for transfer to buzzer; the other half was conditioned initially to buzzer and tested for transfer to light.

The second experimental group was divided into two sub-groups from the beginning. The first sub-group, in preconditioning, received light, followed by buzzer, for 3000 trials. These Ss were then trained to run to buzzer and tested for transfer to light. The remaining half of the second experimental group was first exposed to buzzer, followed by light, and then was conditioned to light and tested for transfer to buzzer (called forward preconditioning).

The temporal relations of the preconditioning phase of experimental group II (forward preconditioning) were reversed for experimental group III (backward preconditioning), while all other stimulus presentation procedures remained the same.

The results demonstrated the transfer effect to an extent that cannot be attributed to pseudo-conditioning. It was found also that the temporal relationship of stimuli presentation in preconditioning affects the amount of transfer that is obtained. The forward presentation procedure, in preconditioning, was superior to either the backward or

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the simultaneous presentation procedures. Silver and Meyer concluded that, although the mediating CR remained obscure, conditions designed to facilitate its fixation resulted in increments in SPC of the kind to be expected.

It should be noted that SPC is an inferred concept. In standard conditioning, for example, effective conditioning is behaviorally observable from the conditioned response elicited by the CS presentations. In the preconditioning phase of SPC experiment, there is no observable response, indeed none is specified. The SPC paradigm, therefore, always includes a standard conditioning procedure (phase II of the SPC paradigm), using one of the preconditoning stimuli as the CS. The effect is then measured by substituting the other preconditioned stimulus in the transfer test (phase III of the SPC paradigm). If such response transfer takes place, it is inferred that SPC has been demonstrated. It should be noted that whether SPC is, or is not demonstrated depends, among other things, upon the standard conditioned response.

Kirby (1963) was the first to report the use of a Conditioned Emotional Response (CER) or fear-conditioning as a measure of SPC. In this experiment, 32 rats learned a bar pressing response for food reinforcement in a standard

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Skinner box. After the learning criterion was reached, the animals were randomly distributed into eight groups, four experimental and four control. During the preconditioning phase, the first experimental group received 200 asynchronous presentations of buzzer and light. That is, the stimuli were overlapped, the onset of the second stimulus following 2 sec. after the onset of the first, then both stimuli terminated simultaneously another 2 sec. later. The first control group received 200, four sec. presentations of buzzer alone. The second experimental group received the same treatment as the first except it received only 100 stimuli presentations. Similarly, the second control group received the same treatment as control group I but only 100 trials of buzzer were presented. The third experimental group received 200 asynchronous presentations of light and buzzer, while the third control group received 200 presentations of light alone. The last experimental group received 100 asynchronous presentations of light and buzzer, and the last control group 100 presentations of light alone. The Inter Trial Interval (ITI) was constant at 30 seconds for all groups.

In the CER training phase of the experiment, the first two experimental and control groups were each divided into 2 sub groups, the first of each receiving 20 trials of

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light lasting for 4 sec., its offset coinciding with the onset of the UCS (shock) which continued for another 2 sec. (forward conditioning). The second sub group each received 20 trials of the UCS (shock) for 2 sec., its offset coinciding with the onset of the buzzer which continued for another 4 sec. (backward conditioning). The third and fourth experimental and control groups received the same treatment in this phase of the experiment as did experimental and control groups I and II except that they, instead of buzzer, received light as the CS in their respective procedures.

In the transfer test (phase III), the day following CER training, all subjects were again placed in the Skinner box and were allowed to press the bar for a food reward. In this test phase, the first and second experimental and control groups received a 4 sec. presentation of buzzer every 30 sec., beginning 30 sec. after the test session began. The remaining experimental and control groups received the same treatment except light was presented instead of buzzer. Daily test sessions were continued until all fear of the transfer test stimulus was extinguished. The following day, all groups were given a Conditioned Stimulus ("CS") test, in which the Ss were presented with the stimulus that was paired with shock in phase II (CS of original CER training). This

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additional phase, it was rationalized, would provide some basis for comparing the relative strengths of SPC and standard conditioning.

The results indicated that the number of exposures to the paired preconditioning stimuli has little effect upon the magnitude of SPC. The mean drop difference of the experimental (but not the control) subjects in the groups where light preceded buzzer in onset in the preconditioning phase, was significant. This was interpreted as positive evidence for SPC. No such differences between experimental and control groups was found in the case in which buzzer preceded light in onset during the preconditioning phase.

In commenting upon his results, Kirby (1963) was unable to account for these stimuli order presentation differences (i.e., the light-buzzer order producing positive transfer in every case, the buzzer-light order in no case). Whether it resulted from the relative intensities of the two preconditioning stimuli (e.g., weak light CS, strong buzzer UCS, if the preconditioning stimuli are so designated), or to the auditory or visual CS properties in the conditioning of a fear response in CER training, was, and remains, an open question.

There are several remaining animal studies investi-

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gating SPC which will not be reviewed here; however, the variables studied and their findings will be discussed at appropriate times throughout this study.

Theoretical Interpretations of the SPC Experiment

A review of the literature reveals that many facts regarding the demonstration of this, at times elusive phenomenon are known. Some of the findings in the SPC experiment are similar to standard conditioning; others, apparently, are not. Silver and Meyers (1954), for example, report that asynchronous presentation of the preconditioning stimuli facilitates learning, a result that is also found in standard conditioning (e.g. the study of CS-UCS intervals). Contrary to standard conditioning findings, Hoffield et al. (1960), and Kirby (1963), report that once a certain number of preconditioning trials have been given, the effect of continued presentation thereafter seems irrelevant.

On the other hand, SPC has several peculiarities which sets it apart from standard conditioning procedures. In the preconditioning phase, no objective behavioral response is specified by the experimenter. Secondly, another issue clearly defined is that reinforcement, as it is understood in the standard conditioning experiment (Hull, 1943),

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appears to be irrelevant in preconditioned learning. This finding is of particular significance since Hull's formulation of reinforcement (drive reduction) has been controversial in learning theory for many years. Osgood (1953), a S-R (stimulus-response) theorist has conceded that the SPC data provide a strong argument against the notion that reinforcement is a necessary condition for learning.

Some of the SPC literature has been used to refute or to uphold two interpretations of SPC, namely Stimulus-Response (S-R), and Stimulus-Stimulus (S-S) learning theory. Therefore, some discussion of these major theories seems appropriate at this time.

Osgood (1953), has argued that the SPC effect can be ascribed to response mediation. He claims that, "a common perceptual reaction" (e.g. attentional) is elicited initially by the preconditioning stimuli and if one of these is now conditioned to a new reaction (e.g. an avoidance response), the self-stimulation produced by the mediation process (i.e. by the common unobserved UCR) is responsible for the "bond" between the preconditioning stimuli. There are other variations of this S-R explanation (e.g. Coppock, 1958; Mower, 1960) but in all cases there is some unobserved response or image that mediates between the two preconditioned stimuli

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which evoks the conditioned response.

