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PRE-EXPOSURE EFFECTS IN SENSORY PRECONDITIONING

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by

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ABSTRACT

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Using a conditioned suppression procedure with rats as subjects, two experiments examined the effects of pre-exposing S_1 and S_2 in the sensory preconditioning (SPC) paradigm. Experiment I demonstrated that there are latent inhibition effects on the CER when S_2 is pre-exposed just prior to SPC training. Subjects received either 0, 25, or 50 pre-exposures of S_2 (CER stimulus) prior to SPC and CER training. In addition, the intensity of S_2 was varied. They were then given three sessions of extinction training to the CER stimulus (S_2) on the day following SPC and CER conditioning. After the last CER extinction day, S_1 (SPC test stimulus) was presented to all subjects in order to see if CER extinction affected the magnitude of SPC. The intensity of S_2, within the limits used in this experiment, failed to produce any differential SPC effects. The SPC test data from the zero and 50 pre-exposure groups who received CER extinction training was compared to similar groups from an earlier study who did not receive extinction training. This comparison revealed no reliable differences. That is, the SPC effect and its reduction by pre-exposure to S_2 survive CER extinction.

Experiment II was a replication of Rappaport's (1974) finding that there are differential effects of pre-exposing S_1 and S_2. A procedure similar to that used in experiment I was used except subjects were pre-exposed to either S_1, S_2 or $S_1 + S_2$ prior to CER training. No extinction training to the CER was given but half of the subjects were presented with a disinhibiting stimulus after pre-exposure. It was shown that S_2

pre-exposure, and not S_1 pre-exposure, reduces any SPC effect. It was also demonstrated that pre-exposing both $S_1 + S_2$ obliterates the SPC effect. Presentation of the disinhibitory stimulus (a 90 sec. click) erased the effect of pre-exposing S_2 but had no effect on the groups pre-exposed to both $S_1 + S_2$. Two different types of pre-exposure effects were demonstrated in that while S_2 pre-exposure and $S_1 + S_2$ pre-exposure both reduced SPC effects the presentation of the disinhibitory stimulus only had effect on the S_2 pre-exposed subjects.

Experiment I and II established that:

1) The strength of the association between S_2 and shock is not the determiner of the associative strength between S_1 and S_2 in that the extinction of the CER does not reduce responding to S_1 during SPC testing.
2) Pre-exposing S_2, and not S_1, serves to eliminate any SPC effects and this pre-exposure effect can be destroyed by the presentation of a disinhibitory stimulus just after pre-exposure.
3) Pre-exposing $S_1 + S_2$ also served to eliminate any SPC effects but the presentation of the disinhibitory stimulus had no effect. This confirms Mackintosh's idea that the subjects had learned that $S_1 + S_2$ are not related.

SECTION I

INTRODUCTION

The term sensory preconditioning (SPC) and the paradigm for SPC was first established by Brogden (1939). In his initial experiment he used eight experimental dogs which were presented with two hundred pairings of "bell immediately followed by the presentation of a light." Eight other control dogs received no experience with the bell or light. In the second phase of his experiment, half of the animals in the experimental group received leg flexion training with light and shock. The control animals were also divided into two groups and received the same avoidance training as the experimental groups to either the bell or the light. In the final phase of Brogden's experiment, the animals which had received bell and shock paired in the second phase received a test stimulus of light, while the animals which received light and shock paired received a test stimulus of bell. Brogden found that his experimental groups made more avoidance responses to the stimulus that had never been paired with shock than did the control group. Brogden interpreted these results as evidence that the flexion responses elicited by the stimulus not associated with shock must be in fact due in part to an association formed when the bell and light were presented contiguously.

To summarize, the SPC paradigm consists of three separate phases: (a) repeated contiguous presentations of two neutral stimuli (S_1 and S_2) neither of which initially evoke an observable response; (b) the conditioning of an overt response to one of the stimuli (S_2); and (c) testing for the transfer of the overt response (R) to the other stimulus (S_1).

As one might have expected, Brodgen's initial study generated a

great deal of controversy in the area of learning. 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 S-S approach to learning. The S-R theory assumes that the preconditioning phase is nothing more than classical conditioning. Figure 1 is a description of the S-R or mediation account of SPC. This interpretation of SPC requires the assumption of weak implicit responses (r_1 and r_2) which are elicited by the two preconditioning stimuli (S_1 and S_2). In accordance with this classical conditioning schema it is assumed that the preconditioned response (r_2) is established as a mediating response as a consequence of pairings S_1 and S_2. In other words, r_2 comes to act as a mediating response in that it produces a stimulus to elicit the overt conditioned response (R). It is hypothesized that a non-observable response (r_2) is conditioned to S_1 with the contiguous presentations of S_1 and S_2. When an observable response (R) is subsequently conditioned to one of the preconditioning stimuli (S_2) the presentation of the alternate preconditioned stimulus will elicit the observable response (R) through the implicit conditioned response (r_2).

One of the earliest studies that offers evidence in support of the suggestion that factors favoring mediating responses enhance SPC comes from Lumsdaine (1939). He conditioned eyeblinks to a light by pairing the light with the blow of a mechanical striker on the cheek near the eye. Later a finger withdrawal response was conditioned 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 response in a majority of the subjects. The data also revealed that in most cases

SCHEMA FOR MEDIATION THEORY

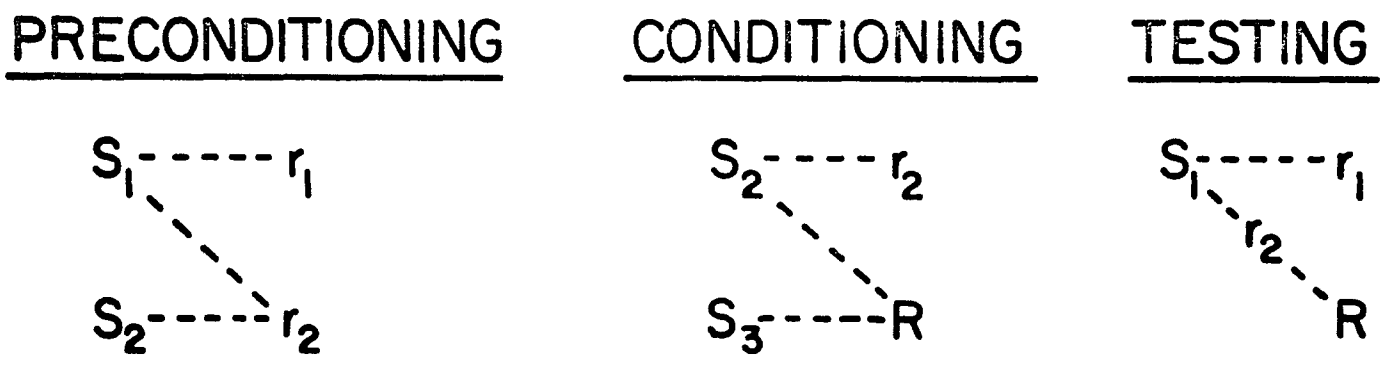


FIGURE 1

the light elicited a winking movement which was closely followed by the finger withdrawal response. This is, of course, what one would expect according to a mediation hypothesis in that the wink served as a mediator to elicit the finger withdrawal response. If the subjects had been pre-exposed to the strike on the cheek the size of the SPC effect would have been smaller since the wink would not be available as a mediator.

