CONTEXTUAL CONDITIONING

AND UCS PREEXPOSURE

ASSOCIATIVE BASIS OF UCS PREEXPOSURE IN EXCITATORY AND INHIBITORY RABBIT EYELID CONDITIONING

By

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ABSTRACT

Exposure to the unconditional stimulus (UCS) prior to its pairing with the conditional stimulus (CS) retards subsequent excitatory conditional response (CR) acquisition in a variety of Pavlovian conditioning preparations. Traditionally, this UCS preexposure effect has been attributed to nonassociative, adaptational-like processes. Recently, however, it has been suggested that associative processes, involving the formation of an association between the UCS and stimuli of the context in which the UCS is preexposed, play a crucial role in the effects of UCS exposure. The experiments reported in this thesis were designed to determine whether conditioning to contextual stimuli may, in fact, mediate the effects of UCS preexposure in rabbit eyelid conditioning.

The results of Experiment 1 demonstrate that the UCS preexposure effect in excitatory eyelid conditioning is evident only if CS-UCS pairings are administered in the same context as UCS preexposure. Thus, mere repeated exposure to the UCS is not sufficient for production of the UCS preexposure effect as would be expected on the basis of any entirely nonassociative account. Experiments 2 and 3 demonstrate that the detrimental effect of UCS preexposure on subsequent excitatory CR acquisition may be attenuated by associative manipulations of contextual stimuli of the preexposure environment. In Experiment 2, contextual stimuli were "latently inhibited" (a procedure known to reduce conditioning to stimuli) prior to the start of UCS preexposure. This procedure, which should have had the effect of reducing conditioning to contextual stimuli, attenuated the UCS preexposure effect. In Experiment 3, contextual stimuli were extinguished (a procedure known to weaken established conditioning). This procedure also attenuated the UCS preexposure effect. The results of Experiment 1, 2, and 3 establish that associative processes involving contextual stimuli are crucially involved in the UCS preexposure effect in excitatory eyelid conditioning.

In Experiment 4, the effect of UCS preexposure on inhibitory eyelid conditioning was examined. UCS preexposure facilitated inhibitory learning, an effect that would be expected if conditioning to contextual stimuli occurs during UCS preexposure, but not if UCS preexposure involves only nonassociative processes.

The results were discussed in relation to various theoretical accounts of UCS preexposure. Although other factors may be involved, the results of the present thesis demonstrate an associative basis for the effects of UCS preexposure in rabbit eyelid conditioning. The role of conditioning to contextual stimuli in other preconditioning stimulus exposure procedures (e.g., latent inhibition, truly random CS/UCS presentations), and in effects involving postconditioning UCS exposure (reinstatement of fear) was also discussed. In conclusion, it is argued that conditioning to contextual stimuli occurs in a variety of stimulus exposure procedures, and that such conditioning may be importantly involved in mediating a variety of learning phenomena.

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CHAPTER 1

INTRODUCTION

In the typical classical conditioning experiment, an organism is presented a neutral stimulus closely followed by the presentation of some biologically significant event (e.g., food, shock, etc.). Initially, the neutral stimulus (referred to as a conditional stimulus, or CS) elicits little relevant activity, while the biologically significant stimulus (referred to as an unconditional stimulus, or UCS) elicits a variety of reactions (e.g., salivation, flinching, etc.), which are termed unconditional responses, or UCRs. Following repeated pairings of the CS and UCS, the CS comes to elicit reactions related to the UCRs originally elicited by the UCS. These reactions elicited by the CS following a period of pairing of the CS and UCS are referred to as conditional responses, or CRs.

One area of interest in classical conditioning research is the identification of factors which reduce the effectiveness of CS-UCS pairings in promoting CR acquisition. One factor which affects the formation of CRs is the novelty of the UCS at the start of CS-UCS pairings. That is, the results of a number of studies demonstrate that CR acquisition is retarded if the UCS is repeatedly presented alone prior to the initiation of CS-UCS pairings' compared to when no such UCS preexposure is administered. The detrimental effect of preconditioning experience with the UCS on subsequent CR acquisition is termed the "UCS preexposure effect." The purpose of the present thesis was to investigate the basis of the UCS preexposure effect.

