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DIRECT MEASUREMENT OF THE MEDIATING RESPONSE IN SENSORY PRECONDITIONING

A DISSERTATION

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RUSSELL F. ENZIE

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DIRECT MEASUREMENT OF THE MEDIATING RESPONSE

IN SENSORY PRECONDITIONING

APPROVED BY

DISSERTATION COMMITTEE

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DIRECT MEASUREMENT OF THE MEDIATING RESPONSE IN SENSORY PRECONDITIONING

CHAPTER I

INTRODUCTION

The term "sensory preconditioning" and the paradigm for sensory preconditioning (SPC) was established by Brogden (1939). In his study, eight experimental dogs were presented with two hundred pairings of a bell and a light, while eight control dogs received no experience with the bell or the light. In the second phase of the experiment half of the animals in the experimental group received avoidance training of bell followed by shock, while the other half received avoidance training with light and shock. The control animals were divided and received the same presentations training as the experimental groups. In the final phase of the study, the animals which had received bell and shock paired in phase two received a test stimulus of light, while the animals which received light and shock paired received a test stimulus of bell. Brogden found that the experimental groups made more avoidance responses to the stimulus that had never been paired with shock than did the

control groups. He interpreted these results as evidence that the flexion response elicited by the stimulus not associated with shock must be due to an association formed when the bell and the light were presented contiguously. For a summary of Brogden's paradigm and alternative paradigms for SPC studies see Table 1.

Reid (1952) criticized Brogden's design on the grounds that the differences between the two groups might have been due to the novelty of the light and bell when presented to the control groups for the first time during the test phase. In order to rule out this flaw in Brogden's design, Reid suggested an alternative paradigm (Table 1) which has come to be the paradigm most generally used in SPC studies. When this design is utilized, all subjects receive equal presentations of the two stimuli used in phase one, with the experimental groups receiving paired stimulus presentations and the control group receiving non-paired presentations of the two stimuli.

In summary, the SPC procedure consists of three phases: 1) repeated contiguous presentations of two stimuli (preconditioning), 2) establishing a response to one of them (conditioning), and 3) testing transfer of this response to the other stimulus (testing). The control group is analogus to the experimental group, with the exception that the two stimuli in the preconditioning phase are not presented contiguously.

Table 1

Paradigms used in Sensory Preconditioning studies

Brogden's design

	Preconditioning	Conditioning	Testing
Exp. Group	Light-Bell	Bell-Shock	Light
Con. Group		Bell-Shock	Light

General design

	Preconditioning	Conditioning	Testing
Exp. Group	S_1-S_2 (Paired)	S_2-S_3 (Paired)	S_1
Con. Group	S_1+S_2 (Not Paired)	S_2-S_3 (Paired)	S_1

Brogden's initial study has generated a great deal of controversy in the area of learning in psychology. Two opposing theories in the area of learning have attempted to explain the phenomenon of SPC. These two theoretical interpretations are the S-R and the S-S approaches to learning.

Several investigators have proposed a S-R interpretation of SPC (Coppock, 1958; Osgood, 1953; Silver & Myer, 1954). Each interpretation is basically the same, with a few subtle differences. In the discussion of the S-R approach, reference will be made to Table 2. Generally, in accord with classical conditioning principles, it is assumed that following paired presentations of two stimuli (S_1 and S_2) in the preconditioning phase, implicit conditioned responses (R_2) are established. In terms of Brogden's study, it is hypothesized that some unobservable response is conditioned with the contigous presentations of bell and light. When an observable response (R_3) is subsequently conditioned to one of the preconditioning stimuli (S_2) the presentation of the alternative preconditioning stimulus (S_1) will elicit the observable response (R_3) through the implicit conditioned response (R_2). In other words, R_2 acts as a mediator in that it acts as response--produced--stimulus to elicit the conditioned response R_3.

In summary, the S-R theory assumes that the preconditioning phase in SPC is nothing more than classical conditioning. It is maintained that while no response may be

Table 2

The S-R conditioning analysis of SPC

Preconditioning	Conditioning	Testing
S_1-------R_1	S_2-------R_2	S_1-----R_1
		R_2
S_2------R_2	S_3-------R_3	S_3-----R_3

observable, there is nevertheless a response being conditioned during the preconditioning phase. This response then acts as a mediator during the test phase to produce the response that was conditioned during the conditioning phase.

The opposing view, the S-S contiguity point of view, was applied to SPC by Birch and Bitterman (1949). The S-S approach is not dependent upon assuming some type of "unobservable response" occurring during preconditioning. In reviewing SPC studies Birch and Bitterman (1949) state that they must, "... postulate a process of afferent modification (sensory intergration), the essential condition for which is contiguity of stimulation [p. 302]." Whereas the S-R theory postulates a response as being necessary for learning to occur in preconditioning and be available as a mediator during testing, the S-S theory advocates a central or afferent modification with no mediating response necessary. As Birch and Bitterman (1951) state, "Here we postulate a purely afferent process of modification which may operate ...in the absence of concurrent motor activity [p. 358]."

These two theories, the S-R and S-S, are the two opposing theories which attempt to explain SPC. As the title of this study implies, the present investigation is concerned primarily with the mediation hypothesis put forth by the S-R theory. Therefore, the literature review will be cast in a framework of evidence that seems to support the

S-R theory versus that evidence that does not support the S-R view.

Before presenting the evidence it should be noted here that studies will be included which involve mediated stimulus generalization. Seidel (1959) makes a distinction between SPC and mediated stimulus generalization (MSG) studies primarily on the grounds that in MSG studies some specified response is observable and a measure of conditioning is obtained during preconditioning. In SPC studies, on the other hand, no response is evident and therefore no measure of conditioning is possible. Other investigators, however, do not make such a distinction. In his discussion of SPC Osgood (1951) cites evidence from MSG studies but gives no indication that he considers SPC and MSG to be two different learning phenomenon. Wickens and Briggs (1951) also state that SPC is simply a special case of MSG. Thus it was concluded that MSG and SPC involve essentially the same learning phenomenon.

Evidence in support of S-R mediation. One of the earliest studies that offers evidence in support of the S-R mediation hypothesis comes from Lumsdaine (1939). Following a procedure employed by Shipley, (1933) Lumsdaine, conditioned eyeblinks to a light by pairing the light with a blow of a mechanical striker on the cheek near the eye. Later, a finger withdrawal was conditioned to the eye blink by pairing the strike on the cheek with a shock to the finger.

During the testing phase, it was found that the light evoked the finger withdrawal in the majority of his subjects. The data also revealed that in most cases the light elicited a winking movement which was closely followed by the finger withdrawal response. This is what would be expected according to the mediation hypothesis, i.e., the wink served as a mediator to elicit the finger withdrawal.

Prokofiev and Zeliony (1926) and Shipley (1933 and 1935) also conducted studies along the same lines (i.e., conditioning a response during the preconditioning phase) but they do not report whether or not a mediating response was present. These early studies were primarily concerned with establishing SPC as a phenomenon in its own right and not simply generalization or some other artifact.

Indirect evidence in support of the mediation view of SPC comes from Wickens and Briggs (1951). Using human subjects, they paired a tone and light fifteen times for one experimental group (E_1) and instructed the subjects to say "now" to the paired stimuli. A second experimental group (E_2) received random presentations of tone and light and were instructed to say "now" after each stimulus. One control group (C_1) responded "now" aloud to the tone alone fifteen times, and a second control group (C_2) to the light alone the same number of times. Each group was then given finger-flexion avoidance training to the light. During the test phase (light presented alone) E_1 and E_2 did not differ,

and E_1 and E_2 showed significantly greater flexions than C_1 and C_2. These differences in groups indicate that a response to stimuli in preconditioning mediates the occurrence of the flexion during the test phase.

Silver and Meyer (1954) trained three experimental groups of twenty rats in preconditioning with either simultaneous, forward or backward conditioning. They found that their pseudoconditioning control groups and a group with no pre-training did not show transfer of the avoidance response in the testing phase whereas all three experimental groups did show transfer. It was also found that the group which received the forward presentation of stimuli was superior to either backward or simultaneous presentation. Silver and Meyer conclude: "Although the postulated mediating CR remains obscure, conditions designed to facilitate its fixation yield increments of the kind to be expected" (p. 59).