The S-S contiguity theorists, notably Anokhan (1961), Birch and Bitterman (1949), claim that "convergence of heterogeneous stimulations", or "sensory integration" (afferent modification) is responsible for the alleged "link". Birch and Bitterman state that, "When two afferent centers are continuously activated, a functional relation is established between them such that the subsequent innervention of one will arouse the other." (1951, p. 358).

Regarding this theoretical controversy, Seidel (1959) states,

> ... ambiguities lead to the ultimate conclusion that the difficulty in deciding upon the currect functional explanation for the mediating process resolves itself into a pseudo problem for psychology. (p. 67)

Due to these and other considerations, a number of experimenters (Seidel, 1958; Brogden, et al., 1958) maintain that SPC requires another interpretation as a phenomenon of learning. In conclusion, it seems that if SPC deserves independent consideration as a learning phenomenon, as both Seidel and Brogden argue, then the various parameters affecting its magnitude should be systematically varied in order to find the conditions necessary for preconditioned learning to take place, thereby enabling predictions to be formulated.

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The Present Study

This study attempts to overcome one of the parametric deficiencies by the systematic manipulation of the stimuli intensities involved during preconditioning training. It is known that, in standard conditioning, the intensity of the CS affects the magnitude of the response (Razran, 1957; Premack, 1965). However, this variable has not been systematically varied in the SPC experiment. In the present study, tone (at three intensities) will precede the onset of light (also at three intensities). Another experiment at the University of Windsor is being conducted, in which the order of presentation of the preconditioning stimuli is reversed (Skilling, 1966). These two studies, alike in all other respects, offer a parametric approach to the further understanding of the SPC phenomenon.

The null hypothesis pertains throughout the present study for all experimental and control subjects. It is expected then, that the magnitude of SPC, as measured in the Transfer test phase, is not a function of the intensity of the preconditioning stimuli. As the evidence for SPC in this experiment is the difference in Transfer test scores between the experimental and control groups, it is further expected that these scores will not differ significantly.

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CHAPTER II

METHOD

Subjects

Fifty-four rats of the Strague-Dawley strain, 27 male, 27 female, were selected from the University of Windsor Colony. This number of Ss could not be run on one occasion, due to the limitations of cage and experimental space. Consequently, they had to be run in two separate batches. The first batch (N=20 plus spares) were of the third generation of the University of Windsor breeding programme. Their average age at the outset of the experiment was 105 days. The second batch, also of the third generation, contained 34 Ss (plus spares), and their average age was 160 days (age differences between batches, will be discussed fully in the Results section, below). The parental population of these rats was obtained from a reputable breeder (Simonson Laboratories).

In order to avoid a rapid weight loss, the Ss of each batch were subjected to a gradual food reduction schedule over a two-week period, prior to the experiment (see Appendix A for details). After habituation to this

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procedure, all Ss remained on the two hour feeding schedule throughout the experiment. Feeding was arranged by groups such that all animals had been food deprived for the same approximate length of time (22 hours), prior to their particular daily experimental training. All Ss were weighed regularly, prior to, during and after the experiment. An analysis of the periodic weight data showed no excessive loss; however, one S had to be replaced by a "spare" due to rapid weight loss resulting from a broken incisor (tooth).

Apparatus

Two pieces of apparatus were employed; a Skinner box in which bar press response training and the Transfer test took place, and a Sensory Preconditioning box in which preconditioning and CER training were given. The Skinner box was a Grason-Stadler, sound-proofed conditioning chamber (model E3125B) having the dimensions of 9¼" high x 7 5/8" wide x 11½" deep. It was equipped for light and sound stimulus presentations. The food pellet dispenser was located outside of the conditioning chamber. The Ss were trained to press a bar for a food reward on a continuous reinforcement schedule. The activation of the bar delivered a pellet of food into the food tray located on the floor to

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the left of the bar (see figure 1). The food reward or reinforcement was a sucrose pellet (Alfred Noyes Sucrose Pellets, .045 gm. weight).

The SPC box consisted of four identical compartments arranged in line (see figure 2). The box was constructed of ¼ in. black plastic except for the front side which was clear, thereby allowing observation by the experimenter as well as for visual inspection of the stimulus by the S. Each compartment had the interior dimensions of 7" high x 7¼" wide x 9½" deep, and each had an electrifiable grid floor. In front of each compartment, an electric light bulb (6 watt, 12 volts) was centrally mounted on an attached stimulus panel. Two sound speakers were located on the stimulus panel and were centrally positioned such that each speaker serviced two compartments. Both light and tone intensities were manually variable in both the Skinner box and SPC box. The three intensities of tone were approximately 73, 82 and 92 decibels. The three intensities of light were 1.7, 4.0 and 26.0 foot candles. The programming of reinforcement trials and stimulus presentations was controlled by related Grason-Stadler equipment.

The sound-proofed experimental room was relatively free of external noise. Throughout the experiment, the room

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Figure 1

Skinner Box

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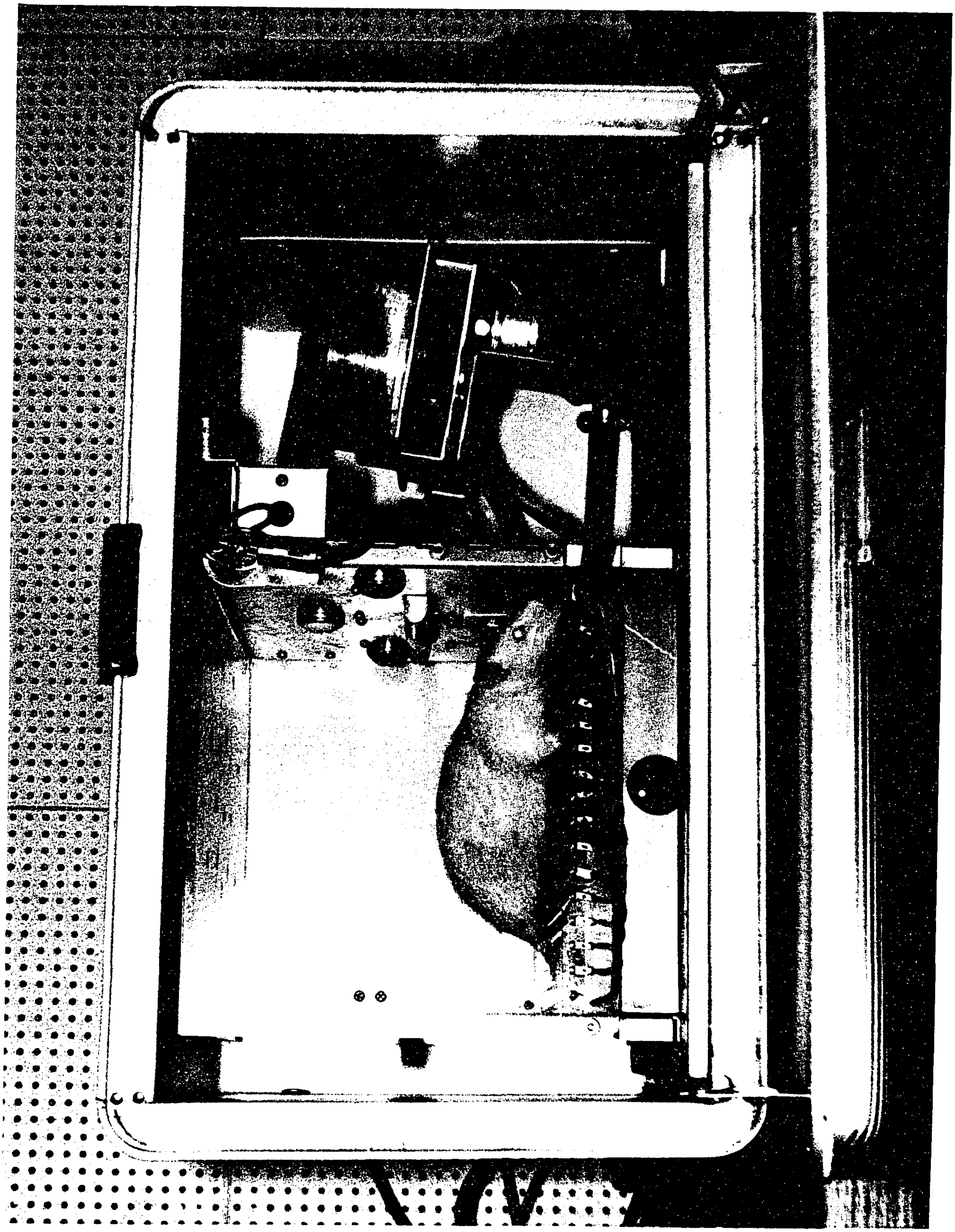