1.1 The UCS Preexposure Effect

One of the earliest demonstrations of the detrimental effect of UCS preexposure on subsequent CR acquisition is a study by MacDonald (1946). MacDonald (1946) examined the effect of preconditioning experience with the UCS on the development of both the conditional finger withdrawal, and the conditional eyeblink, in human subjects. In both experiments, exposing the subject to the UCS prior to the initiation of CS-UCS pairings retarded CR acquisition, compared to when no UCS preexposure was given.

Subsequent studies have replicated the UCS preexposure effect in a variety of conditioning preparations with both human and infrahuman subjects. Taylor (1956), Kimble and Dufort (1956), and Hobson (1968) replicated MacDonald's (1946) demonstration of the UCS preexposure effect in human eyeblink conditioning. The UCS preexposure effect has also been demonstrated in the rabbit eyelid conditioning preparation (Mis and Moore, 1973; Siegel and Domjan, 1971, Experiment 2, 1974).

Kamin (1961) investigated the effect of UCS preexposure on the development of the conditional emotional response (CER) in rats. In the CER procedure (e.g., Annau and Kamin, 1961), animals are given CS-UCS pairings, and then the ability of the CS to suppress some ongoing behavior (e.g., barpressing) with which it is superimposed is taken as a measure of conditioning to the CS. In Kamin's (1961) study, some rats received UCS preexposure prior to receiving standard CER training (Estes and Skinner, 1941), while other rats received no UCS preexposure prior to receiving CER training. The results demonstrated that CER acquisition was slower in rats given UCS preexposure than in rats without any UCS preexposure. The UCS preexposure effect in CER conditioning has subsequently been replicated by Baker and Mackintosh (1979), Brimer and Kamin (1963), Chambers and Szakmary (Note 1), Kremer (1971), Randich and LoLordo (1979a), and Siegel and Domjan (1971, Experiment 1).

The UCS preexposure effect has also been demonstrated in the "autoshaping" procedure (Brown and Jenkins, 1968). In the typical autoshaping experiment, a pigeon is presented a lighted key followed by presentation of food on several occasions. Although food delivery is not contingent on pecking the lighted key, following a history of such keylight-food pairings, the pigeon pecks the keylight. The acquisition of keypecking in this procedure is termed "autoshaping" since the pigeon comes to peck the key without any explicit shaping (Skinner, 1938). It has been suggested (e.g., Moore, 1973) that the autoshaped key peck develops through an associative process similar to that involved in the acquisition of more traditional CRs. The results of several studies (Downing and Neuringer, 1976; Engberg, Hansen, Welker, and Thomas, 1972; Schwartz and Balsam, Note 2; Tomie, Murphy, and Fath, 1980) demonstrate that acquisition of the autoshaped key peck response is retarded if the UCS (i.e., food) is presented prior to the initiation of keylight-food pairings.

The detrimental effect of UCS preexposure on subsequent learning has also been demonstrated in the taste aversion procedure (see Randich and LoLordo, 1979b, for a summary of a number of these studies). In the taste aversion procedure, animals made sick after ingesting a distinctively-flavored, novel solution subsequently avoid ingesting that solution. However, animals exposed to the sickness-inducing treatment (e.g., lithium chloride, X-rays) prior to the time when it is used to condition a taste aversion, generally do not exhibit as much, or as long lasting, aversion to the taste CS as animals not preexposed to the UCS. The UCS preexposure effect in taste aversion learning has been demonstrated with as few as one UCS preexposure (Bravemen, 1975), and even when as many as 10 days elapse between the last UCS preexposure and the start of taste aversion training (Bravemen, 1975).