Bahrick (1953) gave rats simultaneous pairings of a buzzer and a light. Two experimental groups received these pairings under high (14 hour) or low (0 hour) food deprivation while a control group received a light but no buzzer under a high (14 hour) food deprivation condition. All animals were trained to avoid shock at the sound of the buzzer and tested with light. He found that the high deprivation experimental group showed transfer of the avoidance response to a greater degree than either low deprivation experimental animals or high deprivation control animals. The

deprivation conditions existed only during preconditioning, suggesting that high food deprivation enhanced the SPC effect. This study can be taken as support for the mediation hypothesis, since greater activity is assumed during high deprivation, more responses were available for conditioning during phase one. These responses could then act as mediators during the testing phase. As Bahrick states it: "It is possible that the animals in the present experiment learned to make the same movements to the buzzer and the light during preconditioning, and this association could have mediated transfer of the CR from the buzzer to the light." (Bahrick, 1953, p. 41)

Coppock (1958) obtained positive results using a galvanic skin response measure. He found that a group (SPE) which received extinction trials following preconditioning (i.e., presentations of tone alone after paired presentations of tone and light) did not show as many responses during testing as a group (IPE) which received a reversed order paired trials following preconditioning (i.e., presentations of light-tone following paired presentations of tone and light). This supports the mediation viewpoint since in group IPE there was the possibility of an additional mediator (i.e., responses conditioned to tone during the tone-light sequence and responses conditioned to light in the light-tone sequence. The SPE groups, on the other hand, had

extinction trials and a diminution of any response which had been conditioned to tone in the preconditioning phase.

A recent study by Parks (1968) lends support to the mediation hypothesis. Parks suggested that an "orientation reaction" mediates SPC. In order to test this hypothesis he presented one group (E) of rats with a six-second light followed immediately by a six-second tone for thirty presentations. A second group (H) of rats received sixty presentations of the light and tone with a one-minute delay between each stimulus presentation. Following this habituation procedure the H group was treated in the same manner as the E group, i.e., all animals in the H group received thirty paired presentations of the light and tone. A third group (C) received no stimulus presentations. Following precondition presentations all animals received avoidance training with tone acting as the warning stimulus and shock as the unconditioned stimulus. He hypothesized that the H group (habituation group) would habituate to the preconditioning stimuli (i.e., any orientation response would extinguish with repeated presentations of the two stimuli), whereas the E group would maintain the orientation reaction. He further predicted that the orientation reaction would act as a mediator and the experimental group (E) would demonstrate more SPC than either the H group or the C group. His results confirmed his hypothesis.

In sum, there are several studies which point to acceptance of the mediation hypothesis as a plausible explanation of SPC. With one exception (Lumsdaine, 1939) none of the studies reported were able to directly measure the mediating response.

Evidence opposing S-R mediation hypothesis. In a study designed to test the effects of time relations during preconditioning Hoffeld, Thompson and Brogden (1958) offer negative evidence concerning the mediation hypothesis. Four groups of cats received tone-light pairings with the onset of tone and light varying from 0, .5, 1.2, 2, and 4 second intervals. A control group received no presentations of light or tone. All groups received avoidance training to the light. Each experimental group was significantly greater than the control and the 4 second group was significantly greater than the other experimental groups. These data do not fit the data obtained in classical conditioning experiments which emphasize an optimal CS-US interval of less than one-half second (Kimble, 1961). Hoffeld, Thompson and Brogden (1958) conclude that SPC may be considered a phenomenon distinct from classical conditioning.

Hoffeld, Kendall, Thompson and Brogden (1960) gave 12 groups of 6 cats either 0, 1, 2, 4, 8, 10, 20, 40, 80, 200, 400, or 800 tone-light pairings, then shaped an avoidance response to the light. All groups gave significantly more responses in the test phase than did the 0

pairings group, with the 4 pairings group being significantly greater than the other groups. Thus, one pairing seems enough to yield the SPC effect with four pairings being optimum. Again, these findings seem to contradict the findings in classical conditioning that the strength of a conditioned response (CR) (which becomes a mediator in the S-R analysis of SPC) is a function of the number of trials (Seidel, 1959). It would be difficult for the S-R theorists to explain how the group which received only one trial exhibited SPC. They would have to take the position that a CR was conditioned to the tone on only one trial.

In an attempt to show that a Hullian S-R interpretation could not handle the results of SPC as well and a S-S interpretation Bitterman, Reed, and Kubala (1953) designed a study to show that SPC produces as stable an effect as does classical conditioning. The Hullian argument (according to Bitterman, Reed, and Kubala, 1953) is that the need reduction following presentations of two lights L_1 and L_2 would be less than that following light-shock pairings, need reduction being provided by shock termination. Bitterman, et al., concluded that any response conditioned to L_1 would be weaker than a response later conditioned to L_2 "since sEr is said to be positively related to the amount of need reduction" (Bitterman, Reed and Kubala, 1953, p. 178). The design of the experiment was as follows: One group (E_1) of human subjects was presented with ten pairings of two

intensities of light, L_1 and L_2 interspersed with ten presentations of L_2 alone. A second experimental group (E_2) received ten pairings of L_2-L_1 interspersed with ten presentations of L_1 alone. Two control groups (C_1 and C_2) received ten presentations each of L_1 and L_2 alone. During conditioning phase E_1 received ten pairings of L_2-Shock, E_2 received ten pairings of L_1-Shock, C_1 received L_2-Shock, and C_2 received L_1-Shock pairings. A GSR measure was obtained for all subjects during phase two. During the testing phase all subjects received ten presentations each of L_1 and L_2. It was found that the experimental groups showed no difference in extinction of GSR to the classically conditioned stimuli (i.e., the stimulus that was paired with shock) and the SPC stimuli (stimulus that was never paired with shock). On the other hand the curves for the control groups showed a consistently higher level of responses to the classically conditioned stimulus than to the generalization stimulus (stimulus never paired with shock). Bitterman concludes that, "sensory preconditioned response tendency is not inevitably weaker than a response tendency established by the classical procedure" Bitterman, Reed, and Kubala, 1953, p. 181). It should be remembered that according to a Hullian S-R approach the SPC response tendency should be weaker since need reduction following the presentation of two lights would be small.

Seidel (1958) conducted a study in which two groups of food deprived rats received either forty presentations of light and bell paired or forty presentations of light alone. All subjects were then trained to avoid the bell under three different conditions: food deprived, water deprived, or satiated. The subjects were tested under the same three conditions. All three experimental groups showed the same degree of positive transfer when compared to the control group. Despite differences in degree of similarity between the "autonomic response-complex" present during the preconditioning and that present during the training-testing phases, the experimental groups showed equivalent effect of SPC. Seidel concludes: "... the role of the response in an unimportant one" in SPC (Seidel, 1959, p. 70).

From the studies cited, it is clear that the phenomenon of SPC is well established. The major controversy in the area revolves around theories as to how it occurs. Despite a great deal of investigation, this controversy is still unresolved. One of the main problems seems to be a lack of direct evidence of a mediating response. With the exception of Lumsdaine's work (1939) and attempts by Shipley (1933) and Prodefiev and Zeliony (1926) there is no direct measure of the mediation response appearing in the literature.

On the basis of the review of the SPC literature it was concluded that a study attempting a direct measure of

the mediating response hypothesized by the S-R interpretation of SPC studies, was in order. It was realized, however, that one study would not resolve the controversy. Indeed, the controversy may never be resolved! Even if mediating responses were found to be present during testing it still would not be possible to rule out the S-S theorists' contention that no response is necessary. In other words, the mediating response may be a sufficient, but not a necessary condition for SPC to occur. However, in light of the many studies found in the literature addressing this problem, it seemed that a study which attempted to directly measure a mediating response was in order, since the majority of evidence both pro and con is somewhat circumstantial.

The present study. The present study employed a design that permitted the direct measure of a mediation response occurring during the testing phase of a SPC study. More specifically, during the preconditioning phase the two stimuli used were tone and acid. Using a salivary response it was thus possible to determine if classical conditioning was occurring. During the conditioning phase the two stimuli used were acid and shock with a flexion response to acid defined as a CR. Finally, during testing all animals were tested with non-paired random presentations of tone, acid and shock. Thus, by establishing a conditioned response to tone (salivation) and subsequently establishing a conditioned response to acid (flexion), it was possible to determine if

the CR to tone (salivation) was concomitant with flexions to tone during the test phase. This procedure is similar to one used by Prokofiev and Zeliony (1926) who were unable to demonstrate SPC. However, only one dog was tested in their study.

The use of a strong unconditioned stimulus (acid) during the preconditioning phase offers an advantage over the studies which have used novel stimuli (e.g., tone, light, bell, or buzzer) in that it is possible to determine if conditioning is occurring, as the S-R theory hypothesizes. When using novel stimuli and hypothesizing an orientation reaction (e.g., Parks, 1968) it is possible that the orientating response will habituate with repeated presentations, and will not become conditioned to the test stimulus, and thus not be available as a mediator. The use of unconditioned stimuli in the present study is not a novel approach. There are several Russian studies (e.g., Asratian, 1959; Chih-an, 1962) which employed two unconditioned stimuli in conditioning experiments. These studies found that it was possible for an unconditioned stimulus to become a conditioned stimulus for unconditioned stimulus.