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 a review of SPC studies, Birch and Bitterman (1949) state that they must, ".... postulate a process of afferent modification (sensory integration), the essential condition for which is contiguity of stimulation." Whereas the S-R approach postulates a mediating response as being necessary for learning to occur in preconditioning and then be available as a mediator during the testing phase, the S-S theory advocates a central or afferent modification with no mediating response being necessary. According to Birch and Bitterman (1949), the paired presentation of a light and a buzzer during the preconditioning phase of a typical SPC experiment are the necessary conditions for establishing an associative relationship between them. The S-R and S-S position are juxtaposed with respect to the necessity of positing responses to S_1 and S_2 during the preconditioning phase.

A more recent approach to SPC has been the comparison of classical and sensory preconditioning processes. The thrust of this work has been to suggest a similarity in processes between the two procedures. Suboski and Tait (1972, p. 783) suggest that SPC cannot be a form or

subset of classical conditioning. According to them "the operational definition of classical conditioning requires a temporal contiguity between a neutral stimulus and a stimulus that reliably elicits a response. The operational definition of sensory preconditioning requires temporal contiguity between two neutral stimuli. Thus, the operational definition of classical conditioning is more restrictive than the operational definition of sensory preconditioning."

The review of the literature will focus on those studies which examine the similarities in processes between SPC and classical conditioning. Silver and Meyer (1954) were perhaps the first to point out the explicit relationship between SPC and classical conditioning. They reasoned that like classical conditioning, groups given a forward conditioning sequence would be superior to groups given a backward conditioning sequence.

They exposed rats to six main conditions which were forward, backward and simultaneous preconditioning; light and buzzer pseudo-conditioning; and no-pretraining control. Their CR was an avoidance response to shock and their results correlated perfectly with what one might expect in a classical conditioning study. Transfer of the avoidance response to the preconditioning stimulus was observed in all three of the preconditioning groups with the forward group showing the greatest amount of transfer and the backward group the least. Using human subjects and a GSR response to shock, Coppock (1958) was able to replicate this difference between forward and backward conditioning. Pavlov (1927) and Spooner and Kellogg (1947) found that backward conditioning is greatly inferior to forward conditioning in the classical conditioning paradigm.

Gormezano and Moore (1967) have stated that the optimum interstimulus interval (ISI) will vary with species, response, and other

parameters of conditioning experiments. Suboski and Tait (1972) sought to test out the hypothesis that "the optimum interstimulus interval during preconditioning depends on the optimum interstimulus interval for the overt response conditioned in the second phase of the SPC paradigm." They employed a conditioned suppression procedure where the strength of conditioning was measured by suppression of drinking. They used ISI's of 0, .25, .5, 1, 2, 4, or 8 seconds during preconditioning for the groups tested with S_1 (SPC groups). The groups tested with S_2 (CER groups) received a constant 10 second stimulus during the preconditioning phase with the intervals between S_2 onset and foot shock being 0, .25, .5, 1, 2, 4, or 8 seconds. They found that there was a maximum SPC effect with a four second ISI during preconditioning. Interestingly, the CER also showed the same pattern with maximum suppression occurring at four seconds. Thus, the authors conclude that ISI effects in SPC appear to be similar to those in classical conditioning using conditioned suppression as an index of classical conditioning.

Prewitt (1967) examined the relationship between the amount of training and SPC. Using rats as subjects she found that the strength of SPC, as measured by the suppression of licking, was a monotonically increasing function of the number of paired preconditioning trials (0, 1, 4, 16, and 64 pairings). Performance at the top value employed, 64 trials, did not differ significantly from the performance of subjects receiving sixteen trials. This monotonic relationship is in line with what one would expect in classical conditioning. Similar relationships have been found in other classical conditioning experiments within the limits of those used by Prewitt (1967), (see Libby, 1951).

Only one experimenter has investigated the relationship between the intensity of preconditioning stimuli and SPC magnitude. Wokoun (1959),

using rats as subjects, used a buzzer and three intensities of light as preconditioning stimuli. Three groups of subjects were first exposed to the buzzer, termed the preconditioning unconditioned stimulus (S_2). In three other groups the conditions were reversed so that one of the three intensities of light served as S_1 while the buzzer was used as S_2. During acquisition S_2 was paired with shock in an avoidance task. Testing consisted of exposing the subjects to the alternate stimulus, i.e., the stimulus not used during avoidance acquisition. Wokoun found that SPC magnitude was curvilinearly related to S_2 intensity. That is, at the lower levels of S_2 intensity, there was an increase in the amount of SPC as PUCS intensity increased; however, at the highest level of PUCS intensity (100 W) there was also a decrease in the amount of SPC. A negative relationship was found between SPC magnitude and S_1 intensity. In the classical conditioning literature there is evidence of a positive relationship between UCS intensity and CR. frequency in eyelid conditioning (Spence and Taylor, 1951; Spence, 1953; Prokasy, Grant, and Meyers, 1958). Pavlov (1927) found that a more intense CS was more effective than a less intense one in salivary conditioning with dogs. Kamin and Shaub (1963) found significant differences in the rate of acquisition, in a conditioned suppression paradigm, using three different intensities of white noise as the CS.

Tait, Black, Katz, and Suboski (1971) attempted to demonstrate the effects of discrimination training on SPC. They used a conditioned suppression paradigm in which subjects received 7, 14, 28 or 56 pairings of tone and light and an equal number of unpaired tones of a different

frequency. They then paired the light with footshocks in CER training and measured the ability of each tone to suppress drinking. The paired tone yielded significantly more suppression than the unpaired tone. There has been considerable work in differential eyelid conditioning which has yielded results which are parallel with the above SPC work (Spence and Farber, 1954 and Spence and Tandler, 1963).