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Figure 2

Sensory Preconditioning Box

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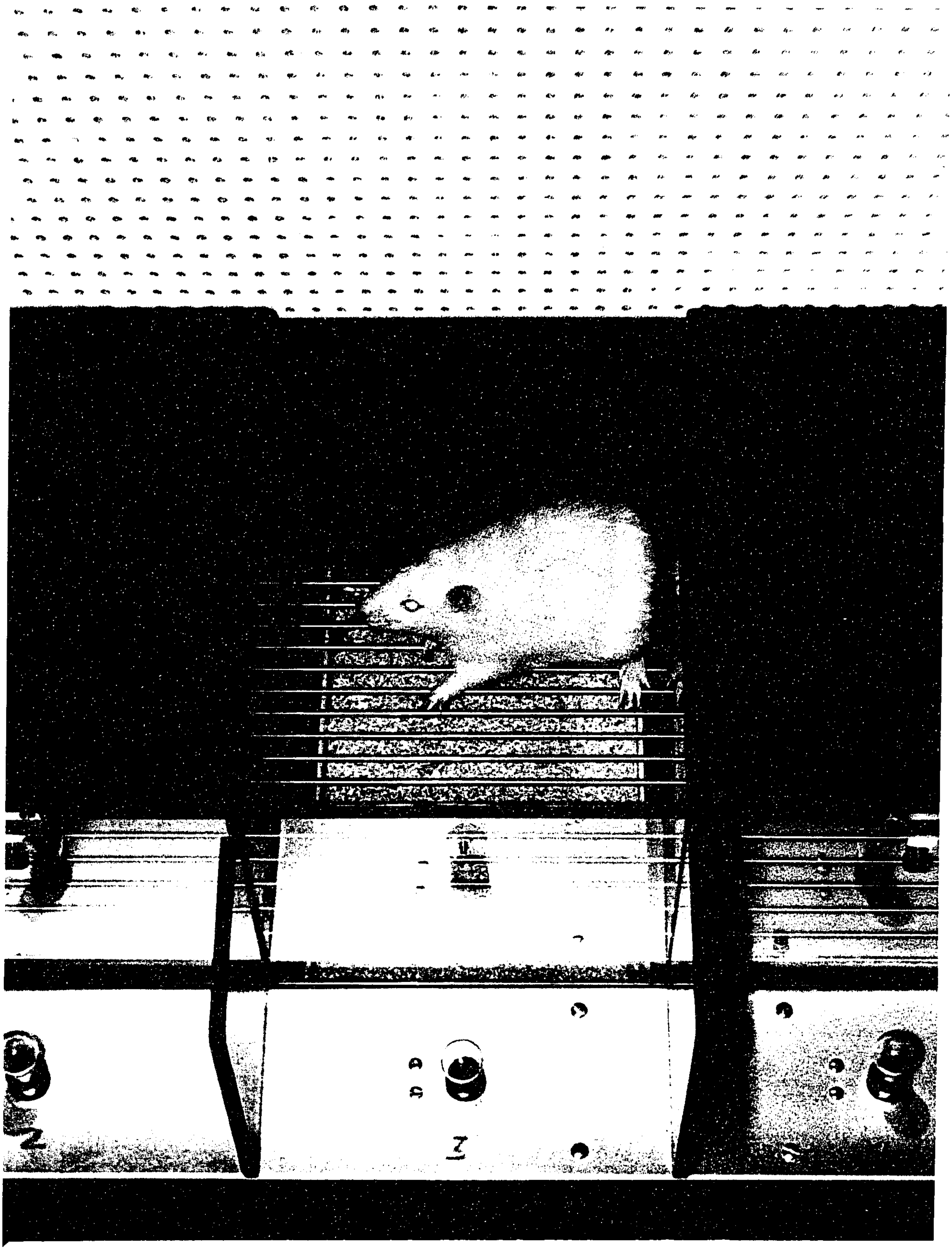

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was kept dark except for a small observation lamp suspended over the experimenter's table. The Ss were transported to and from the experimental room in covered plastic pails. During bar-press response training, and the Transfer and CS tests, the animals were processed individually. During SPC and CER training, they were processed in groups of 2, 3, or 4 animals. The Ss were brought from the colony room to the experimental room immediately prior to, and returned immediately after daily experimentation; otherwise, the subjects remained in their colony room home cages (2 animals per cage). Water was available ad lib in the home cage at all times.

Procedure

In this experiment there are three separate training procedures (bar-press response, preconditioning, and conditioned emotional response), and two test procedures (transfer and conditioned stimulus tests). Each will be described in detail immediately below.