In order to rule out stimulus generalization three pseudoconditioning control groups were used. (See procedure section for specific details.) The presentation of the stimuli in the present study differed from the control procedures of past classical conditioning studies in that the

stimuli were presented in a purely random order. Rescorla (1967) maintains that the traditional control procedures for nonassociative effects are not adequate controls. He argues that by limiting the control procedure to all unpaired presentations of the CS and the UCS a new contingency which allows the CS to become a signal for the absence of the UCS is introduced. The conventional pseudoconditioning control may lead to conditioned inhibition and therefore enhance the separation between control and experimental groups. A more appropriate comparison would be between the experimental group which received a CS-UCS contingency and the control group which received no contingency, either conditioned excitation or conditioned inhibition. In other words, it is better to have a control in which there is a balance between the predictability of no stimulus versus the predictability of a stimulus occurring. As an alternative Rescorla suggests the use of an independently random presentation of the CS and UCS across varied intervals, i.e., the presentation schedule for the CS is electronically independent of the presentation schedule of the UCS. It becomes possible for the CS and UCS to occur together on some occasions, to be paired, or to be non-paired, just as in the traditional control procedures. Thus the presentation of the CS offers no information about the occurrence of the UCS.

The present study differs from most studies in SPC in that during testing, acid and shock were presented in

addition to the tone. This is similar to the study reported by Bitterman, Reed and Kubala (1953). The present study employed this procedure for several reasons. First, on the basis of pilot work, it was found that rapid extinction of the flexion response occurred when animals were tested with tone or acid. It was decided that shock should be present during testing in order to keep the motivation of the animals at a high level and thus retard extinction of the flexion response. Secondly, this design offers a <u>test</u> of generalization in addition to simply attempting to rule generalization out through the use of the three control groups. It was hypothesized that if the two groups which received acid-shock pairings flexed equally as much to acid presentations in testing, but not equally to tone, stimulus generalization could be ruled out. In other words, an equal number of flexes to acid during testing in the two groups receiving acid-shock pairings during the conditioning phase would reflect conditioning, whereas, an equal number of flexes to tone would reflect stimulus generalization, since only the experimental group received tone-acid pairings during preconditioning.

As a final point, it should be noted that the present study also used a classical conditioning paradigm during the conditioning phase. This is identical to the procedure used by Prodofiev and Zeliony (1926), Shipley (1933), Lumsdaine (1939), and Bitterman, Reed, and Kubala (1953). This was

done as a matter of expediency in equipment design rather than for some theoretical reason. There is no evidence that SPC is effected by using a classical versus instrumental procedure during the conditioning phase. The important point is that a response must be conditioned to the acid.

In sum, the present study attempted to test the S-R theory of mediation responses occurring to produce the effect of SPC. To that end, a design which allowed direct measurement of a mediating response was used. The mediation hypothesis predicts that during preconditioning a response will be conditioned to tone and that this response will be present during testing and will act as a mediator to produce the response that was conditioned during phase two.

CHAPTER II

METHOD

Subjects. The subjects for this experiment were twenty mongrel, adult dogs, ranging in weight from twenty-eight to forty-three pounds. An additional twelve dogs were rejected for use in the experiment due to failure to meet the conditioning criterion during the preconditioning phase. Eight dogs were rejected due to failure of the surgical preparation. All dogs were obtained from a federally licensed dog kennel (Alexanders's Kennels, Maysville, Oklahoma). Upon arrival at the university laboratory each dog was assigned to a cage, weighed, and treated if symptoms of distemper and parasites were observed. Food was provided on an ad lib basis until the start of the experiment.

Apparatus. The apparati consisted of a restraining stock, a Varian Graphic recorder, Ralph Gerbrands event marker, Grason-Stadler shock supply, Mallery Sonalert electronic audible signal devise, Sage Automatic injector, and conventional relay equipment.

The restraining stock (Figures 1, 2) was a modification of a stock used by Miller (1967). When placing a dog