Tait, Simon, and Suboski (1971) examined the effects of partial reinforcement in SPC. They varied the proportion of stimulus presentations that are followed by S_2 in the preconditioning phase. Rats received either 100, 50, 25% or random pairing followed immediately by CER training to S_2. They found that suppression of consummatory drinking to S_1 was directly related to the percent of pairings. Resistance to extinction over four days of testing was inversely related to the percentage of pairings in the preconditioning phase. These results also parallel what one would expect in classical conditioning, that is, partial pairing retards acquisition and increases resistance to extinction. Humphreys (1939) in an eyelid conditioning study verified that partial reinforcement will indeed lead to greater resistance to extinction. Brimer and Dockrill (1966) and Hilton (1969) have also demonstrated greater resistance to extinction with partial reinforcement using a conditioned suppression paradigm.

Tait, Marquis, Williams, Weinstein and Suboski (1969) examined the effect of presenting S_1 alone immediately following the SPC training phase; an extinction procedure. SPC training was followed by 0, 1, 4, 16, or 64 extinction trials and then subjects were given CER training. Their results also corresponded closely to what one might expect in classical conditioning in that the magnitude of SPC, as measured by

suppression of licking, was found to be a decreasing function of the number of extinction trials following SPC.

There is evidence on the effects of CS pre-exposure prior to CS-US pairings in the classical conditioning literature (Lubow, 1965; Lubow and Moore, 1959; and Williams, 1963). There is also evidence on the effects of US pre-exposure in the eye blink literature (Taylor, 1956). They have shown that both CS pre-exposure and US pre-exposure prior to CS-US pairing retards acquisition during subsequent pairings. It should be noted that latent inhibition effects have been obtained using many types of stimuli, in GSR conditioning, eyelid conditioning and animal studies (Lubow, 1973).

Mackintosh (1973) found that pre-exposing the CS and US randomly, prior to conditioning, has effects that are quite different from simple CS and US pre-exposures. That is, the effect is not additive because the subject is learning that there is no relationship between the CS and US as compared to when they are pre-exposed separately and the subject learns to ignore the CS or US. Mackintosh (1973), using pigeons and an autoshaping paradigm, divided the birds into four equal groups. Group CS-only was pre-exposed to the CS prior to the autoshaping procedure. Group CS/food received similar pre-exposure to the CS plus an equal number of presentations of US. Group US-only received an equal number of food presentations and a control group was placed in the apparatus without any stimulus presentations. After four sessions of pre-exposure training all of the pigeons received forty trials in each of eight daily sessions. Each trial consisted of a 5 sec. CS followed by a 5 sec. US. The difference in responses per minute on the eighth day of testing showed that both the food-only and the CS-only groups were responding

at almost the same rate as the control group while the CS/food group was responding at a significantly lower rate. In fact, the CS/food group showed no evidence of auto shaping.

Rappaport (1974), using rats as subjects and a conditioned suppression procedure, was able to support Mackintosh's finding in the SPC paradigm. He found that combined S_1 and S_2 pre-exposures produced a greater decrement than either one separately. In fact, the effects of S_1 and S_2 pre-exposure were not additive since S_2 pre-exposure had a greater effect than S_1 pre-exposure. If one views S_1 and S_2 pairings as being parallel to CS-US pairings then the Rappaport (1974) findings demonstrate that the subjects learned that there was no relationship between S_1 and S_2 and hence there was no possibility of an SPC effect. On the other hand, S_2 pre-exposure did retard acquisition as would be expected if SPC and classical conditioning are similar phenomena, i.e., latent inhibition. Since pre-exposure to S_2 had a greater effect than S_1 pre-exposure one can view the results as supporting a mediation argument because the response to S_2 (r_2) is assumed to be the mediating response.

Rappaport's (1974) findings cannot be unambiguously interpreted at this point. S_2 pre-exposure may have resulted in decrements in the strength of CER conditioning: a latent inhibition effect on the acquisition of the CER. If this were true, differences in the strength of association between S_2 and shock rather than a reduction in the associative strength of S_1 and S_2 occurring during pre-exposure and SPC training. A similar criticism could be made of the combined S_1 and S_2 pre-exposure effects since the combination contains 50 S_2 pre-exposures prior to conditioning. Experiment I attempts to answer these points by pre-exposing the subjects to S_2 and then giving them SPC and CER training. This

will be followed by testing to S_2 during the first testing phase instead of S_1. The amount of pre-exposure and the intensity of S_2 is also manipulated in order to determine whether the ordering of treatments on S_2 and S_1 would be the same regardless of the stimulus intensity. It might also be argued that a more intense, hence salient, S_2 might increase the size of the SPC effect by increasing the CER effect. Experiment I attempts to answer these questions:

1. Are there any latent inhibition effects on the CER as a function of the number of S_2 pre-exposures?

2. Will the intensity of S_2 effect the magnitude of SPC and/or CER?

3. If the strength of the association between S_2 and shock is the determiner of the associative strength between S_1 and S_2 then extinction of the CER should reduce responding to S_1. That is, will extinction of the CER obliterate responding to S_1?

Experiment I is then a test of the idea that the pre-exposure effects that Rappaport (1975) found were due to latent inhibition effects on the CER.

SECTION II

METHOD FOR EXPERIMENT I

Subjects. Thirty-six male Sprague Dawley rats, weighing approximately 500 grams each were used. All subjects were deprived of water 24 hours prior to the start of the experiment.

Apparatus. A Ralph Gerbrands Model C rat chamber was used as the experimental chamber. A water bottle spout was accessible to the rat through a hole in the center of a Plexiglas plate. The tip of the water tube was approximately 4 cm. above the grid floor.

The house light profided an average illumination of 1 foot candle in the experimental chamber as measured by a Gamma Model 800 photometer. The preconditioning stimuli (S_1 and S_2) were the light from a 6 watt jewel lamp, placed 7 cm. above the water spout, and a tone presented from an overhead speaker. The tones were 87db., 96db., and 102db. SPL (re. .0002 dynes/cm^2). The tones were all 3000 cps. and were superimposed over a 65db. background noise level produced by an exhaust fan. The surface of the jewel lamp had a luminance of 7.23 ft. lamberts as measured by a Macbeth illuminometer. When the tone was not being presented a 65 db. SPL (re. .0002 dynes/cm^2) white noise from the same overhead speaker served as masking noise. Shocks were administered by a Grason-Stadler (model 700) constant current generator and grid scrambler to 18 2 mm-diameter grids, spaced 1.5 cm. apart edge to edge. Licks were recorded by a Lehigh Valley drinkometer attached to the spout of the water bottle. A metal floor plate was used to cover the grids during lick training and testing sessions and the water bottle was refilled daily.