From the above review, it is clear that the novelty of the UCS at the time of its pairing with the CS is an important determinant of CR acquisition performance. The UCS preexposure effect appears to be quite robust, having been demonstrated in a variety of conditioning preparations, using several different types of UCS events, and with both human and infrahuman subjects (see Randich and LoLordo, 1979b, for more detailed discussion of procedures used in several UCS preexposure experiments).

1.2 Traditional, Nonassociative Accounts of the UCS Preexposure Effect

The UCS preexposure effect has traditionally been interpreted as involving nonassociative, adaptational-like processes. For example, MacDonald (1946) suggested that UCS preexposure reduced the "motivational" or "drive-producing" properties of the UCS, thereby rendering the UCS a less effective reinforcer. Similarly, Taylor (1956) and Kamin (1961) suggested that the relevant effect of UCS preexposure was to attenuate an "internal emotional reaction" originally elicited by the UCS. This "internal emotional reaction" was assumed to be a critical aspect of the reinforcing effectiveness of the UCS. Thus, by reducing the magnitude of this reaction, the ability of the UCS to support conditioning was correspondingly diminished. Another nonassociative interpretation of the UCS preexposure effect noted by several authors (e.g., Mis and Moore, 1973; Taylor 1956) involves the possibility that repeated experience with the UCS serves to reduce the sensory impact of the UCS, thus rendering the preexposed UCS more similar to a less intense UCS than a nonpreexposed UCS. Since the rate of CR acquisition is related to UCS intensity (e.g., Mackintosh, 1974, pp. 70-71; Pavlov, 1927, pp. 31-32), it has been suggested that the UCS preexposure effect may reflect the effects of UCS intensity on CR acquisition. Finally, another nonassociative account of UCS preexposure has recently been offered (Randich and LoLordo, 1979a) based on the suggestion that behavioral output is determined by the interaction of two antagonistic processes.[1] Briefly, this account holds that UCS preexposure retards CR acquisition because, with repeated exposure to the UCS, there is the development of a

[1]The suggestion that behavioral output is the result of two antagonistic processes is the basis of several models of behavior (e.g., Groves and Thompson, 1970, Solomon and Corbit, 1974).

"process" which acts to attenuate the organism's propensity to subsequently respond to the UCS during CS-UCS pairings. The exact nature of the "process" which supposedly antagonizes the organism's responsiveness to the UCS is not, at present, well specified.

Although nonassociative theories of UCS preexposure differ as to the precise nature of the mechanism by which repeated exposure to the UCS supposedly retards CR acquisition, all such theories are similar in asserting that mere repeated exposure to the UCS is sufficient to produce retarded CR acquisition.

1.3 An Alternative Associative Account of the UCS Preexposure Effect in terms of Blocking

Recently, it has been suggested (e.g., Mis and Moore, 1973; Tomie, 1976 a,b; Willner, 1978; Tomie, Murphy, and Fath, 1980) that the UCS preexposure effect may involve associative processes. In general, an associative account of the UCS preeexposure suggests that during the period of UCS preexposure some learning occurs with respect to the UCS. This learning then somehow interferes with the formation of an association between the nominal CS and the preexposed UCS during subsequent CS-UCS pairings. One implication of an associative analysis of UCS preexposure is that mere repeated exposure to the UCS may not, as suggested by nonassociative accounts of UCS preeexposure, be sufficient, by itself, to produce retarded CR acquisition. Rather, an associative analysis of UCS preexposure suggests that the UCS preexposure effect may importantly depend on the organism's experience with environmental stimuli present at the time of UCS exposure, as well as with the UCS itself.