1. Bar-Press Response Training Procedure

As mentioned above, all animals were gradually accustomed to being deprived of food for 22 hours each day, over a 14-day period (see appendix B for the schedule of gradual food deprivation). The day following the completion

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of the food reduction schedule, each animal was placed individually in the Skinner box for 5 min. in order to familiarize it with the apparatus. This daily procedure continued for two more days. The day following, bar-press training for 5 min. per day was begun. Initially, in bar-press response training, the bar was smeared with wet mash and five "free" pellets were placed in the food delivery tray as an inducement for the animal to approach the bar. This practice of "priming" was given in successive daily training sessions until no longer required. In addition to this priming technique, response shaping was also employed, if necessary. That is, the experimenter, by a remote control switch, reinforced the animal when its behavior was bar-orientated. The number of bar-pressing responses was automatically recorded and the animal was reinforced with one pellet of food for each bar-press response. Daily sessions of training continued until the subject had reached the training criterion, an asymptote defined as three or more approximately equal scores on four successive training sessions. After the subjects had met this criterion, they were randomly assigned, on the basis of sex and weight, to the preconditioning training groups as shown in Table 2 below.

Nine experimental groups of four animals each (two

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male and two female), and nine control groups of two animals each (one male and one female), comprised all the treatment groups, as called for by the design of the experiment. One control and one experimental group represented each of the nine possible treatment combinations (three intensities of light and three intensities of tone), hence there was a total of nine experimental and nine control groups (see Table 2).

2. Sensory Preconditioning Procedure

The day following the completion of bar-press response training, group sensory preconditioning training (groups of 2, 3 or 4 Ss) was started. The preconditioning (PC) stimuli for the experimental groups were presented asynchronously: that is, the onset of the second stimulus, light, was preceded 2 sec. by the first stimulus, tone, and both terminated simultaneously another 2 sec. later. This technique of forward conditioning (the first stimulus is designated the CS and the second stimulus, the UCS) has been demonstrated to be a more effective conditioning procedure than either simultaneous or backward presentation of the CS-UCS order in SPC experiments (Silver and Meyer, 1954; Hoffeld, Thompson and Brogden, 1958). The Transfer test stimulus, tone, was presented alone during Preconditioning training to all control

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animals for 4 sec. The average Inter-Trial Interval (ITI) for both experimental and control groups was 30 sec. (range 15 - 37 sec.). All animals received two days of preconditioning training at the rate of 100 trials per day, making a total of 200 trials in all.

3. Conditioned Emotional Response Procedure

The day following preconditioning, group CER training (groups of 2, 3 or 4 Ss) started for all animals, and continued for two days with 20 trials administered per day, making a total of 40 CER training trials. All Ss were administered light as the CS which was paired asynchronously with shock (UCS). The intensity of the light used in this phase of the experiment was the same as the particular S had received in preconditioning training. The level of shock was determined empirically by the experimenter. This assessment was made immediately after the completion of SPC training. This was done by individually placing each S in the SPC box and slowly increasing the shock intensity until pronounced discomfort (jumping, urinating, deficating) was observed, the particular shock level being noted and duplicated in CER training. In all cases, the CS, light, preceded the onset of shock by 2 sec. and both terminated together 2 sec. later.

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As in preconditioning training, the inter-trial-interval in CER training was randomly varied, averaging 30 sec. with a range of between 15 and 37 sec.

4. Transfer Test Procedure

The day following the completion of CER training, the Transfer test was given. Each S was placed individually in the Skinner box for a 5 min. period and was allowed to press the bar for food reinforcement. The Transfer test stimulus tone (of 4 sec. duration), was presented periodically, beginning 18 sec. after the S was placed in the apparatus. The inter-trial-interval was identical to that in use during both preconditioning training and CER training. The number of CR's (bar-presses) evoked during this test session was automatically recorded in the same manner as in original bar-press response training. Daily 5 min. test sessions were administered until the S's rate of bar-pressing approximated that of the original criterion estimate, i.e., until fear of the Transfer test stimulus was extinguished.

5. Conditioned Stimulus Test Procedure

The day following the completion of the Transfer test, the final test was administered. This test is the Conditioned Stimulus ("CS") test. This test, also given

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in the Skinner box, involves substituting the stimulus used as the CS (light) during CER training. The number of CRs (Bar-press responses) evoked were recorded, and all other experimental conditions were the same as in the Transfer test, described immediately above.

Response Measures and Statistical Analysis of the Data

Three main response scores were obtained for each subject. They are: (1) a "Stable" ("S") response score, which is the mean number of bar-press responses for each S over the last four test sessions of bar-press response training; (2) a "Transfer" ("T") test score, which is the number of bar presses emitted during the Transfer test; and (3) a "Conditioned Stimulus ("CS") test score, which is the number of bar presses evoked during the "CS" test. In order to make these scores indicative of the treatment and test conditions, following the procedures employed by other workers (e.g., Brady, 1951; Kirby, 1963; Singh, 1959), the number of responses evoked before the first and after the last stimulus test presentation (tone or light) were subtracted from the total number given during the 5 min test (Transfer and CS test). The number of bar-press responses evoked during the same temporal periods in the training sessions, thus deter-

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mining the Stable ("S") response score of each S, were subtracted from the total number given during the five min. session in the same manner as described above. Thus, the "S", "S", and "CS" scores are equated temporally.

Two subsidiary measures were also obtained. The first is the number of fecal boluses (called the Defecation score) deposited during all training and test phases of the experiment. The second is the number of bar-press responses evoked during the time of the 4 second presentations of both the Transfer test stimulus (Tone) and the "CS" test stimulus (light).

The complete design of the experiment is shown in Table 2, below.

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Table 2

Training and Test Procedures and Stimuli Intensities*

Response Training	N/Gp	Sex	Group	Preconditioning Stimuli	CER Stimuli	Transfer Test Stimulus	CS Test Stimulus
	4	2M, 2F	E	T1 - L1	L1 - shock	T1	L1
(dependent variable)	4	2M, 2F	E	T2 - L1	L1 - shock	T2	L2
	4	2M, 2F	E	T3 - L1	L1 - shock	T3	L3
Acquisition of bar	4	2M, 2F	E	T1 - L2	L2 - shock	T1	L1
press response, all	4	2M, 2F	E	T2 - L2	L2 - shock	T2	L2
animals. After	4	2M, 2F	E	T2 - L2	L2 - shock	T3	L3
criterion reached,	4	2M, 2F	E	T1 - L3	L3 - shock	T1	L1
Ss randomly assigned	4	2M, 2F	E	T2 - L3	L3 - shock	T2	L2
on basis of sex and	4	2M, 2F	E	T3 - L3	L3 - shock	T3	L3
weight to one of the	2	1M, 1F	C	T1 - alone	L1 - shock	T1	L1
18 treatment groups,	2	1M, 1F	C	T2 - alone	L1 - shock	T2	L2
listed opposite.	2	1M, 1F	C	T3 - alone	L1 - shock	T3	L3
	2	1M, 1F	C	T1 - alone	L2 - shock	T1	L1
	2	1M, 1F	C	T2 - alone	L2 - shock	T2	L2
	2	1M, 1F	C	T3 - alone	L2 - shock	T3	L3
	2	1M, 1F	C	T1 - alone	L3 - shock	T1	L1
	2	1M, 1F	C	T2 - alone	L3 - shock	T2	L2
	2	1M, 1F	C	T3 - alone	L3 - shock	T3	L3
Number of trials or Presentations				200 (100/day)	40 (20/day)	10	10
Apparatus: Skinner box				SPC box	SPC box	Skinner box	