Procedure. The subjects were randomly assigned to nine groups of four subjects each. The nine groups consisted of three levels of

pre-exposure and three different levels of S_2 intensity.

Pre-training. After 24 hours of water deprivation all subjects were given two days of lick training. Lick training consisted of a 12 minute exposure to the water commencing with the first ten second burst of licking. During pretraining the floor of the chamber was covered with the metal plate.

Pre-Exposure and SPC training. Twenty-four hours after the last pretraining session the subject was placed in the experimental chamber. The metal plate covering the grid and the water tube were not present. After a fifteen minute adaptation period the subjects were given either 0, 25, or 50 presentations of S_2 at one of three levels of intensity (low, medium, or high) with a minimum interval between stimuli offset and onset of 2 sec. and a maximum interval of 63 sec. (The average interval between S_2 presentation was 30 sec.). SPC training was started immediately at the end of the habituation procedure. SPC training consisted of 16 S_1-S_2 pairings with each stimulus being ten seconds in duration and S_1 offset coinciding with S_2 onset. A one minute intertrial interval was used.

CER training. All subjects were given CER training immediately after SPC training with S_2 in SPC serving as the CS for CER conditioning. CER training consisted of ten trials, with a one minute intertrial interval, in which the CS was a ten second tone. The US, a 1.3 ma., .75 sec. shock, was delivered at CS offset.

Testing. Four test sessions occurred 24, 48, 72, and 96 hours after the SPC training began. The water bottle was made available and the metal plate was used to cover the grids. As soon as the subject licked continuously for approximately 10 sec., the stimuli were presented ten times with a fixed intertrial interval of 70 sec. S_2 was

presented during the first three test sessions and S_1 was presented during the fourth and final test session.

SECTION III

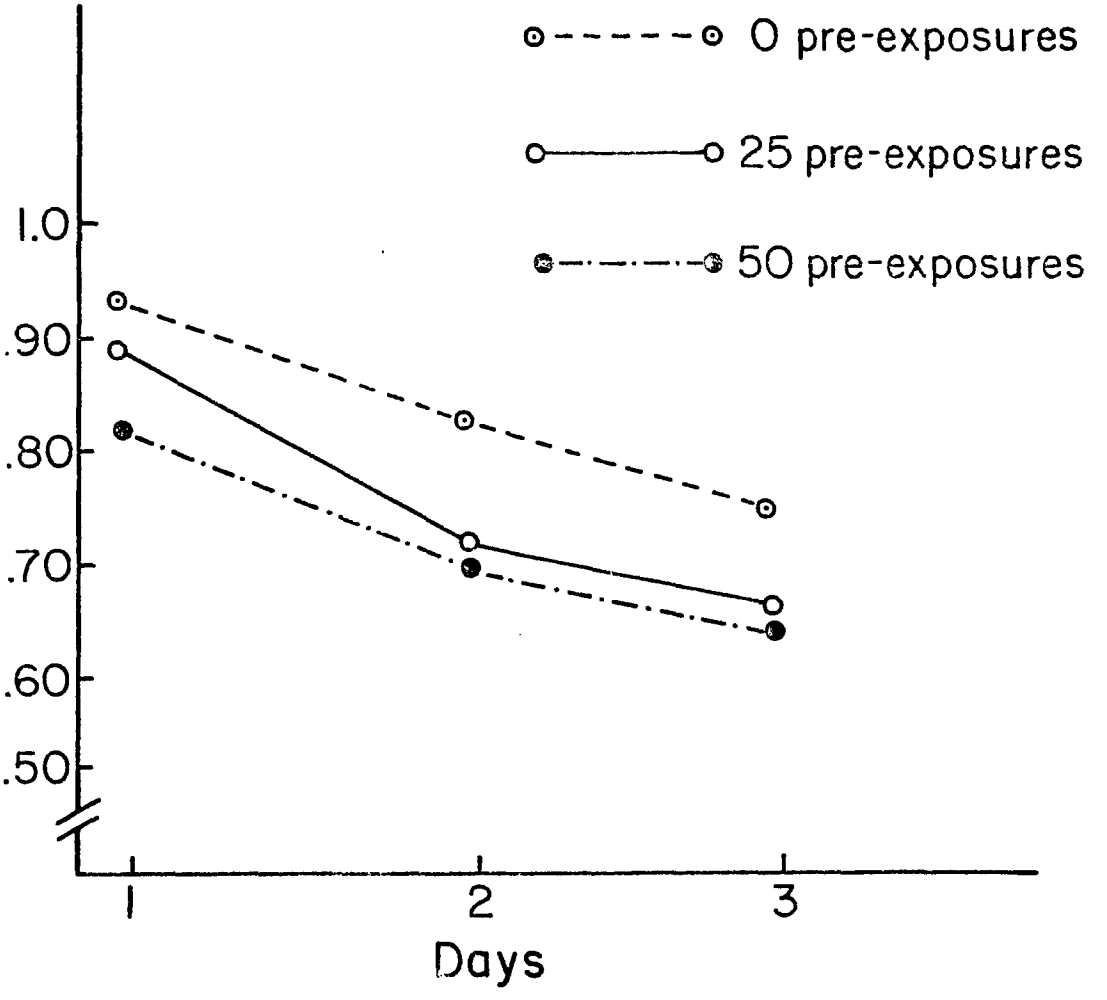
RESULTS OF EXPERIMENT I

Individual suppression ratios were obtained by dividing the total number of licks made during the ten seconds prior to stimulus presentation into the number of licks during stimulus presentation and the number of licks made during the ten seconds prior to stimulus presentation. A suppression ratio of .50 would indicate no suppression and a suppression ratio of 1.0 would indicate complete suppression. During testing to S_2 (the CER stimulus) there was a significant change in suppression ratios across days ($F_{2,54} = 37.36$, $p<.05$). All subjects had suppression ratios above .50, averaging .89 on test day one, .79 on test day two, and .66 on test day three. There was not a significant interaction between days and the amount of pre-exposure ($F<1$), between days and the intensity of S_2 ($F_{4,54} = 1.12$, $p>.05$), and between the amount of pre-exposure, intensity, and days ($F_{8,54} = 1.05$, $p>.05$). There was a significant pre-exposure effect across days as the strength of the CER diminished ($F_{2,27} = 5.05$, $p<.05$). Because the effects of pre-exposure did not interact across days it can be assumed that the differences between pre-exposure groups remained constant across days. There was not a significant intensity effect across days ($F_{2,27} = 2.03$, $p>.05$) and there was not a significant interaction between the amount of pre-exposure and S_2 intensity across all three days ($F<1$). There was a significant difference between days and because this factor did not significantly interact with any of the other factors the data from each day can be analyzed separately.