1.3.1 The UCS Preexposure Effect and the Phenomenon of Blocking.

One associative account of the UCS preexposure effect that has been suggested by several authors (e.g., Mis and Moore, 1973; Tomie, 1976 a,b; Willner, 1978; Tomie, Murphy, and Fath, 1980) is based on the phenomenon of "blocking" (Kamin, 1968, 1969). In the typical blocking experiment (e.g., Kamin, 1968, 1969), an experimental, or "blocked", group of animals is first given a period of training in which a stimulus (A) is paired with the UCS on several occasions. Following this initial training, experimental animals receive a period of training in which stimulus A, previously paired with the UCS, is compounded with another stimulus (B), and this A/B compound stimulus is followed by the UCS. Finally, stimulus B is presented alone to determine the amount of conditioning to this element as a result of the A/B compound training trials. A control group of animals receives identical A/B compound stimulus training, followed by testing with stimulus B, but is not administered the initial period of training in which stimulus A is paired with the UCS. At the start of A/B compound stimulus training, stimulus A is a signal for the UCS in experimental group animals, but not in control group animals. The outcome of the "blocking" experiment is that during testing with stimulus B alone, control group animals evidence more conditioning to stimulus B than experimental group animals, despite the fact that stimulus B is paired with the UCS an equal number of times in both groups. This result demonstrates that conditioning to stimulus B during the period of A/B compound training is retarded, or "blocked", in experimental group animals by virtue of the prior pairings of stimulus A with the UCS.

1.3.2 A Blocking Analysis of the UCS Preexposure Effect

It has been suggested (e.g., Mis and Moore, 1973) that the UCS preexposure effect may be conceptualized as an example of blocking. The essential outcome in both a blocking experiment (e.g., Kamin, 1968) and a UCS preexposure experiment (e.g., Mis and Moore, 1973) is that following a period in which the UCS is experienced, CR acquisition is slower during subsequent CS-UCS pairings than if the UCS is not exposed prior to the start of CS-UCS training. In the blocking procedure (e.g., Kamin, 1968), during the initial period of UCS exposure, the UCS is explicitly paired with a stimulus (e.g., stimulus A). However, in a UCS preexposure experiment (e.g., Mis and Moore, 1973), during the initial period of UCS exposure, the UCS is not explicitly paired with a stimulus. Although the UCS is not explicitly paired with a stimulus in the UCS preexposure experiment during preexposure, presentation of the UCS does, in fact, occur in conjunction with a variety of stimuli. Stimuli normally occurring in conjunction with the UCS during preexposure consist of the physical features of the experimental situation (e.g., the experimental chamber, amount of illumination in the chamber, ambient noise level in the chamber, etc.). These stimuli, comprising as they do the context in which the experiment is conducted, are referred to as contextual stimuli (Rescorla and Wagner, 1972).

It has been suggested (e.g., Rescorla and Wagner, 1972) that contextual stimuli may function as effective CSs. In fact, the results of several studies (Best, Best, and Mickley, 1973; Blanchard and Blanchard, 1969; McAllister and McAllister, 1962; Pavlov, 1927, pp. 13-15; Sheafor, 1975; Subkov and Zilov, 1937) demonstrate that contextual stimuli may function as signals for occurrence of the UCS. Learning involving contextual stimuli serving as CSs for the occurrence of the UCS is referred to as "contextual conditioning" (e.g., Sheafor, 1975).

Based on the foregoing discussion, it is possible to draw a parallel between the procedural details of a blocking experiment (e.g., Kamin, 1968) and the procedural details encountered in most UCS preexposure experiments: During UCS preexposure, contextual stimuli are paired with the UCS, and thus may become signals for the UCS. When the UCS is subsequently paired with the nominal CS, these same contextual stimuli are normally present. Thus, conditioning to the nominal CS may be retarded, or "blocked", in a manner analogous to that observed in the basic blocking experiment.