* Stimulus Intensities
T1 -- High -- L1
T2 -- Med. -- L2
T3 -- Low -- L3

M = male
F = female

E = experimental
C = control

T = tone
L = light

CHAPTER III

RESULTS

General: Statistical Considerations

Before presenting the results, it is most appropriate, at this point, to discuss the difficulties involved in the statistical analysis of the data. It had been planned originally to apply the Regression Analysis model (see Kirby, 1963, p. 130 ff.) in the analysis of the scores. It had also been planned, in the initial design of the experiment, to place an equal number of Ss in each experimental and control treatment group. However, when the design had to be unbalanced (4 Ss in E groups, 2 Ss in C groups), because of the limitations of Ss, colony room space, and competing experimental room time commitments, the Regression Analysis model could not meet these altered conditions (assumption of or orthoganality or equal number of replications). As a consequence, other statistical models had to be considered. These alternatives will be discussed briefly, immediately below.

The first possibility was to apply an analysis of

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covariance technique. After much calculation and consultation, this model ultimately had to be rejected also, since it could not adequately handle the before-after ("S"-"T") scores of the unbalanced design.

The second method to be considered was to apply the Inflexion Ratio technique. However, there is one inherent weakness in this model: it assumes a relationship between the two scores (before-after), while what is most preferred in the kind of measures obtained in the present experiment, is a method which will test the scores for such a relationship. Consequently, this method was also rejected.

The next alternative was to consider a non-parametric statistical test. This possibility was soon rejected because there is, at present, no known model of this type which will allow the examination of covariates.

After these methods were rejected for the reasons indicated, it was decided to adopt the following procedure. In a SPS experiment of the present type, the critical measure of the SPC effect is the difference between the experimental and control scores. Specifically, the experimental Ss should show a significant decrement in the Transfer test situation while the control Ss should not. If neither the E nor the C Ss show the drop (or both do to a similar

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degree), then it cannot be concluded that the phenomenon has been demonstrated. With these possible outcomes in mind, it can be argued that it is legitimate to analyse the C and E group scores separately, rather than together (the preferred method, of course). It can be further argued that _if_ the analysis of the C group scores shows no significant before-after difference, then it is permissible to perform a similar analysis of the E scores. Now, if the E scores (before versus after) differ _significantly_, a significant decrement in responding in this case, then it can be rationalized that the SPC effect has been demonstrated. The proposed model is not as powerful a statistical test as is desired but it will allow, with reasonable certainty, the adequate assessment of the two scores. Therefore, it was decided to analyse the scores on this basis, using Analysis of Covariance (see Winer, p. 595 ff). Since there are three main scores ("S", "T", and "CS") to be analysed, two at a time ("S" vs. "T"; "S" vs. "CS") for the separate assessment of the E and C groups, this means that there will be four analyses in all.

Antecedent Conditions

Before going on to present the main findings, it must be shown that no significant differences exist between the

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two batches of Ss. If this antecedent condition proves to be non-significant, then it is justifiable to go on to examine "S - T - CS" scores. If no differences are obtained, then it is legitimate to conclude that the SPC effect, if obtained, is a result of the SPC treatment procedures employed, and not to any other "uncontrolled" variable.

It is possible that differences, due to S age and experimenter training sophistication, between batches I and II, contributed to the before-after score differences. Two comparisons were used to assess this possibility. First, a t-test comparison of the mean number of minutes required to learn the bar-press response by batches was made. Second, a t-test comparison of fecal boluses deposited during CER training, by batches, was made. Both comparisons were non-significant ($p > .05$). Therefore, it was concluded that age differences and batch differences did not contribute significantly to the before-after score differences.

Main Results

The total number of responses observed in the "S", "T" and "CS" tests, as previously defined, are shown in Table 3. The individual scores on all three measures by treatment group can be found in Appendix C.

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Table 3

Total number of responses by SPC groups evoked during the Stable ("S"), Transfer ("T"), and Conditioned Stimulus ("CS") tests

(N=54, 4 per experimental group, 2 per control group)

Preconditioning stimuli for experimental and respective control groups	Total no. stable responses ("S")	Transfer test stimulus	Total no. transfer test responses ("T")	"CS" test stimulus	Total no. "CS" test responses
T1 - L1	280	T1	138	L1	186
T1	78	T1	74	L1	85
T2 - L1	259	T2	217	L1	232
T2	138	T2	142	L1	125
T3 - L1	328	T3	6	L1	94
T3	133	T3	52	L1	48
T1 - L2	263	T1	211	L2	242
T1	117	T1	98	L2	80
T2 - L2	293	T2	261	L2	269
T2	148	T2	122	L2	84
T3 - L2	255	T3	220	L2	223
T3	122	T3	124	L2	127
T1 - L3	238	T1	191	L3	256
T1	130	T1	113	L3	136
T2 - L3	312	T2	238	L3	297
T2	184	T2	81	L3	105
T3 - L3	207	T3	167	L3	198
T3	102	T3	116	L3	134

1. Control Group Comparisons - Transfer Test

The first analysis of the data was performed on the control groups, which were exposed in preconditioning to the Transfer test stimulus alone. It was argued above that if the analysis revealed no reliable difference between the before ("S") score and the after ("T") score, then it would be logical to perform a similar analysis of the Experimental group's before-after scores.

The results of the Control Ss' scores ("S" versus "T") are shown in Table 4 below. An inspection of the rows of Table 4 shows the amount of variation in the scores as a result of the various control treatments imposed on the Ss. The F-ratio associated with the first factor, light, is less than one, from which it is concluded that the "S" and "T" scores do not differ significantly. Likewise, the second factor, tone, and the first-order interaction, light x tone, show only chance differences on the two measures (both F-ratios are less than 3.98, the required minimum value, to be significant at the 5 per cent level of confidence.) In summary, these results show that the Control Ss do not display a decrement in responding in the Transfer test, a necessary condition, it may be added, for the demonstration of SPC in the Experimental treatment groups.

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Table 4

Analysis of Co-Variance of Control Groups: Stable and Transfer Scores (N=18)

Source of Variation	Adjusted sums of squares	Degrees of Freedom	Mean Square	F ratio (1)	Significance level
Light	351.66	2	175.83	1	N.S. (2)
Tone	268.09	2	134.05	1	N.S.
Light x tone	3004.28	2	1502.14	3.16	N.S.
Residual variance	5224.48	11	474.95		

(1) F ratio of 3.98 or greater required to be significant at 5 per cent level of confidence

(2) N.S. = non-significant

2. Experimental Group Comparisons - Transfer test

The second analysis was performed on the before ("S") and after ("T") scores of the various experimental treatments administered in the study. An examination of Table 5, below, by the factors involved (sex, tone, light) will immediately reveal to the reader that there are more sources of variation in the scores as compared to a similar analysis performed on the control groups (Table 4). This is accounted for by the fact that sex differences had to be ignored in the Control group comparisons. That is, since there was only one male and one female S in each control treatment group, the sex factor had to be excluded in the analysis. In the Experimental groups, it will be recalled, two Ss of each sex were exposed to each treatment, thereby allowing the present analysis to examine scores on this factor.