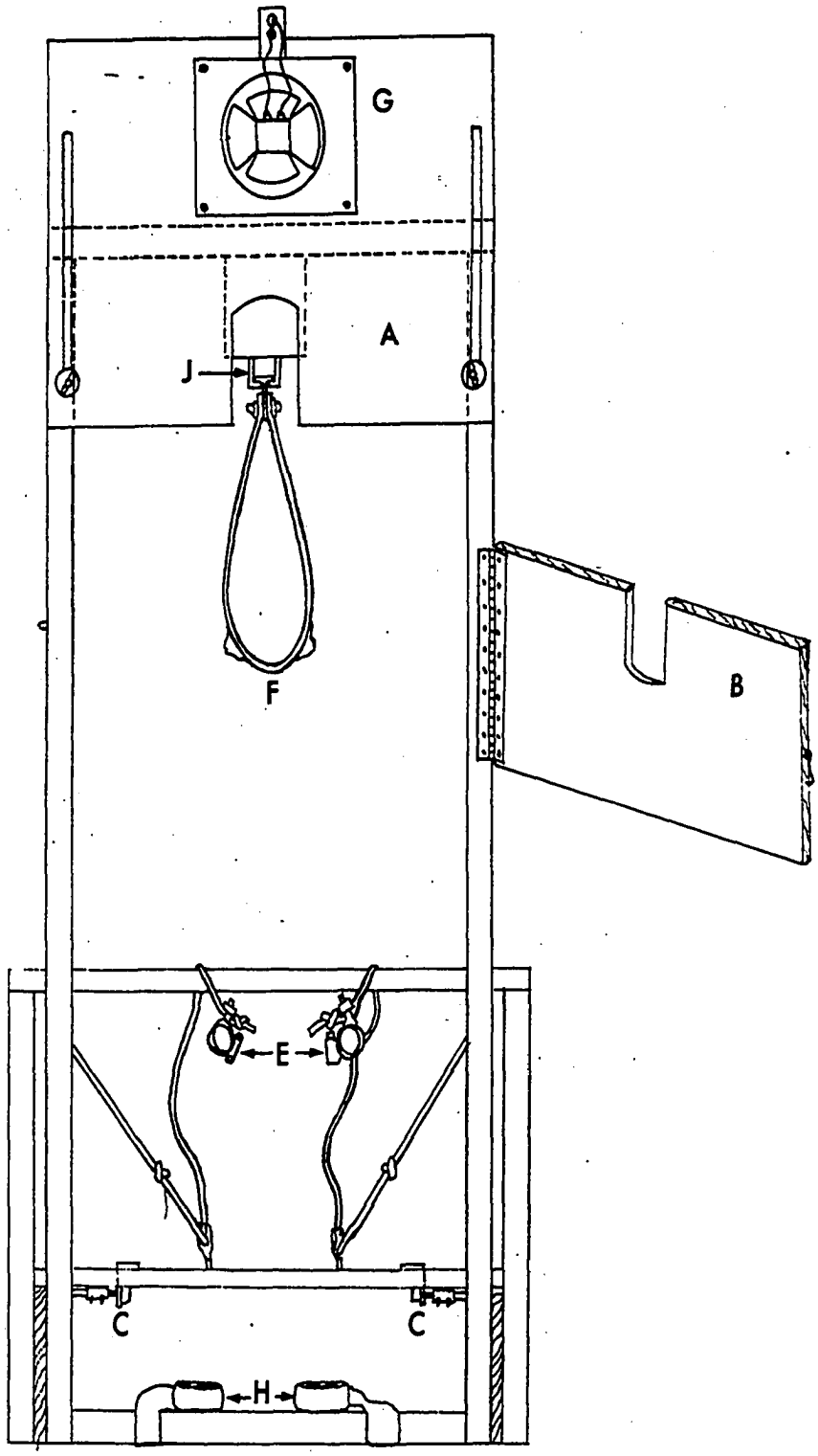

Fig. 1. Frontal view of the restraining stock

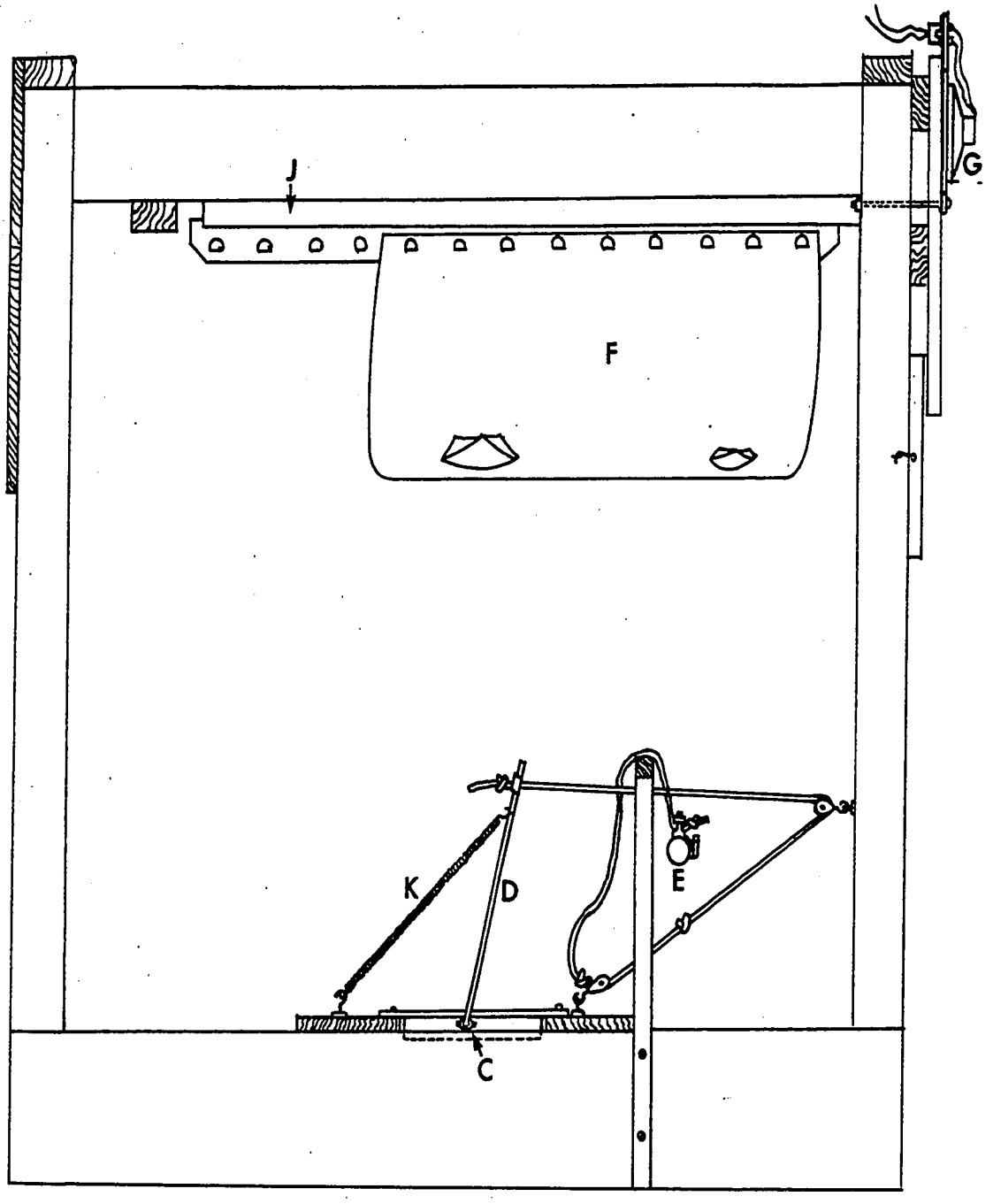

Fig. 2. Side view of the restraining stock

in the stock, a square piece of leather (F) approximately three feet by three feet with four holes for the dog's legs was snapped to an aluminum T-bar four feet long. This T-bar with the attached leather sling was inserted into an aluminum channel (J). The lower portion of the neck restrainer (B) was hooked into place, then the upper portion of the neck restrainer (A) was lowered onto the dog's neck. The front legs were restrained with rubber clamps attached to nylon ropes (H). An adjustable stand provided partial support for the dog's hind legs.

The nylon rope attached to the dog's right hind leg was fastened to a bar (D, Figure 2) which was attached to a precision potentiometer (10 K, Beckman Instruments). A flexion response resulted in the movement of the bar which changed the resistance across the potentiometer. The potentiometer was part of a Wheatstone bridge circuit connected to a graphic recorder (Varian Associates, G-14).

The stock was located in an experimental room measuring twelve by six feet. A blower (7500 rpm) provided masking noise. The sound pressure in the experimental room was recorded on a General Radio 1551A sound level meter. The meter had a flat response to KC 2 x 10^{-4} dynes per square centimeter. With programming equipment not in use, the sound pressure level was recorded at 67 db with a fast meter response. A second reading with programming equipment on, was also recorded at 67 db with a fast meter response.

All recording equipment was located in a sound resistant room twelve feet from the experimental room.

A constant current shock supply (Grason-Stadler, E6070B) provided electrical stimulation to the right hind leg. A one-second, 5 ma shock was delivered to the dog's right hind paw through small allegator clips placed between the first and second and the third and fourth toes.

A two cc, 3% acetic acid solution was administered with an automatic injector (Sage Instruments, 197). The injector was wired in series with an adjustable time relay which permitted regulation of the amount of acid given. Acid was delivered into the dog's mouth through a permanently implanted fistula.

The tone used was 2800 cps (Mallory Sonalert, SC628). The sound pressure of the experimental room with the tone on was 87 db (General Radio, 1551A meter).

Stimuli were presented through the use of commercially available relay equipment. The order and temporal relationships of stimuli presented in each phase of the experiment was programed on a patch board (American Pamcor Inc., 1631 System Universal). Trials were presented at variable intervals ranging from 1.75 minutes to 3.5 minutes with an average intertrial interval of 2.5 minutes. The actual presentation of trials was controled by two interval programers (Ralph Gerbrands, 1A) with tape speeds of eight 16 mm film frames per minute.

Surgical preparation. Approximately 30 minutes prior to surgery all dogs were administered a 2 cc intramuscular injection of triflupromazine hydrochloride (E. R. Squibb, Vetame) which is a mild seditive. A barbituate anesthetic (Diamond Laboratories Inc., Diabutal) was given through intravenas injection.

The surgical preparation consisted of two phases: 1) the permanent canulation of the left paratid duct (Stensen's duct) and 2) the creation of an artificial fistula for injection of acid into the oral cavity. The technique used in this experiment for canulation of the parotid was similar to that reported by Shapiro and Miller (1965) and Miller (1967).

The surgery was carried out with as much asepsis as possible. The external labial tissue and head were shaved and washed with Septisol surgical soap. A polyethylene tube (Clay-Adams, PE 50) approximately six inches long was then inserted into the parotid duct. This tube facilitated the identification and localization of Stensen's duct during the surgery. An incision approximately one inch in length was made in the external labial tissue over the course of the duct anterior to the Masseter muscle. The duct was located and dissected from surrounding tissue. Prior to surgery a special polyethylene tube (Clay-Adams, PE 50) was prepared by heat welding a small tab to the crook of a V-shaped bend. A reduction of the inside diameter of the tube at the bend

was prevented by inserting a copper wire which had an external diameter approximately equal to the inside diameter of the polyethylene tubing. Two 00 black silk sutures twelve inches in length were then tied to the tab approximately 1/4 inch apart. One end of the V-shaped tube was attached to a metal probe which was passed subcutaneously from the incision to the top of the head. A 1/4 inch longitudinal incision was then made in the exposed duct, and the portion of the original tube posterior to that incision was pulled from the duct. The other end of the V-shaped tube was cut the same length as the withdrawn portion of the original tube and then inserted into the duct. In order to prevent saliva from draining into the subdural tissue, the duct now enclosing one end of the V-shaped tube was ligated with black silk. Contamination from the mouth was prevented by removing the original tube and ligating the portion to the duct anterior to the V-shaped tube. The two black silk sutures previously tied to the tab of the V-shaped tube were then sewn to the tissue surrounding the duct. This was done so that any pulling on the tube protruding from the dog's head resulted in tension of the surrounding tissue rather than on the duct. The incision in the external labial tissue was then closed with 00 black silk. Following surgery, secretions from the parotid gland flowed from the polyethylene tube protruding from the dog's head.

The second phase of the surgery consisted of placing a permanent polyethylene fistula in the dog's left upper lip. A leather punch was used to make a small hole just above the first molar. Prior to surgery a one-half inch section of tubing (Clay-Adams, PE 320) was flared at one end with heat and inserted through a washer-shaped polyethylene disc approximately one-half inch in diameter. The PE 320 tube with washer was guided through the hole in the dog's cheek with a smaller diameter polyethylene tube (Clay-Adams, PE 260). Another polyethylene disc of approximately the same size as the first disc was placed over the PE 320 tube protruding from the dog's cheek and a second flange was made.

When a dog was placed in the stock for an experimental session, a polythylene tube (Clay-Adams, PE 260) leading from the acid injector was inserted into the fistula. A polyethylene tube (Clay-Adams, PE 100) attached to a glass column filled with a solution of 50 per cent isopropyl alcohol was slipped over the tube protruding from the dog's head. When acid was injected into the oral cavity the resulting salivation displaced the solution in the glass tube. Drops were formed between a 22 guage hypodermic needle and a sharp pointed 1/16 inch brass rod. The contacts of a commercially available Grason-Stadler drinkometer were connected to the needle and the brass rod. Drops closing the contacts were recorded by an even marker previously described.