On day one testing to S_2, the CER stimulus, comparisons between the three pre-exposure groups revealed no significant differences ($F_{2,27} = 1.77$, $p>.05$). Looking at figure 2 the average suppression ratio on day

FIGURE 2

CER EXTINCTION



one for the zero pre-exposure group was .94, .90 for the 25 pre-exposure group and .84 for the 50 pre-exposure group. That is, the group given 50 pre-exposures of S_2 prior to CER training did not exhibit a latent inhibition effect since their suppression ratios were not significantly different from the zero pre-exposure group. Comparisons between the different intensities of S_2 on day one revealed no significant differences ($F_{2,27} = 1.5$, $p>.05$) and there was no interaction between the amount of pre-exposure and the intensity of S_2 ($F<1$).

On day two testing there was again some evidence of a pre-exposure effect on the CER with the zero pre-exposure group having a suppression ratio of .82, the twenty five pre-exposure group having a suppression ratio of .69 and the fifty pre-exposure group having a suppression ratio of .68. These differences were not significant ($F_{2,27} = 3.17$, $p>.05$). Comparisons between the three different intensities on day two testing revealed no significant differences ($F<1$) and there was no significant interaction between the amount of pre-exposure and the intensity of S_2 ($F_{4,27} = 1.5$, $p>.05$).

On day three testing to S_2 the twenty five and fifty pre-exposure groups both had average suppression ratios of .63 and the zero pre-exposure group had a suppression ratio of .71. These differences were not significant ($F_{2,27} = 2.93$, $p>.05$). There was a small but reliable difference between the three intensities of S_2 on day three ($F_{2,27} = 3.95$, $p<.05$). with the highest intensity group having a suppression ratio of .72, the intermediate intensity group .61, and the lowest intensity group .65. On all three days the 50 pre-exposure group had less suppression than the zero pre-exposure group and the 25 pre-exposure group suppressed somewhere between the zero and 50 groups.

In order to test for the presence of an SPC effect after CER

extinction, S_1 was presented twenty-four hours after day three testing to all of the subjects. The suppression ratio for the zero pre-exposure group was .76, .71 for the twenty-five pre-exposure group and .60 for the fifty pre-exposure group. These differences between the amount of pre-exposure were significant ($F_{2,27} = 6.16$, $p<.05$). That is, pre-exposure to S_2 had an effect on S_1 testing even though pre-exposure to S_2 had no effect on the CER on day three testing. The intensity of S_2 had no effect on S_1 testing ($F_{2,27} = 2.2$, $p>.05$) and there was no interaction between the amount of pre-exposure and the intensity of S_2 ($F_{4,27} = 1.0$, $p>.05$).

SECTION IV

DISCUSSION OF EXPERIMENT 1

The data from experiment 1 clearly shows that there were latent inhibition effects on the CER across days. That is, subjects who received 50 pre-exposures of S_2 prior to conditioning were significantly different from the zero pre-exposure group during extinction testing. More interestingly, the results from test day one reveal that the magnitude of the CER was not influenced by the pre-exposure of S_2. Rappaport's (1974) finding that pre-exposing subjects to S_2 prior to SPC training caused a degradation of the SPC effect could be criticized on the grounds that the pre-exposure of S_2 served to diminish the strength of the CER and hence decrease the magnitude of the SPC effect. The findings of experiment 1 answer this criticism because the group receiving 50 pre-exposures of S_2 prior to conditioning did not differ significantly from the group given zero pre-exposures on day one testing to the CER stimulus (S_2). Why were there no latent inhibition effect on the CER on day one testing? Firstly, a rather high shock intensity was used (1.3 ma, .75 sec) which may have created a ceiling effect. Secondly, the subjects received ten shocks with a thirteen minute period as compared to other CER studies in which a milder shock is used and where the CER training trials are spaced farther apart (Kamin, 1965). One can, in short, conclude that Rappaport's (1974) procedure, in which the subjects were pre-exposed to S_2 prior to conditioning, did not lead to a diminution of the CER on the day that the SPC test stimulus (S_1) had been previously presented.

The intensity of S_2, within the limits used in this experiment, failed to produce differential SPC effects. In fact, during S_2 testing,

i.e., CER extinction, the intensity of S_2 was not significant across days. That is, the highest intensity tone was no more resistant than the lowest intensity tone. Kamin (1965) has reported a CS intensity effect in a CER paradigm. His procedure was different from the one employed in this experiment, i.e., spaced instead of massed CER training, lower shock intensity, and a wider range of intensities (41 to 81db).

Rizley and Rescorla (1972), using a conditioned suppression procedure, were able to demonstrate that the extinction of the first order response does not adversely effect responding to the second order stimulus in second order conditioning. They attempted to replicate this finding in the SPC paradigm by extinguishing the CER and then testing to S_1 in order to see whether there still was an SPC effect. Unfortunately they were never able to demonstrate an SPC effect because of some methodological problems, i.e., S_1 and S_2 were of different duration, SPC training was divided between two days, and a mild shock was used during CER training (.5ma, .5sec). They were forced to resort to a savings measure in order to measure SPC. That is, animals given SPC training should show faster acquisition of the CER to S_1. It must be kept in mind that prior to the Prewitt (1967) procedure the SPC effect was not always reliably demonstrated. Nevertheless, Rizley and Rescorla (1972) concluded the extinction of the CER does obliterate the SPC effect. This conclusion is limited by the fact that there never was an SPC effect to obliterate.

In the present experiment the groups, combined across intensities, who received zero pre-exposures of S_2 averaged .76 when tested to S_1 after CER extinction. A more direct test of the presence of an SPC effect after CER extinction is the comparison of the zero and fifty pre-exposure groups from the current experiment with the identical zero and

50 pre-exposure groups from Rappaport's (1974) study who did not receive CER extinction training. Comparison of these two groups reveals no significant differences ($F<1$). This is direct evidence that the SPC effect and its reduction by pre-exposure to S_2 survive CER extinction. It can be concluded that the current strength of the association between S_2 and shock is not the determiner of the associative strength between S_1 and S_2. Extinction of the CER did not reduce responding to S_1.