The F-ratio column (last on right of the table) indicates that two main factors (tone and light) and one triple interaction factor (sex x tone x light) are highly reliable in accounting for a difference in response rate in the Transfer test (there is one chance or less in 100 that F-ratios of these magnitudes would be observed on the basis of chance alone. The other factors (sex, sex x tone, sex x light, tone x light) did not contribute significantly to the

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Table 5

Analysis of Co-variance of Experimental Treatment Groups: Stable and Transfer Scores
(N = 36)

Source of variation	Adjusted sums of squares	Degrees of freedom	Mean squares	F ratio (1)	Significance level (2)
Sex . . . . =	472.09	1	472.09	2.74	N.S.
Tone. . . . . =	4118.36	2	2059.18	11.96	< 1 per cent
Light . . . . =	3424.56	2	1712.28	9.95	< 1 per cent
Sex x tone . . . . =	321.92	2	160.96	< 1	N.S.
Sex x light . . . . =	802.48	2	401.24	2.39	N.S.
Tone x light . . . =	1816.40	4	454.10	2.68	N.S.
Sex x tone x light =	6110.47	4	1527.62	8.88	< 1 per cent
Residual variance	2926.03	17	172.12		

(1) The F-ratio is obtained by dividing the mean square (MS) of each factor by the mean square of the residual variance or unaccounted for variance.

(2) An F-ratio of at least 6.11 is required in order to be significant at the 1 per cent level of confidence.

observed variance in the Transfer ("T") test scores, and will not be mentioned again in this thesis.

The factor of Tone, of course, is the most important measure involved as it is presented periodically, it will be recalled, during the Transfer test. The other factors that contribute to the variance (sex, light, and their interactions) are constitutional or antecedent conditions. For example, light is intimately associated with tone in preconditioning training and with shock in CER training but "objectively" is absent in the Transfer test. Although the inferred mediation or neural process operant through the three phases of the experiment (tone - light; light - shock; tone alone in the Transfer test), may evoke a whole chain of events in the Transfer test (e.g., tone means light; light means shock; therefore S stops responding because of fear), it is the factor of tone alone which can be interpreted most simply, most directly in the above analysis. In review, these results show that the experimental groups did display a decrement in responding in the Transfer test, the necessary condition for the demonstration of SPC.

3. Control Group Comparisons - Conditioned Stimulus Test

The third analysis was performed on the "S" and "CS"

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Table 6

Analysis of Co-variance of Control Treatment Groups: Stable and Conditioned Stimulus Test Scores

(N = 18)

Source of variation	Adjusted sums of squares	Degrees of freedom	Mean squares	F ratio (1)	Significance level (2)
Light . . . . =	179	2	89.5	< 1	N.S.
Tone . . . . =	1219	2	609.5	< 1	N.S.
Light x tone . . . . . . =	4791	2	2395.5	1.71	N.S.
Residual variance . . . =	7659	11	696.3		

(1) F-ratio of 3.98 or greater required to be significant at 5 per cent level of confidence

(2) N.S. = non-significant

scores of the various experimental treatments administered in the study. The Conditioned Stimulus (CS) test was administered, it will be recalled, to ensure that CER training had been effective. Table 6, below, shows that the effect of the CS, light, was not a significant source of variance between the two sets of scores ("S" - "CS"). In addition, neither tone nor the light-tone interaction was a significant source of variance. It was concluded that the Control Ss had not been effectively fear conditioned in CER training.

4. Experimental Group Comparisons - Conditioned Stimulus Test

The fourth analysis was performed on the "S" and "CS" scores of the various experimental treatments. Table 7, below, shows that only tone and light were significant ($p < .01$) sources of variance in the data. It was concluded that the experimental Ss had been effectively fear conditioned to the CS, light, during CER training.

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Table 7

Analysis of Co-variance of Experimental Treatment Groups: Stable and Conditioned Stimulus Test Scores

(N = 36)

Source of variation		Adjusted sums of squares	Degrees of freedom	Mean squares	F ratio (1)	Significance level (2)
Sex	=	199	1	199	1.33	N.S.
Tone	=	3000	2	1500	10.87	< 1
Light	=	3247	2	1624	11.77	< 1
Sex x tone	=	306	2	153	1.15	N.S.
Sex x light	=	885	2	443	3.22	N.S.
Tone x light . . .	=	832	4	208	1.57	N.S.
Sex x tone x light	=	417	4	104	<1	N.S.
Residual variance	=	2346	17	138		

(1) The F-ratio is obtained by dividing the mean square (MS) of each factor by the mean square of the residual variance or unaccounted for variance.

(2) An F-ratio of at least 6.11 is required to be significant at the 1 per cent level of confidence.

CHAPTER IV

DISCUSSION OF RESULTS

The purpose of this experiment was to demonstrate the effect of varied preconditioning stimuli intensities upon the magnitude of SPC. All Ss were first trained to press a bar for food reward. Once this response had stabilized, preconditioning and CER training phases were administered, and were followed by the Transfer and "CS" tests. It will also be recalled that the main measure of SPC in this study was a differential decrement in bar-press response rate in the Transfer test. The assumption was made that if the Experimental Ss showed a response decrement on this measure, but the Control Ss did not, then it could be concluded that the SPC effect had been obtained.

Before discussing the main findings of this study, several antecedent measures will be examined as possible uncontrolled sources of bias in the data.

The first involves ensuring the neutrality of the transfer stimulus, tone. It is possible, for example, that the presentation of tone, in itself, might spontaneously

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evoke a fear response, thereby inhibiting the bar-press response during the Transfer test. There are two sources of information which discredit this possibility. The first, and foremost, concerns Transfer test response rates. If tone, at any of the three intensity levels employed, produces a fear response, then the control animals should show a significantly lower bar-press response rate in the Transfer test compared to their stable (or "S") rate of response. The statistical results indicate that there is no significant difference between the two measures for the Control Ss. Second, in a pilot study, which is not reported in the Thesis, a group of four animals were presented with tone alone, the day after a stable bar-press rate had been established in the same manner as had been done in the experiment proper. The two scores ("S", and the pre-stimulus test) did not differ significantly ($p > .05$). The Transfer stimulus Tone, therefore, is considered "neutral" and is not likely to evoke a fear response.

Another possible source of bias refers to batch differences in two of the critical training stages of the experiment (bar-press response and CER). A t-test was used to compare the two batches in terms of the number of minutes to learn, to criterion, the bar-press response. The results of

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this test were non-significant ($p > .05$). A second measure which might reflect batch differences was the number of fecal boluses (called the D-score) deposited during CER training. The D-scores of the two batches were compared by a t-test. The results were non-significant ($p > .05$). Therefore, it is concluded that any differences which may be observed are not due to differential rates of fear conditioning between the two batches, as shown by the defecation scores. The main results will now be discussed.