Procedure. Upon arrival at the university laboratory each dog was assigned to one of four groups. A summary of the treatment each group received can be seen in Table 3. The experimental group (E) was exposed to pairings of tone and acid during phase one (preconditioning), and pairings of acid and shock during phase two (conditioning). Control group one (C_1) received the same treatment as group E in phase one but received acid and shock in a independently random order during phase two. Control group two (C_2) received tone and acid in a independently random order in phase one, and paired acid and shock in phase two. The fourth group (C_3) received a independently random order of tone and acid in phase one and independently random presentations of acid and shock in phase two. In phase three (testing) all groups received pre-arranged presentations of tone, acid, and shock.

Two days before surgery all dogs were given adaptation training in a restraining stock. The adaptation stock was built to the same dimensions as the experimental stock and was located in a room of the same dimensions as the experimental room. Adaptation training consisted of five 30 minute sessions in the adaptation stock.

The subjects received full food rations prior to surgery and no food the day of surgery. Dogs were maintained on half rations throughout the procedure. Each animal was given a small amount of food prior to each

Table 3

Summary of Procedure for all Groups

Group	Days 1-3 Stock Adaptation	Days 3-4 Surgery	Days 5-9 Preconditioning	Days 10-14 Conditioning	Days 15-16 Testing
E N=5	S placed in restraining stock for 2.5 hours	Surgery and recovery	Two sessions per day of 10 tone-acid pairings	Two sessions per day of 10 acid-shock pairings	Three sessions of 4 tones and 4 acids and 4 shocks not paired
C_1 N=5	Same as Group E	Same as Group E	Same as Group E	Two sessions per day of 10 acid and 10 shocks not paired	Same as Group E
C_2 N=5	Same as Group E	Same as Group E	Two sessions per day of 10 tones and 10 acids not paired	Same as Group E	Same as Group E
C_3 N=5	Same as Group E	Same as Group E	Same as Group C_2	Same as Group C_1	Same as Group E

session in order to clear the salivary tube of any deposits that might have formed since the last session.

Preconditioning. Thirty-six to forty-eight hours after surgery each dog was given a small amount of food and placed in the stock. The door of the experimental room was closed and the masking fan and program equipment was turned on. Depending upon group assignment each dog received either a six second tone followed immediately by 2 cc acid (i.e., a delayed conditioning procedure) or tone and acid randomly presented. All dogs received 10 tones and 10 acids per session which lasted approximately 26 minutes. This procedure was repeated twice a day for five days with approximately six hours between each session. In other words, the dogs in groups E and C_1 received 100 pairings of tone and acid and groups C_2 and C_3 received 100 tones and 100 acids presented in a random order. The actual presentation of the random tones and acids was accomplished by using two interval programers and two independently programed tapes. The tone-acid pairings were presented through the use of a single interval programer.

After each session the subjects were returned to their home cages and given a small amount of food. Records were taken of the amount of salivation that occurred six seconds prior to tone, during tone, and six seconds after tone. In like manner records were taken on the amount of salivation that occurred prior to, during, and after acid.

Conditioning. After five days of phase one all dogs entered the conditioning phase (phase two) of the experiment. Depending upon group assignment, each dog received either a 2 cc acid injection followed two seconds later by a one second 5 ma shock delivered to the right hind foot, or a 2 cc acid injection and shock randomly presented. As in phase one, all dogs received 10 acids and 10 shocks per session which lasted approximately 26 minutes. This procedure was repeated twice a day for five days. After each session, the subjects were returned to their home cages and given a small amount of food. Records were taken on the amount of salivation prior to, during, and after acid and prior to, during, and after shock. In addition, flexion to acid and shock was recorded.

Testing. During the testing phase, which consisted of three sessions in the stock, all dogs received prearranged presentations of tone, acid, and shock. For the actual order of presentation see Table 4. All dogs received four presentations each of a six-second tone, a 2 cc acid injection, and a one second 5 ma shock during each session. The amount of salivation and number of flexions to each stimulus was recorded. Upon completion of phase three, all dogs were sent back to Alexander's Kennels.

Table 4

Order of stimulus presention during phase three for all groups

Session		
1	2	3
Tone	Tone	Tone
Acid	Shock	Acid
Shock	Acid	Shock
Tone	Tone	Tone
Shock	Acid	Shock
Acid	Shock	Acid
Tone	Tone	Tone
Acid	Shock	Acid
Shock	Acid	Shock
Tone	Tone	Tone
Shock	Acid	Shock
Acid	Shock	Acid

CHAPTER III

RESULTS

The main response measures analyzed in this study were: 1) the number of conditioned responses (CR's) that occurred to tone in all groups during preconditioning, 2) the number of CR's that occurred to acid in all groups during conditioning, 3) the number of flexes to tone during testing, 4) the latencies of the flexes to tone during testing, 5) the number of flexes to acid during testing, and 6) the latency of the flexes to acid during testing.

Preconditioning. A conditioned response was said to occur when the total number of drops occurring during the six-second tone was two greater than the number of drops six seconds preceeding the tone. This was done because the error of measurement of the drop counter was one drop since a portion of the required volume of liquid necessary to close the electrical contact could remain on the end of the needle.

The mean number of CR's is plotted for all four groups by days in Fig. 3. The means and standard deviations for each group across days were: E group $\bar{X}$=56.90,

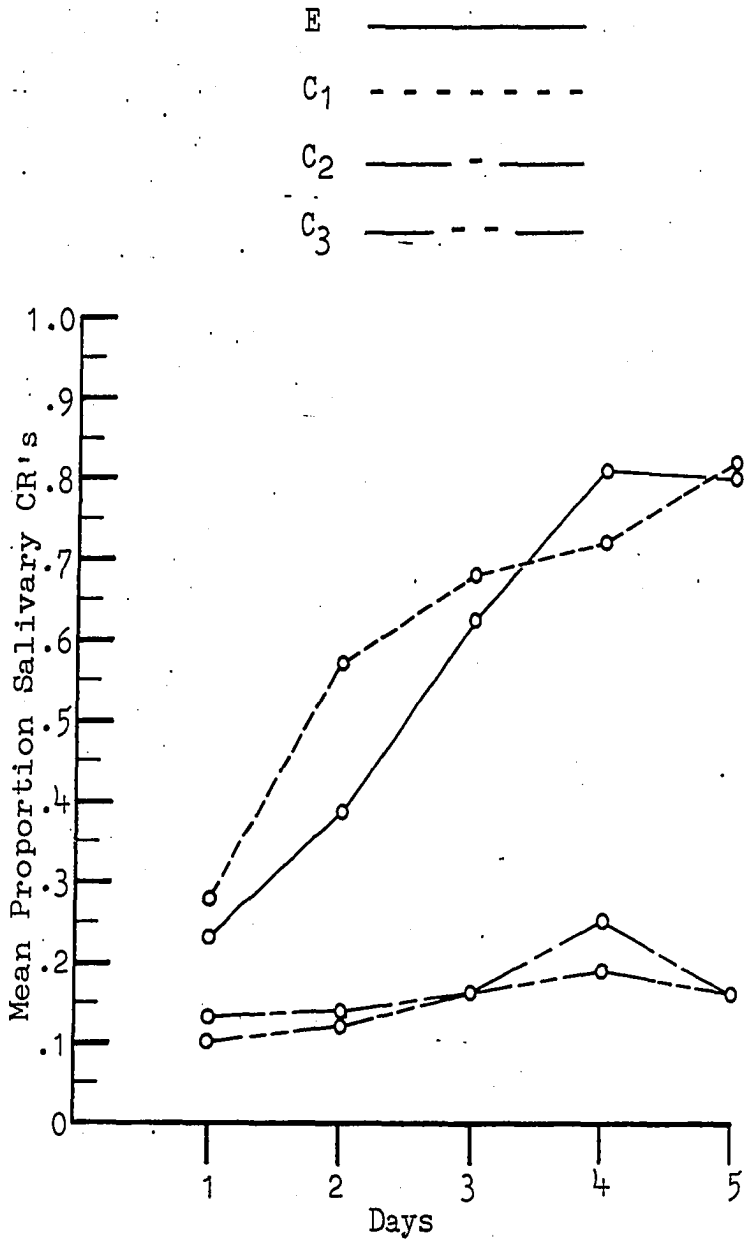

Fig. 3. Mean proportion of salivary CR's during preconditioning.