Rappaport's (1974) finding that pre-exposure of S_2 prior to SPC training degrades the SPC effect was also replicated. In the current experiment the groups given 50 pre-exposures to S_2 prior to SPC training were significantly different from the groups given zero pre-exposures to S_2 on day four testing to S_1. It should be noted that the mediation account of SPC makes this prediction since the associative strength between S_1 and S_2 is determined by r_2 and not by R_3 (the response to shock).

SECTION V

INTRODUCTION TO EXPERIMENT II

Experiment I has established that the reduction of the SPC effect after pre-exposure to S_2 is not due to the decrement in the CER effect. Pre-exposure effects in SPC seem to be very similar to if not identical with habituation. According to Hilgard and Bower (1966),

> When a novel stimulus of sufficient intensity impinges on a receptor, it evokes a strong and definite electrical response in the relays of that input channel, and in the reticular formation. This is the electrical accompaniment of the "orienting reflex" discussed by Pavlov and Sokolov. However if the stimulus is repeated in a regular, monotonous series, the evoked response diminishes to a low stable level, often not even detectable.

This control prevents organisms from responding to stimuli that are no longer of significance. Habituation is not a permanent effect and any habituated response can be dishabituated. Weyers, Peeke and Herz (1973) state that, "dishabituation refers to the removal, or cancellation of habituation by interpolation of an extraneous stimulus differing from the habituation." Sokolov (1960) reports that dishabituation can also be produced by altering the length of the stimulus or by omitting it from its usual place in a stimulus sequence. Lantz (1973) has demonstrated in a CER paradigm that the presentation of a novel stimulus after CS pre-exposure reduces latent inhibition effects.

In experiment II the effects of presenting a disinhibitory stimulus prior to SPC training and immediately after pre-exposure to S_1 or S_2 or both are studied. This experiment also carefully examines and distinguishes between habituation like phenomena and changes in associative strength produced by unpaired presentations of S_1 and S_2 prior to

SPC training. It is a test of the Mackintosh hypothesis that pre-exposure effects are not additive and that when subjects are pre-exposed to the random presentation of two stimuli they learn that they are not related. That is, subjects can learn that two stimuli are reliably unrelated in the same manner that they learn that two stimuli are reliably related (SPC). Presenting S_1 and S_2 randomly prior to SPC training is something more than habituation and because of this the presentation of a dishabituating stimulus after pre-exposure should have less effect. On the other hand, subjects who are pre-exposed to S_1 alone or S_2 alone and then presented with a dishabituating stimulus, just prior to SPC training, should show an increased SPC effect when compared with subjects treated in the same manner but not given a dishabituating stimulus(Rappaport, 1974). Experiment 2 is a direct test of this hypothesis.

SECTION VI

METHOD FOR EXPERIMENT 2

Subjects. Thirty two naive male Sprague Dawley rats were used. They were approximately 180 days old and weighed approximately 500 grams.

Apparatus. The apparatus was the same as that used in experiment 1.

Procedure. The subjects were randomly assigned to eight groups of four subjects each. Three different habituation groups were used: one in which S_1 alone habituated, one in which S_2 was habituated and a third group in which both S_1 and S_2 were presented randomly. All habituation groups received 50 pre-exposures except for the combined group which received 50 of each. In order to counterbalance for stimulus effects, the tone served as S_1 for half of the groups and the light served as S_1 for the other half of the groups. In addition a straight SPC group was added as a control. The procedure was identical to that used in experiment 1 except that the habituation groups had either 50 presentations of S_1, 50 presentations of S_2, or 50 of each presented on the same VI schedule as in experiment 1. In addition all subjects were presented with a dishabituating stimulus (90 sec. click, 3 CPS, 84db) just prior to SPC training.