1.4 Summary and Purpose of the Present Thesis

Exposure to the UCS prior to the initiation of CS-UCS pairings retards CR acquisition. Several nonassociative accounts of the UCS preexposure effect have been suggested. In general, nonassociative accounts of the UCS preexposure effect suggest that the relevant effect of preconditioning experience with the UCS is to reduce the organism's reactivity to the UCS (e.g., less sensory impact, reduced emotionality, etc.). Alternatively, it has been suggested that associative processes may be involved in the UCS preexposure effect. One way in which associative processes may contribute to the UCS preexposure effect is by "blocking" of conditioning to the nominal CS by contextual stimuli (e.g., Mis and Moore, 1973; Tomie, 1976 a,b; Willner, 1978; Tomie, Murphy, and Fath, 1980). The purpose of the present thesis is to investigate the possibility that associative processes contribute to the UCS preexposure effect. In particular, the present thesis examines the possibility that the UCS preexposure effect in rabbit eyelid conditioning (e.g., Siegel and Domjan, 1971, Experiment 2, 1974) results, at least in part, from associative processes similar to those involved in the phenomenon of blocking (Kamin, 1968, 1969).

CHAPTER 2

EXPERIMENT 1. THE CONTEXTUAL SPECIFICITY STUDY

2.1 Blocking by Contextual Stimuli and the Contextual Specificity of the UCS Preexposure Effect

According to the context blocking analysis of the UCS preexposure effect, preexposure to the UCS retards subsequent CR acquisition because, during UCS preexposure, contextual stimuli are conditioned to the UCS. These conditional contextual stimuli subsequently "block" the development of an association between the nominal CS and UCS.

One implication of the context blocking analysis of UCS preexposure is that the UCS preexposure effect should be dependent upon the presence of the same contextual stimuli during both the period of UCS preexposure and the period of CS-UCS pairings. In other words, according to the context blocking analysis, the UCS preexposure effect should be specific to the context in which preconditioning UCS presentations are administered.

The contextual specificity of the UCS preexposure effect is a central prediction of the context blocking analysis of UCS preexposure. One way to determine whether the UCS preexposure effect does, in fact, display contextual specificity is to alter the contextual stimuli between the period of UCS preexposure and the initiation of CS-UCS pairings. If, as suggested by the context blocking analysis, the UCS preexposure effect results from blocking by conditional contextual stimuli, it would be expected that the UCS preexposure effect would be attenuated by altering contextual stimuli between preexposure and CS-UCS pairings.

2.2 Method

2.2.1 Design. The experiment involved a 2 x 2 factorial design. One factor concerned the form of UCS preconditioning treatment given subjects. Half the subjects were given UCS preexposure (designated "Px"). The remaining half of the subjects were not given UCS preexposure, and were simply restrained in the experimental environment for a period of time corresponding to that for subjects given UCS preexposure (designated "NPx"). Subjects were further subdivided on the basis of the experimental environment in which they received their respective UCS preconditioning treatment. Half the subjects in each of the two groups formed on the basis of the different UCS preconditioning treatments (i.e., Px and NPx) received their respective UCS preconditioning treatment in the presence of the contextual stimuli present during a subsequent period of CS-UCS pairings (designated the conditioning environment--"CE"). The remaining half of the subjects in each of the two groups formed on the basis of the different UCS preconditioning treatments (i.e., Px and NPx) received their respective UCS preconditioning treatment in the presence of contextual stimuli different from those present during the subsequent period of CS-UCS pairings (designated the nonconditioning environment--"NCE"). Thus, four independent groups of rabbits were formed: (1) UCS preexposure in the conditioning environment, Px-CE; (2) UCS preexposure in the nonconditioning environment, Px-NCE; (3) No UCS preexposure, restraint in the conditioning environment, NPx-CE; and, (4) No UCS preexposure, restraint in the nonconditioning environment, NPx-NCE.

Originally, 12 rabbits were assigned to each of Groups NPx-CE, NPx-NCE, and Px-CE, and 13 rabbits were assigned to Group Px-NCE. However, two rabbits in each of the Groups NPx-CE and NPx-NCE, and one rabbit in Group Px-NCE, had to be discarded due to illness. In addition, three rabbits in Group NPx-NCE had to be eliminated from the study due to equipment failure. Thus, data were collected from 7, 10, 12, and 12 subjects in Groups NPx-NCE, NPx-CE, Px-CE, and Px-NCE, respectively.