S.D.=30.09; C_1 group, $\bar{X}$=61.36, S.D.=25.54; C_2 group, $\bar{X}$=17.26, S.D.=9.56; and C_3 group $\bar{X}$=14.38, S.D.=9.07. A four by five, repeated measurement analysis of variance was performed on the mean number of CR's occurring during preconditioning as a function of groups and days. A summary of this analysis is given in Table 5. Before this analysis was done, an analysis of the variances was computed to determine if the assumption of homogeneity of variance was met. This analysis was not significant, F_{max} (4,5)=11.03, $p > .05$, indicating that the assumption of homogeneity of variance was met. A significant F ratio was obtained between groups, across days, and for the groups by days interaction. In order to show that the two groups which received tone-acid pairing during preconditioning (E and C) showed a greater number of CR's to tone across days than the two groups which did not receive tone-acid pairing (C_2 and C_3), an orthogonal comparison was computed contrasting E and C_1 vs. C_2 and C_3. This analysis was significant at less than the .01 level of significance, F (1,16)=86.89 with E and C_1 ($\bar{X}$=59.13) having a greater number of CR's than C_2 and C_3 ($\bar{X}$=15.82). A further comparison was made contrasting the two groups which received paired presentations of tone-acid (E vs. C_1), and this contrast failed to reach significance, F (1,16)=.45, $p > .05$ with the means for group E and group C_1 being 56.90 and 61.36 respectively. A contrast made between the two pseudoconditioning groups (C_2 and C_3) failed to reach

Table 5

Summary of Analysis of Variance for the number of CR's in Preconditioning

Source of Variance	df	MS	F
Between groups			
Groups	3	15,755.22	29.18*
Ss w. Groups	16	539.93	
Within subjects			
Days	4	3,463.88	21.22*
Days x Groups	12	717.79	4.39*
Days x Ss w. Groups	64	163.20	

*Prob. less than .01

significance, F (1,16)=.19, $p > .05$, with the means for C_2 and C_3 being 17.26 and 14.38 respectively.

Conditioning. During the conditioning phase, a conditioned response was defined as a flexion response occurring after acid presentation and before the onset of shock. The criterion for identifying a flex was a pen deflection of at least one millimeter.

The mean proportion of CR's is plotted for all four groups across days in Fig. 4. The means and standard deviations for each group summed across days were: E, $\bar{X}$=83.80, S.D.=21.40; C_1, $\bar{X}$=2.80, S.D.=4.60; C_2, $\bar{X}$=70.77, S.D.=33.47; and C_3, $\bar{X}$=3.40, S.D.=4.94. The assumption of homogeneity of variance was not met, F_{max} (4,5)=53.30, $p < .01$. However, Box (1953) has shown that analysis of variance is a powerful enough test to be relatively un-effected by heterogeneity of variance. Since the probabilities obtained were so low, e.g., F (3,16)=88.60, $p < .001$, it was concluded that an analysis of variance would yield results relatively safe from alpha error. A four by five, repeated measurement analysis of variance was performed on the mean proportion of CR's obtained as a function of groups and days. A summary of this analysis can be seen in Table 6. The analysis shows a significant between groups effect, between day effect, and day by group interaction. Three orthogonal comparisons were also computed. First, in order to determine if the two conditioning groups (E and C_2)

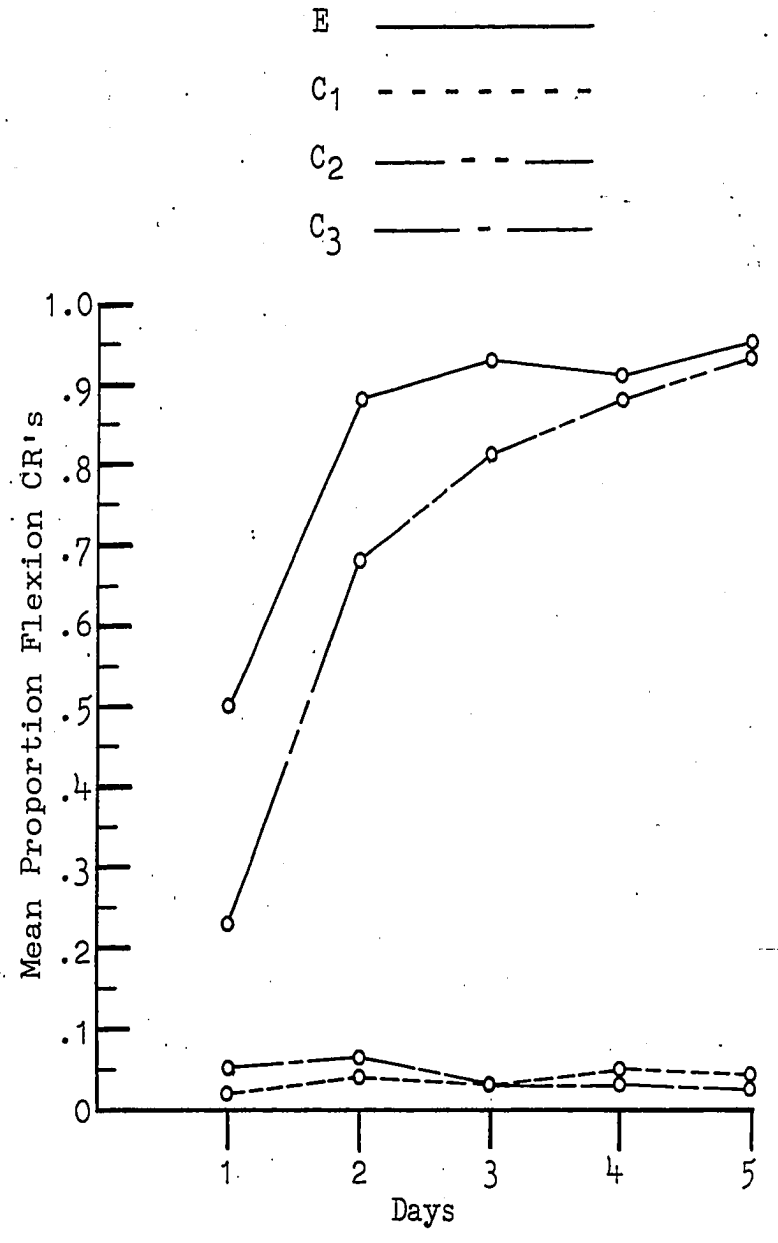

Fig. 4. Mean proportion of flexion CR's during conditioning.

Table 6

Summary of Analysis of Variance for the number of CR's in Conditioning

Source of Variance	df	MS	F
Between groups			
Groups	3	46,565.60	88.60*
Ss w. Groups	16	525.52	
Within subjects			
Days	4	2,627.88	21.21*
Days x Groups	12	1,051.96	8.50*
Days x Ss w. Groups	64	123.72	

*Prob. less than .01

obtained a greater number of CR's than the two pseudoconditioning groups (C_1 and C_3), a contrast comparing these groups was computed. This analysis was significant at less than the .01 level of significance, F (1,16)=261.77, with E and C_2 ($\bar{X}$=77.29) having a greater number of CR's than C_1 and C_3 ($\bar{X}$=3.10). A second comparison was made contrasting the two conditioning groups (E vs. C_2). This contrast failed to reach significance, F (1,16)=4.04, $p > .05$, with the means for group E and C_2 being 83.80 and 70.76 respectively. A third contrast was computed comparing the two pseudoconditioning groups (C_1 vs. C_3). This contrast also failed to reach significance, F (1,16)=.008, $p > .05$, with the means for groups C_1 and C_3 being 2.8 and 3.4 respectively. These results indicate that the number of CR's increased over days for the two groups which received pairings of acid and shock, but did not increase in the groups receiving pseudoconditioning.

Testing. For the first step in analyzing the data obtained during the testing phase, the number of flexes that occurred for each group to the test tones was computed. It was found that the experimental group (E) flexed a total of twenty-three times; C_1 flexed nine times; C_2, five times; and C_3 thirteen times. A χ^2 of 14.32 with three degrees of freedom was significant at less than the .01 level of significance. The mediation hypothesis would predict that in order for flexes to occur, a mediating response of salivation

must occur concomitant with the flexes. However, only two of the twenty-three flexes in the experimental group occurred with a salivation response present. That is, the empirical probability of flexes occurring concomitant with a salivary response was only .086.

The latencies of the flexes to tone for all groups were analyzed with a one-way analysis of variance for unequal groups. The flexion latency to tone was measured from the onset of tone to the point where a deflection of the pen was more than one millimeter. Analysis of variance showed that there was a significant groups effect, $\underline{F}\ (3,46)=4.58$, $\underline{p} < .01$. A contrast comparing the experimental group with all control groups was also significant, $\underline{F}\ (1,46)=4.67$, $\underline{p}$ .05. The means (E=.75 sec, N=23; C_1=1.11 sec., N=9; C_2=2.41 sec., N=5; and C_3=1.26 sec., N=13) indicate that the latency of the flexes was significantly shorter for the experimental group. A test for homogeneity of variance indicated that this assumption was met, $\underline{F_{max}}\ (4,20)=1.29$, $\underline{p} > .05$.