SECTION VII

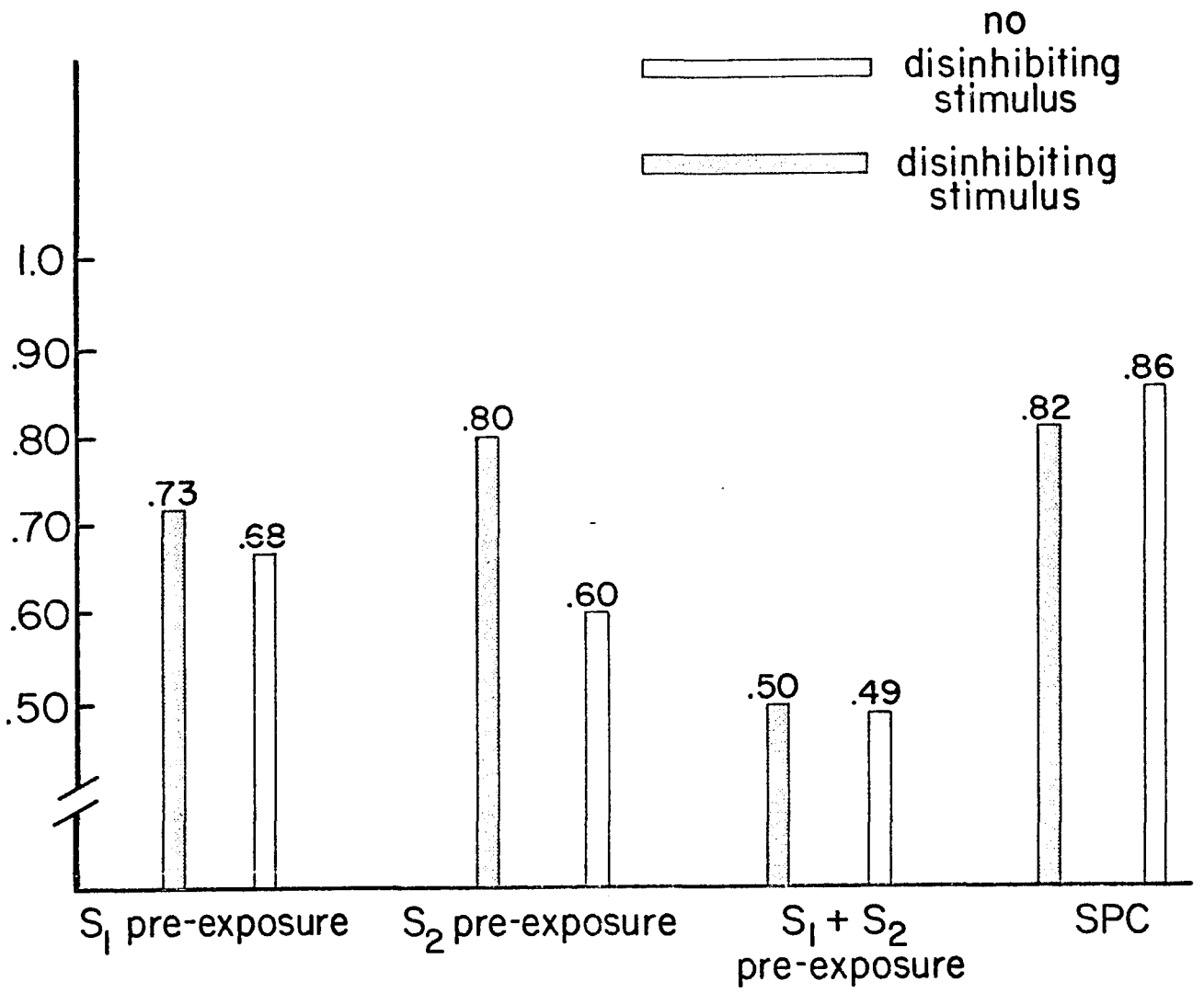
RESULTS OF EXPERIMENT II

Individual suppression ratios were obtained in the same manner as in experiment 1. Analysis of the data revealed that there was no significant difference as to whether S_2 was a light or tone ($F<1$) and stimulus type did not interact with any other factor. Because there were no stimulus effects or stimulus interactions the data were collapsed across stimuli and the original 4 x 2 x 2 ANOVA was combined into a 4 x 2 ANOVA. There were significant differences in the type of pre-exposure given ($F_{3,56} = 36.13$, $p<.05$). There was an effect produced by the dishabituating stimulus ($F_{1,56} = 5.01$, $p<.05$). Figure 3 is a comparison between the groups receiving the dishabituating stimulus with the groups that did not. There is an interaction between the type of pre-exposure and the presence or absence of the dishabituating stimulus ($F_{3,56} = 4.12$, $p<.05$). This interaction indicates that the dishabituating stimulus did not have the same effects on all pre-exposure groups.

A Neuman-Keuls analysis was performed to test the reliability of differences between the individual groups. All differences are reported at the .05 level. The test revealed significant differences between the S_2 pre-exposure groups with the average suppression ratio of the dishabituated group being .80 and the group receiving no dishabituating stimulus being .60. The dishabituated S_2 group was not different from the SPC groups.

As can be seen in figure 3, the dishabituating stimulus had virtually no effect on the combined S_1 and S_2 pre-exposure group. The combined S_1 and S_2 pre-exposure group was also different from all other groups except the S_2 group not receiving the dishabituating stimulus. That is,

FIGURE 3


no disinhibiting stimulus
disinhibiting stimulus
1.0
.90
.80
.70
.60
.50
.73
.68
.80
.60
.50
.49
.82
.86
S1 pre-exposure
S2 pre-exposure
S1 + S2 pre-exposure
SPC

the presence or absence of the dishabituating stimulus was significant only for the S_2 pre-exposed groups. All F values on the second day of testing were less than 1.

SECTION VIII

GENERAL DISCUSSION AND CONCLUSIONS

Rappaport (1974) demonstrated that the random presentation of both S_1 and S_2 just prior to SPC training served to retard the acquisition of SPC. This evidence lends more credibility to the Suboski and Tait (1972) theory that common operations on S_1 and S_2 have effects that are comparable to similar operations on the CS and US in classical conditioning. The current experiment replicates the finding of a latent inhibition effect in SPC as well as showing a disinhibition that is similar to that found in classical conditioning (Lantz, 1973). The data from Rappaport's (1974) experiments was also interpreted as supporting a mediation account of SPC for two reasons. First, the pre-exposure of S_2 alone reduced SPC effects more than the pre-exposure of S_1 alone. This could be interpreted within the mediation framework, as evidence that the pre-exposure of S_2 prior to SPC training reduces the strength of r_2 which is the response that determines the strength of the SPC effect. This finding has been replicated in the current experiment. Second, Rappaport (1974) indirectly showed that the magnitude of the SPC effect was not strongly related to the strength of the CER. This was accomplished by presenting S_2 after SPC testing (S_1) and then seeing if the magnitude of the SPC effect correlated with the strength of the CER. The correlation coefficient obtained was -.13. Experiment I refined and replicated this finding.

The nature of these mediating responses has always been a mystery. Cousins, Zamble, Tait and Suboski (1971) ruled out the possibility that these responses were necessarily peripheral in nature by showing that the SPC effect could be obtained in curarized rats. The mediation

argument was not dealt a fatal blow by this finding because it was still possible that these responses may occur entirely within the central nervous system.

If the mediation account of SPC is correct then the magnitude of SPC should have been related to the intensity of S_2 in experiment I. That is, the magnitude of the SPC effect should have been related to the strength of r_2 which should in turn be related to the intensity of S_2. Furthermore, because the magnitude of SPC is not related to the intensity of S_2, at least across the range of intensities used in experiment I, it is unlikely that the mediating response is an orienting response. Thompson (1972) has predicted that if the response mediating SPC is an orienting response then SPC should increase with the number of preconditioning trials for intense stimuli, and should be maximal with a few preconditioning trials for intermediate stimuli. Experiment I was not a direct test of this hypothesis but nevertheless Thompson (1972) would have predicted differential intensity effects.

The data from experiment II and from Rappaport's (1974) earlier work parallel the data obtained by Mackintosh (1973) in an autoshaping paradigm. He was able to demonstrate that random presentations of both the CS and US prior to CS-US pairings impaired acquisition and produced a lower asymtotic level of conditioning. In Rappaport's (1974) work the subjects who were randomly pre-exposed to both S_1 and S_2 and then given SPC training had an average suppression ratio of .49 - the same as in the current experiment. It should be noted that pseudo-conditioning controls from earlier experiments had suppression ratios averaging .59. It has been established that random presentations of both S_1 and S_2 prior to SPC training completely blocks the effect of sixteen S_1-S_2 pairings.

Thompson's (1972) explanation of SPC is nothing more than a central rather than peripheral mediation account. That is, r_1 and r_2 are thought to be OR_1 and OR_2. It is difficult for a mediation account to explain the combined S_1 and S_2 pre-exposure effect for two reasons. First, there is no evidence in the habituation literature that two responses, either peripheral or central, can be simultaneously habituated. Even if one accepted the idea that random pre-exposure of both S_1 and S_2 obliterated the SPC effect because there are additive habituation effects, the current dishabituation finding could not be explained. That is, if the random pre-exposure of both S_1 and S_2 is a habituation like process, then the presentation of a novel stimulus after pre-exposure should abolish any habituation effects. Figure 3 clearly shows that the dishabituating stimulus wiped out the S_2 pre-exposure effect but had no effect on the combined S_1 - S_2 pre-exposure group.