The analysis of the Transfer test scores of the Experimental and Control groups demonstrated the SPC effect (see Tables 4 and 5). However, before this interpretation can be accepted, it is first necessary to examine the "CS" test results. The "CS" test was administered, it will be recalled, to demonstrate that a fear response had been established. It might be observed that the Experimental Ss show less inhibition of the bar press response during this test, but the Control Ss would be expected to show a significantly greater drop in rate of responding. These differential rates of response, if observed, can be interpreted to result from different extinction rates between the two groups (Experimental vs. Control). That is, it is possible that the Experimental Ss exposed to tone - light pairings in precon-

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ditioning may show less fear of the CS, light, in the "CS" test because its fear of the transfer test stimulus (Tone), during the Transfer test, had been extinguished, prior to their exposure to the "CS" test. The Control Ss, on the other hand, exposed only to tone in preconditioning, may not show reduced fear of the CS, light, in the "CS" test, simply because of their different preconditioning experience. Another hypothetical outcome is that reported by Kirby (1963), in which he observed no difference in bar-press rates in the "CS" test; both the Experimental and Control groups showed a highly significant decrement in response compared to their stable response rate.

The results of the "CS" test, considering the possibilities suggested above appear to be confounding. The Control Ss did not decrease their rate of response, thus suggesting that a fear response had not been established. The Experimental Ss, however, did significantly decrease their response rate during the "CS" test. These results might be interpreted to mean that since the Control Ss had not been effectively fear-conditioned in CER training, then any conclusion about the demonstration of SPC in the Experimental Ss (who show fear of the CS test stimulus) remains ambiguous. Some of the subsidiary measures will have to be examined in

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detail before any such conclusion can be drawn. These measures are the D-scores during CER training, and sex differences in the Control Ss.

A t-test was applied to the mean number of fecal boluses deposited by the Experimental and Control Ss during CER training. The mean difference between the groups was non-significant ($p > .05$). This suggests, at least, that both the Experimental and Control Ss displayed equal fear of the CER training procedure (see Appendix D for bolus scores).

In the statistical analysis of the Transfer and CS test scores for the Control Ss, the factor of sex differences had to be ignored because of the insignificant number of replications (minimum of 2 Ss of each sex required). Therefore, it was decided to investigate sex differences in the Transfer and "CS" test results. The mean decrement between the Stable response score and the Transfer and "CS" test score (i.e., "S" - "T" and "S" - "CS") was calculated opposing sexes of the Control and Experimental Ss, but disregarding treatment differences. The results are shown in Table 8, below.

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Table 8

Mean Drop in Conditioned Stimulus Test Scores by Experimental and Control Groups, and Sex, Disregarding Treatment

Group	Sex	Mean Conditioned Response Test Drop ("S"-"CS" scores)
Control	M	18.6
Control	F	5.2
Experimental	M	12.0
Experimental	F	7.6

Examining the Control Ss, the first factor to be noted is that the female Ss, compared to the male Ss, do not seem to have been effectively fear-conditioned, as both rates of decrement should be approximately equal between the sexes. In examining the mean drop in response in the Experimental Ss, it again appears that the female Ss show less effective establishment of the fear response conditioning procedure than do the male Ss, although this observation may be confounded by the hypothesized extinction factor commented upon above. If these analyses, both logical and statistical, are accepted by the reader, then it may be concluded that a prominent sex difference has been observed in the present study, the males showing a much greater sensitivity to the SPC experiment than do the females. A second conclusion also follows from these analyses: that a positive demonstration of

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the SPC effect has been obtained. This interpretation is more readily acceptable when it has also been shown, in the analysis of the E treatment groups, that sex was observed to be a significant factor in the rate of response transfer in the Transfer test, the females again showing less of the effect than do the males (mean drop rates of 15.7 and 21.4, respectively).

In the light of the above arguments, the conclusion that a reliable demonstration of the SPC phenomenon has occurred seems justified. A theoretical factor which may be aduced to further reinforce this conclusion may be stated as follows. The animal, it will be remembered, is in a state of conflicting drives (hunger vs. fear) during both the Transfer and "CS" tests. That is, the animal has been deprived for 22 hours prior to these critical tests, and it has also been conditioned to fear the critical test stimulus. On practical grounds, it would seem difficult for the Experimental S to suppress a strong hunger drive, which it has the opportunity to alleviate, when exposed to the periodic appearance of the transfer test stimulus, while the Control subject under the same conditions might not show this suppression. The fact that Ss so low on the phylogenetic scale as is the rat, exposed to either an Experimental or Control treatment

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procedure, show such differences in suppression of a strong hunger drive, is here taken to be a strong argument for the SPC phenomenon in general, as well as for the results of the present study in particular.

The effect of the preconditioning stimuli intensities upon the magnitude of SPC seems to be akin to the laws of standard conditioning. It is known from standard conditioning that the best conditioning arrangement is one in which the CS is relatively weak compared to the UCS (Kimble, 1961; Razran, 1957). Since the present study is a parametric one, using three intensities of both tone and light, individual preconditioning stimulus treatments can be examined to see if the same relationships pertain in the SPC paradigm. According to the Kimble and the Razran speculations, the preconditioning stimulus intensity arrangement most conducive to the transfer effect would be the Tone_3 - Light_1 pairing. An examination of the Transfer test scores (Appendix C) reveals that this arrangement results in greater transfer effect than any other stimulus combination. It is also apparent that some preconditioning pairings are less effective in promoting the SPC effect than are others. For example, of the treatment groups using the Tone_2 pairings (with Light 1, 2, or 3), not one shows the transfer

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phenomenon. With similar preconditioning stimulus intensities and procedures, Kirby (1963, see Chapter I for a review of this study) also did not get a reliable measure of SPC. The other preconditioning stimulus pairings show only moderate to little evidence of the effect. Therefore, from these results, it appears that preconditioning stimulus intensities are very important in obtaining a successful demonstration of the phenomenon, the $T_3 - L_1$ combination, specifically, providing the maximal SPC effect.

In concluding this discussion, it must be admitted that the present status of SPC is that, although generally accepted as undeniable empirical fact, it is a weak and unstable affair. But the present author is in agreement with Bitterman, Reed, and Kubala when they wrote:

> ... the study of sensory preconditioning has not progressed beyond the earliest stages, and the negligible effects sometimes reported may reflect only the fact that optimal conditions have not been employed .... that these experiments have, on occasion, given positive results may be taken as evidence for the strength, rather than the weakness, of sensory preconditioning. (1953, p. 179).

The results of the present study give further credence to this statement.