A similar analysis was made on the number of flexes occurring to acid during testing for all groups. It was found that the E group flexed thirty-five times; C_1 four times; C_2 thirty-six times; and C_3 eleven times. A χ^2 of 37.60 with three degrees of freedom was obtained which was significant at less than the .01 level of significance. Inspection of the number of times flexions occurred indicates

that there was no difference between the two groups which received acid-shock pairing during the conditioning phase of the study.

In order to determine if stimulus generalization could account for the results obtained, the latencies of the flexes to acid for all groups were also analyzed. A one-way analysis of variance for unequal groups showed that there was a significant difference between groups, $\underline{F}$ (3,82)=13.82, $\underline{p} < .01$. A contrast between the two groups which received acid-shock pairing in the conditioning phase with the two groups which received pseudoconditioning trials (E and C_2 vs. C_1 and C_3) was also significant, $\underline{F}$ (1,82)=40.73, $\underline{p} < .01$. Inspection of the mean latencies (E=1.14 sec.; C_1=3.24 sec.; C_2=1.15 sec.; and C_3=2.84 sec.) indicates that E and C_2 had identical latencies and were significantly lower than the two other groups. An $\underline{F_{max}}$ test was computed on the variances (E=.66; C_1=1.28; C_2=.65; C_3=2.35) and yielded a significant ratio, $\underline{F_{max}}$ (4,30)=3.56, $\underline{p} < .05$. On the basis of Box's study (1953) and the large F ratios obtained, it was concluded that the results of the analysis of variance were relatively safe from alpha error.

Tables A through D of the Appendix include all data used in the above computations.

CHAPTER IV

DISCUSSION

The purpose of the present study was to attempt to provide evidence relating to the mediation hypothesis put forth by the S-R theory in its explanation of SPC. Of major importance to this study was to determine if a mediating response was present when flexion occurred during testing.

Preconditioning. The mediating response chosen as most likely to occur during testing was a salivary response that was conditioned to tone during phase one for the experimental group. It therefore becomes important to show that conditioning actually occurred during preconditioning. Analysis of the mean proportion of CR's indicated that conditioning did occur in the two groups which received tone-acid pairings (E and C_1) but did not occur in the two groups which received the pseudoconditioning random trials (C_2 and C_3). It was therefore concluded that a reliable salivation response to tone was present in groups E and C_1. Since tone elicited salivation during preconditioning,

it was possible for salivation to be elicited by tone during testing and act as a mediating response.

Conditioning. The design for all SPC studies requires that a response be conditioned to the second of the two stimuli used during preconditioning (i.e., a response conditioned to acid in the present study). Analysis of the mean proportion of CR's obtained during conditioning indicated that the two groups which received acid-shock pairings (E and C_2) had a significantly higher number of CR's than the two groups which received the pseudoconditioning procedure (C_1 and C_3). It was concluded that conditioning did occur in the two groups which received acid-shock pairings (E and C_2).

Rescorla (1967) suggested that the difference between a conditioning group and a pseudoconditioning group may be enhanced by the use of traditional control procedures in which one stimulus can become a signal for the absence of the other stimulus. The present study utilized a procedure that Rescorla (1967) maintains is more appropriate. The stimuli in the present study were presented in an independently random order, such that the presence of one stimulus could not become a signal for the absence of the other. It is interesting to note that in both the preconditioning and conditioning phases, the groups which received the pseudoconditioning procedure showed a small degree of conditioning. While the number of CR's in these groups

never approached the level obtained by the groups receiving paired presentations of the stimuli, a slight increase was noted over days during preconditioning (See Fig. 3). The fact that these groups (the two pseudoconditioning groups) showed any CR's at all may be due to the fact that by using Rescorla's procedure, some pairings were possible. These few pairings could account for the number of CR's obtained by the pseudoconditioning groups. It will be for future studies to determine if results obtained by using Rescorla's technique differ significantly from the results obtained by using the traditional technique of pseudoconditioning. While the present study obtained a wide separation between the conditioning groups and the pseudoconditioning groups, use of the traditional procedure of pseudoconditioning may have resulted in an even wider separation.

Testing. Analysis of the data obtained during testing indicated that the experimental group had a significantly higher number of flexion responses than any of the three control groups. The latencies of these flexions were also analyzed. This was done in an attempt to rule out stimulus generalization. If stimulus generalization were occurring, it would be expected that the latencies for all four groups would be the same. However, the latency of the flexion responses was significantly shorter for the experimental group than for the pseudoconditioning groups. The

evidence from both the number and latency of flexion responses was taken to show that sensory preconditioning was demonstrated in the present study.

Of major importance to the present study was the absence of the hypothesized mediating response, salivation, during flexions to test tones. Analysis of the data indicated that there were very few mediating responses present. Of the twenty-three flexions observed during testing in the experimental group, only two occurred in conjunction with salivation. On the basis of this result, it would seem that a mediating response was not necessary for SPC to occur. Even though salivation appears to be the most likely response that could serve as a mediator, the data do not support this hypothesis. Therefore, the results of this study may be taken as support for the S-S interpretation of SPC.

It should be pointed out, however, that the salivation response may not have been the only response available to act as a mediator. It is possible that salivation may have been only a part of a response complex that was conditioned during preconditioning, and was not strong enough to be measured by the equipment utilized in this study. It is possible that some type of "orientation response" was present and acted as a mediator as Parks (1968) postulates. It will be recalled that Hoffeld, Kendall, Thompson and Brogden (1960) found a maximum SPC effect with only four presentations of the stimuli during preconditioning. These

data are consistent with Parks' (1968) data since the orientating response may have habituated with more than four presentations of the stimuli in preconditioning. In light of Parks' results, however, it seems that any orientating response that occurred during preconditioning in the present study would have habituated with the large number of presentations.

One other result requires discussion. As in all SPC studies, there was the possibility that the observed SPC effect may have been due to stimulus generalization. The subjects in the experimental group may have responded to the onset properties of any stimulus and not only to tone. However, the lack of significant differences between the experimental group and the group which received acid-shock pairings during conditioning (C_2) when both groups received acid presentations during testing indicates that stimulus generalization may not have been present. Both groups (E and C_2) flexed an equivalent number of times, and had equivalent latencies of flexion response when acid was presented during testing. This was expected since both groups were conditioned to flex to acid. However, if stimulus generalization were acting to elicit a flex to the onset of any stimulus, both groups should have flexed an equal number of times to tone. This, however, was not the case. It was therefore concluded that a genuine SPC effect was obtained in the present study.

Significance of the present study. Two opposing theories have arisen in the field of learning in an attempt to explain how learning occurs. The first, the S-R approach, postulates that when learning occurs there is a connection between a stimulus and a response. In other words, the central connections are between afferent and efferent neurons. The S-S point of view, on the other hand, holds the view that the connections that are formed when learning occurs are of a afferent-afferent nature or a stimulus-stimulus connection. No response is necessary in order for learning to occur. When two afferent centers are contiguously activated, a connection is established between them such that the subsequent arousal of one will arouse the other. The S-S theory postulates a purely afferent process which occurs in the absence of a motor response (Birch and Bitterman, 1951).

Sensory preconditioning studies have offered a means of opposing the S-R and S-S theories. The S-R theorists assume that SPC can be explained on the basis of some heretofore unmeasurable response occurring that acts as a mediator to produce the SPC effect. The S-S view postulates that the response is not a necessary condition for SPC to occur. The literature has many examples of studies which provide support for one theory or the other. The fact that SPC studies are still appearing in the literature (e.g., Prewitt, 1967 and Parks, 1968) suggests that the controversy

remains important. The great majority of evidence that is presented on both sides of the controversy is largely indirect evidence, i.e., studies that assume that variables affecting the classical conditioning paradigm should also apply to the preconditioning phase of SPC (e.g., Hoffeld et al., 1958; Hoffeld et al., 1960; Silver and Meyer, 1954; and Coppock, 1958). The difficulty seemed to be that the S-R theorists were postulating a response that could not, or had not been directly observed and measured. Only one study (Lumsdaine, 1939) emphasizes a direct measurement of a mediation response occurring in SPC. Therefore, another study that provided a direct measure of a mediating response seemed in order.