The present data point to the necessity of distinguishing two different types of pre-exposure effects. The first type can be labeled single stimuli pre-exposure effects (SPE) which may best be handled through the use of the physiological habituation model (Thompson, 1972). This process is most likely related to the orienting response in that after repeated pre-exposure to a single stimulus the organism no longer makes orienting response to that stimulus. The organism no longer responds to stimuli that predict no environmental change. The habituated response can be brought back to its initial level of responding by the presentation of a novel stimulus after pre-exposure.

The second type of pre-exposure effect can be called learned pre-exposure effects (LPE). In this type of pre-exposure the subjects are presented with random presentations of stimuli that are later paired.

The subjects learn that the two stimuli are not related. That is, in the case of SPC, the appearance of S_1 does not reliably predict the occurrence of S_2. In the case of SPE the subjects are still naive as to the relationship between S_1 and S_2. In fact, LPE creates a sort of proactive interference effect for future conditioning of the pre-exposed stimuli. This interference effect is the distinguishing characteristic of LPE. Gamzu and Williams (1971) found that pigeons exposed to random presentations of key light and food before classical conditioning of the key peck response, were still responding at a lower rate than control birds after thirty-five training sessions. Kremer (1971) replicated this finding using rats and a conditioned suppression procedure. Mackintosh's (1973) pigeons who were randomly pre-exposed to both the CS and the US never learned to autopeck even though they were given over fifteen autoshaping sessions. In short, LPE effects are durable and survive large numbers of acquisition trials. A more direct test of this interference effect would be to extend the number of S_1 - S_2 pairings after random pre-exposure to see at what point, if ever, SPC effects occur.

The S_1 pre-exposure data does raise some problems. Why was there no difference between the S_1 pre-exposed group that received the dishabituating stimulus and the group that did not receive the dishabituating stimulus? It is possible that S_1 pre-exposure effects produced less blocking of the SPC effect and hence the habituation was incomplete. A more likely explanation is that because of the similarity between S_1 pre-exposure and SPC testing (S_1 presentation) the subjects may have learned that S_1 presented by itself is probably not a signal for shock.

In summary, the data presented raise some doubts about a mediation account of SPC. On the other hand, the mediation account is the only theory that predicts differential pre-exposure effects. Experiment I

demonstrated that SPC effects survive CER extinction and that S_2 pre-exposure does produce latent inhibition effects on the CER. Experiment I also demonstrated that the intensity of S_2, within the limits used, does not effect the magnitude of SPC. Experiment II showed that there are both latent inhibition and disinhibition effects in SPC that parallel those found in classical conditioning. It was also demonstrated that combined S_1 and S_2 pre-exposures obliterate SPC but at the same time SPC were not affected by the presentation of a dishabituating stimulus after pre-exposure. This was taken as clear evidence that there are different kinds of pre-exposure effects and that the mediation account is not an adequate explanation by itself for SPC.

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Exp. 1 - CER Extinction

Source	SS	DF	MS	
pre-exposure	.24161	2	.1208	5.05*
Intensity	.096950	2	.048475	2.03
pre x Int	.04211	4	.010528	.44
within		27	.023905	
Days	1.0438	2	.52191	37.36*
pre x Days	.026956	4	.0067389	.48
Int x Days	.062628	4	.015657	1.12
Pre x Int x Days	.00739	8	.014674	1.08
		54	.013972	

Exp. 1 - Test Day 1

Source	SS	DF	MS	
pre-exposure	.0706	2	.0353	1.7718
Intensity	.0598	2	.0299	1.5016
pre x Int	.0061	4	.0015	.0775
within	.5380	27	.0199	

Exp. 1 - Test Day 2

Source	SS	DF	MS	
pre-exposure	.1456	2	.0728	3.1685
Intensity	.0292	2	.0146	.6359
pre x Int	.1376	4	.0344	1.4967
within	.6206	27	.0229	

Exp. 1 - Test Day 3

Source	SS	DF	MS	
pre-exposure	.0522	2	.0261	2.9256
Intensity	.0704	2	.0352	3.9452*
pre x Int	.0156	4	.0039	.4392
within	.2412	27	.0089	

Exp. 1 - Test Day 4

Source	SS	DF	MS	
pre-exposure	.1562	2	.0781	6.16*
Intensity	.0547	2	.0273	2.16
pre x Int	.0508	4	.0127	1.00
within	.3423	27	.0126	

Comparison of 0 and 50 pre-exposure groups

with and without extinction training.

Source	SS	dF	MS	F
pre-exposure	.2575	1	.2575	32.61*
extinction training	.0014	1	.0014	.18
pre x extinction	.0162	1	.0162	2.06
within	.0947	12	.0078	
Total	.3699	15		

ANOVA of Experiment II, 4 x 2 x 2

Source	SS	df	MS	f
stimulus type	.0031	1	.0031	.003
Dis vs. No dis	.0455	1	.045	4.61*
Pre-exposure	.9766	3	.3256	33.217*
Stim x Dis	.0210	1	.0210	2.15
Stim x Pre	.0058	3	.0019	.197
Dis x Pre	.1113	3	.0371	3.78*
Stim x Pre x Dis	.0070	3	.0023	.239
Error	.4705	48	.0098	

ANOVA of Experiment II, 4 x 2

Source	SS	df	MS	f
Pre-exposure	.9776	3	.3256	36.08*
Dis vs. No dis	.0455	1	.0455	5.05*
Pre x Dis	.1113	3	.0371	4.107*
within	.5054	56	.0090	

Neuman-Keuls, Experiment II

	S_1+S_2(H)	S_1+S_2(D)	S_2(H)	S_1(H)	S_1(D)	S_2(D)	SPC	SPC(D)			
	.49	.50	.61	.69	.73	.80	.82	.86	r	q.95(r,56)	$\frac{.0090}{8}$
S_1+S_2 (H)	-	.01	.12	.20	.24	.31	.33	.37	8	.15	
S_1+S_2 (D)		-	.11	.19	.23	.30	.32	.36	7	.14	
S_2 (H)			-	.08	.12	.19	.21	.26	6	.14	
S_1 (H)				-	.04	.11	.13	.17	5	.13	
S_1 (D)					-	.07	.09	.13	4	.12	
S_2 (D)						-	.02	.06	3	.11	
SPC							-	.04	2	.09	
SPC (D)											