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Suggestions for Further Research

1. The understanding of the conditions affecting the occurrence of SPC and its magnitude would be clearer if it were not complicated by having to use an unobserved, inferred behavioral response in the preconditioning phase of the experiment. The sophisticated techniques of cortical implants may provide a method by which to trace the more precise neural changes occurring during SPC.

2. Female subjects do not seem as sensitive to the CER training procedures as do the male subjects. Therefore, it would seem preferable to use male subjects in future studies if the maximal transfer effect is to be obtained.

3. It seems that the preconditioning stimuli intensities most conducive to demonstrating the SPC effect as indicated by the findings of this study and as predicted by standard conditioning procedures, should be utilized in future research, (specifically, weak CS, followed in onset by strong UCS).

4. Although there is no evidence in the present study to make such an assertion, it seems that the CS-UCS interval is very important in determining the magnitude of transfer (Hoffeld et al., 1958). Therefore, it is suggested that a longer CS-UCS interval be employed in future studies.

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CHAPTER V

SUMMARY

The purpose of the present experiment was to study the magnitude of sensory preconditioning as a function of preconditioning stimulus intensities. The design called for eighteen different treatment groups (nine Experimental and nine Control groups). The experimental group treatments consisted of the asynchronous presentation of tone (at three intensity levels) and light (also at three intensity levels). Each of these experimental groups had its respective control group, in which only the first preconditioning stimulus (tone) was presented during the preconditioning phase. A bar-pressing response was firmly established prior to SPC training. A fear response (CER) was utilized as part of the SPC training procedure and provided the response condition necessary to measure the SPC effect. A second critical test ("CS" test) provided a measure of the effectiveness of the fear conditioning procedure employed.

It was found that the Experimental groups gave significantly fewer bar-press responses during the Transfer test

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than did the Control group. It was concluded that, although SPC had been demonstrated, this interpretation was contingent upon a pronounced sex difference in the second critical ("CS") test. That is, the males were much more sensitive to the SPC procedures than were the females and hence displayed significantly more evidence of the transfer effect.

The multiple comparisons of the Experimental treatment groups showed that the preconditioning order, tone at low intensity, asynchronously paired with light at high intensity, produced much greater transfer effect than any other intensity combination. This finding is comparable to the results obtained in standard conditioning experiments, in which a weak CS preceding the onset of a strong UCS, generally produces greater strength of response than when the CS and UCS have other intensity values.

Several suggestions for future research are made.

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Appendix "A"

Male Subject Weights in Grams

S Number	Sex	Weight Prior to CER Training	Weight after "CS" test
1	M	425	419
2	M	451	447
3	M	502	496
4	M	409	401
5	M	506	511
6	M	473	470
7	M	516	492
8	M	469	470
9	M	423	420
10	M	481	477
11	M	450	446
12	M	570	575
13	M	492	501
14	M	483	482
15	M	468	460
16	M	526	523
17	M	491	496
62	M	421	416
64	M	436	430
67	M	431	427
68	M	399	395
69	M	341	338
70	M	388	390
71	M	366	364
73	M	404	401
74	M	345	348
75	M	357	352

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Appendix "A"

Female Subject Weights in Grams

S Number	Sex	Weight Prior to CER Training	Weight after "CS" test
19	F	273	262
20	F	303	301
21	F	300	296
22	F	267	271
23	F	260	254
24	F	271	261
25	F	290	293
26	F	281	282
27	F	294	284
29	F	312	309
30	F	239	238
31	F	254	250
32	F	252	253
33	F	264	268
34	F	301	293
35	F	207	307
36	F	254	251
77	F	278	265
78	F	260	263
80	F	251	247
83	F	256	248
86	F	222	226
87	F	215	219
88	F	226	229
89	F	246	241
92	F	278	272
93	F	225	224

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Appendix "B"

Fourteen Day Gradual Food Reduction Schedule

Days	Animals Fed From	To
1 - 2	9.00 a.m.	5.00 p.m.
3 - 4	9.00 a.m.	4.00 p.m.
5 - 6	10.00 a.m.	4.00 p.m.
7 - 8	10.00 a.m.	3.00 p.m.
9 - 10	11.00 a.m.	3.00 p.m.
11 - 12	11.00 a.m.	2.00 p.m.
13 - 14	11.00 a.m.	1.00 p.m.

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Appendix "C"

Corrected Individual Responses by SPC Groups evoked during the Stable ("S"), Transfer ("T"), and Conditioned Stimulus ("CS") test by treatment group*

(N=54, 6 animals x 9 groups)

	LIGHT 1			LIGHT 2			LIGHT 3		
	S	T	CS	S	T	CS	S	T	CS
TONE 1	69	72	67	70	41	50	47	38	44
	97	50	56	38	20	40	21	51	66
	81	0	33	90	87	87	79	70	73
	33	16	30	65	63	65	91	32	73
	33	34	36	71	57	76	59	60	66
	45	40	49	46	41	4	71	70	70
TONE 2	62	64	64	81	90	63	93	49	91
	105	69	74	75	74	75	51	26	47
	48	43	52	68	55	71	97	90	77
	44	41	40	59	42	60	71	73	82
	74	64	67	67	53	22	88	0	0
	64	78	58	81	69	62	96	81	105
TONE 3	100	3	20	72	75	69	71	75	80
	111	2	46	91	58	60	70	47	58
	56	0	22	44	40	49	30	28	33
	61	1	6	48	47	45	36	17	27
	77	0	8	56	58	51	33	43	55
	56	52	40	66	66	76	69	73	79

* Scores are inserted in the experimental design above, the first four scores in each cell are experimental animals in the sex order of M, M, F and F. The last two scores represent control animals in the sex order M, F.

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Appendix "D"

Total Subject Fecal Bolus ("D") Scores During CER Training

S. Number	Sex	"D" Score	S Number	Sex	"D" Score
1	M	18	19	F	14
2	M	11	20	F	11
3	M	13	21	F	9
4	M	14	22	F	21
5	M	9	23	F	12
6	M	20	24	F	15
7	M	16	25	F	16
8	M	14	26	F	14
9	M	10	27	F	17
10	M	11	29	F	18
11	M	19	30	F	11
12	M	18	31	F	12
13	M	15	32	F	11
14	M	21	33	F	18
15	M	8	34	F	17
16	M	16	35	F	20
17	M	12	37	F	15
62	M	14	77	F	14
64	M	13	78	F	19
67	M	20	80	F	12
68	M	17	83	F	8
69	M	11	86	F	11
70	M	23	87	F	20
71	M	17	88	F	13
73	M	14	89	F	19
74	M	11	92	F	23
75	M	18	93	F	11

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VITA AUCTORIS

1940	Born in Barrie, Ontario, to Donald and Dorothy McLean.
1955	Started education at Harrow District High School, Harrow, Ontario.
1961	Started studies at Assumption University of Windsor, Windsor, Ontario.
1965	Awarded Hons. Bachelor of Arts degree from University of Windsor.
1965	Registered as full-time graduate student in the Department of Psychology at the University of Windsor, Windsor, Ontario.

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