The major finding of the present study was that the most likely response that could have acted as a mediator was not present during the majority of the flexion responses during testing. With the concession that salivation may not have been the only response present to act as a mediator, the results of the present study seem to support the S-S contiguity point of view. These results are consistent with the results obtained by Hoffeld et al. (1958) who found that a greater SPC effect was obtained when the time interval between the onset of a tone and the onset of a light in preconditioning was 4 seconds. The S-R theorists would have difficulty explaining how a delay of that long (the time period between S_1 and S_2) could produce a

conditioned response when the majority of studies dealing with the CS-US interval have found that an interval of about one-half second is optimum (Kimble, 1961). Hoffeld and his associates (1960) have also found that SPC is stronger if only four pairings are presented during preconditioning. Again, the S-R theorists must postulate that a conditioned response was established in a very few trials which is not consistent with studies dealing with the number of trials needed to establish a conditioned response.

The present study, which provided a new method for directly measuring a mediating response of salivation in sensory preconditioning, failed to support the mediation response hypothesis.

CHAPTER V

SUMMARY

The phenomenon named sensory preconditioning (SPC) was first demonstrated in an experiment reported by Brogden (1939). It was found that if a bell and a light were presented simultaneously 200 times, and then one of these two stimuli was made a CS for conditioned flexion, by pairing it with shock, the other stimulus also evoked the flexion response, even though it had never been paired with shock. One controversy that surrounds SPC is whether or not a mediation response is necessary for the effect to be observed. An S-R interpretation of SPC studies maintains that some response is conditioned during preconditioning and that this response acts as a mediator to elicit the effect of SPC. The opposing view, the S-S contiguity theory, maintains that a mediating response is not necessary for SPC to occur. Rather, all that is required is that an association be formed during preconditioning through the contiguous presentation of two stimuli. The purpose of the present study was to provide a direct measure of the mediating response, if indeed it were present.

Four groups of five dogs were assigned to one of four treatment groups. The experimental group (E) was exposed to pairings of tone and acid during phase one (preconditioning), and pairings of acid and shock during phase two (conditioning). Control group one (C_1) received the same treatment as the E group in preconditioning but received acid and shock in a independently random order during conditioning. Control group two received tone and acid in a independently random order in preconditioning and paired acid and shock in conditioning. The fourth group (C_3) received a independently random order of tone and acid in preconditioning and independently random order of acid and shock in conditioning. In phase three (testing) all groups received pre-arranged presentations of tone, acid, and shock.

The present study differed from past studies in several ways. First, strong unconditioned stimuli were used (acid and shock). In the majority of past studies two "neutral" stimuli such as tone and light have been used during preconditioning. Second, the present study employed a new control group procedure suggested by Rescorla (1967). Stimuli presentations in the pseudoconditioning control groups were presented on a purely random basis. Third, the present study employed a testing procedure that was designed to keep the motivation of the subjects at a high level and permitted a test of stimulus generalization. The test

procedure used was the unpaired presentations of tone, acid, and shock during testing, rather than just tone presentations.

The main findings of this study were that the experimental group showed more flexions to tone during testing than any of the three control groups. In addition, of all the flexes to tone in the experimental group, only two were accompanied by the salivary response. It was concluded that while SPC was demonstrated, a mediating response did not seem to be necessary to produce the SPC effect. It was pointed out, however, that salivation may have only been a small part of a response complex conditioned to tone during preconditioning, and that absence of the salivary response could not be taken as evidence that some other unmeasurable response was not present to act as a mediator.

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APPENDIX

Table A

Mean proportion CR'S for all dogs across days during preconditioning

Group	Dog	Days 1	2	3	4	5
E						
	C-45	20	50	73	90	80
	C-29	10	10	20	80	90
	C-28	65	70	75	85	80
	C-27	20	40	90	70	60
	C-8	0	20	55	80	90
C_1						
	C-42	10	30	55	65	70
	C-15	50	95	78	90	90
	C-14	30	70	80	80	80
	C-13	0	20	65	66	85
	C-12	50	70	65	60	80
C_2						
	C-37	10	25	10	25	20
	C-36	10	10	20	25	15
	C-19	10.5	6.5	30	15	15
	C-18	11	25	21	45	25
	C-16	26	6	5	15.5	5
C_3						
	C-23	11	0	20	10	30
	C-47	5	11	0	20	10
	C-39	15	15	16	15	5
	C-38	0	10	15	25	10
	C-21	10	25	31.5	25	25

Table B

Mean proportion CR'S for all dogs across days during conditioning

Group	Dog	Days 1	2	3	4	5
E						
	C-45	30	85	100	100	95
	C-29	71	93.5	100	100	88
	C-28	65	100	100	100	100
	C-27	70	85	85	60.5	94
	C-8	18.5	80	80	95	100
C_1						
	C-42	5	15	10	0	0
	C-15	0	5	0	0	0
	C-14	5	0	5	5	15
	C-13	0	0	0	0	0
	C-12	0	0	0	0	5
C_2						
	C-37	20	85	100	100	79
	C-36	0	30	20	50	90
	C-19	10	70	95	95	100
	C-18	45	60	100	100	100
	C-16	40	90	90	95	100
C_3						
	C-23	5	0	5	0	0
	C-47	0	15	0	0	5
	C-39	15	5	10	0	0
	C-38	0	0	0	0	0
	C-21	5	10	0	0	10

Table C

Flexion Latencies in seconds for the twelve test tones

Group	Dog	Tone 1	2	3	4	5	6	7	8	9	10	11	12
E													
	C-45	.66	.96	2.14	1.77	.44	--*	--	--	--	.59	--	1.62
	C-29	--	--	.37	--	.15	--	--	--	--	--	--	1.18
	C-28	--	.59	--	.30	.22	.30	.30	.15	.30	.15	--	--
	C-27	--	--	--	--	1.18	--	--	1.62	--	--	.22	--
	C-8	2.07	--	--	.15	--	--	--	--	--	--	--	--
C_1													
	C-42	--	1.11	--	--	--	1.85	2.14	--	--	--	--	--
	C-15	--	--	--	--	--	--	--	--	--	--	--	--
	C-14	1.85	--	--	--	--	--	--	--	--	--	--	--
	C-13	--	--	--	--	.59	--	--	--	--	--	--	--
	C-12	--	.30	.30	--	.81	--	--	--	--	--	1.03	--
C_2													
	C-37	NF	--	--	--	--	--	--	--	--	.22	--	--
	C-36	NF	--	--	--	--	--	--	--	--	--	--	--
	C-19	NF	--	--	--	--	--	--	--	.52	--	--	--
	C-18	4.36	5.51	1.55	NF	--	--	--	--	--	--	--	--
	C-16	NF	--	--	--	--	--	--	--	--	--	--	--
C_3													
	C-23	NF	--	--	--	--	--	--	--	--	--	--	--
	C-47	--	--	--	--	--	--	--	--	--	--	--	--
	C-39	NF	1.40	--	--	--	1.26	--	--	--	1.03	--	1.40
	C-38	.37	.59	--	.30	.52	--	--	--	--	--	--	.59
	C-21	--	1.92	4.58	--	--	--	--	1.03	--	--	1.40	--

*No flex

Table D

Flexion latencies in seconds for the twelve test acids

Group	Dog	Acid 1	2	3	4	5	6	7	8	9	10	11	12
E	C-45	.59	.59	.96	.59	.59	1.26	--*	--	1.00	.89	--	.59
	C-29	1.77	1.48	.89	2.66	2.51	--	--	--	--	--	--	--
	C-28	.81	.44	--	.30	.15	.30	.30	--	--	--	.37	.37
	C-27	1.26	--	--	--	2.66	--	1.18	--	--	.30	2.07	2.21
	C-8	2.16	1.11	.74	.15	2.07	2.36	2.21	--	--	--	--	--
C_1	C-42	--	--	--	--	1.33	2.21	--	--	--	--	--	--
	C-15	--	--	--	--	--	--	--	--	--	--	--	--
	C-14	--	--	--	--	--	--	--	--	--	--	--	--
	C-13	--	3.99	--	--	--	--	--	--	--	4.43	--	--
	C-12	--	--	--	--	--	--	--	--	--	--	--	--
C_2	C-16	1.18	1.48	2.21	2.07	1.62	1.62	--	--	--	--	--	--
	C-18	.44	1.18	2.21	.59	1.40	.66	--	2.51	--	--	--	--
	C-19	.59	.96	--	1.40	--	--	--	--	1.55	--	--	--
	C-36	.66	.59	.37	--	.89	1.03	1.03	1.92	--	.30	--	--
	C-37	.44	.59	1.48	1.33	1.03	1.26	1.26	--	.30	1.03	1.26	.96
C_3	C-23	--	--	--	--	--	--	--	--	--	--	--	--
	C-47	--	--	--	--	--	--	--	--	--	--	--	--
	C-39	4.58	--	--	--	3.84	--	--	3.99	--	--	--	--
	C-38	--	.52	--	1.48	--	3.69	1.11	4.13	.74	3.69	3.54	--
	C-21	--	--	--	--	--	--	--	--	--	--	--	--

*No flex