<u>2.2.2 Subjects</u>. The subjects were 49 experimentally naive New Zealand male rabbits, weighing 2-3 kg and approximately 8-10 weeks old at the beginning of the experiment. All subjects were housed in individual cages with food and water freely available throughout the experiment.

<u>2.2.3 Apparatus</u>. The outer eyelid response was recorded with a modification of the technique described by Gormezano (1966). Briefly, movement of the subject's outer eyelid was conducted, via a string and pulley arrangement, to the shaft of a microtorque potentiometer. Voltage changes through the potentiometer were graphically recorded, and provided a record of conditional and unconditional eyelid activity.

The UCS was a 100-msec, 5 mA, 200-V A.C. shock, delivered through a pair of chronically implanted tantalum wire electrodes (.0177 cm diameter), mounted approximately 1 cm apart and 1 cm below the left eye of the subject. The CS was a 600-msec, 2,000-Hz tone at 76 db A above 20 N/m^2 delivered through a 56 cm^2 loudspeaker located behind the subject.

The different UCS preconditioning treatments given subjects (i.e., either Px or NPx) were administered in either of two experimental contexts (i.e., the CE or the NCE). Each subject receiving its UCS preconditioning treatment in the CE was restrained in a clear, Plexiglas box (18 x 14 x 41 cm--see Gormezano, 1972, p. 171, for a picture of the restraining box) located within one of six identical, sound-attenuated, darkened chambers (55 x 41 x 70 cm--Scientific Prototype Model SPO 300). The operation of a ventilation fan located in the rear of the chamber produced an ambient noise level at the position of the subject's head of 60 db A above 20 $\mu N/m^2$. In contrast, each subject receiving its UCS preconditioning treatment in the NCE was restrained in a black, plastic box (19 x 16 x 37 cm--see Frey and Gavin, 1975, p. 115, for a picture of the restraining box) located on a table in an illuminated room where white noise, at 79 db A above 20 $\mu N/m^2$, and a "clicking" sound, recurring 7 times a second, were constantly present.

2.2.4 Procedure. Each subject participated in the experiment for each of 20 daily, 60-min sessions. During the first two sessions, subjects were prepared for the experiment and habituated to the handling and restraint procedures. On Day 1, each rabbit was placed in a restraint box, the left side of its head was shaved, the shock electrodes were implanted, and a wound clip (for attaching the string of the potentiometer) was fastened to its left upper eyelid. The animal then remained in the restraint box for the remainder of this first 60-min session. Day 2 consisted of further habituation to the restraint box and eyelid recording apparatus for 60 min.

On Days 3-12, rabbits were assigned to one of the four independent groups, and received their respective UCS preconditioning treatment. During this UCS preconditioning treatment phase, rabbits in Groups NPx-CE and NPx-NCE were simply restrained in their designated experimental context without any UCS presentations. During the UCS preconditioning treatment phase, rabbits in Groups Px-CE and Px-NCE received 20 daily UCS presentations during each of 10 daily sessions. The interval between UCS presentations was either 1.5, 3.0, or 4.5 min (mean: 3.0 min), with the different intervals occurring according to a predetermined irregular sequence.

Conditional eyelid training sessions, which were the same for all subjects, commenced on the day after the last UCS preconditioning treatment session (i.e., Day 13), and continued for the remainder of the experiment (Day 20). During conditional eyelid training sessions, all subjects received 20 daily CS-UCS pairings for each of eight days. CS-UCS pairings involved the 0.1-sec UCS overlapping the last 0.1 sec of the 0.6-sec CS, thus the interstimulus interval (ISI) was 0.5 sec. The interval between CS-UCS paired trials (i.e., the intertrial interval, or ITI) was either 1.5, 3.0, or 4.5 min (mean: 3.0 min), with the different intervals occurring according to a predetermined irregular sequence.

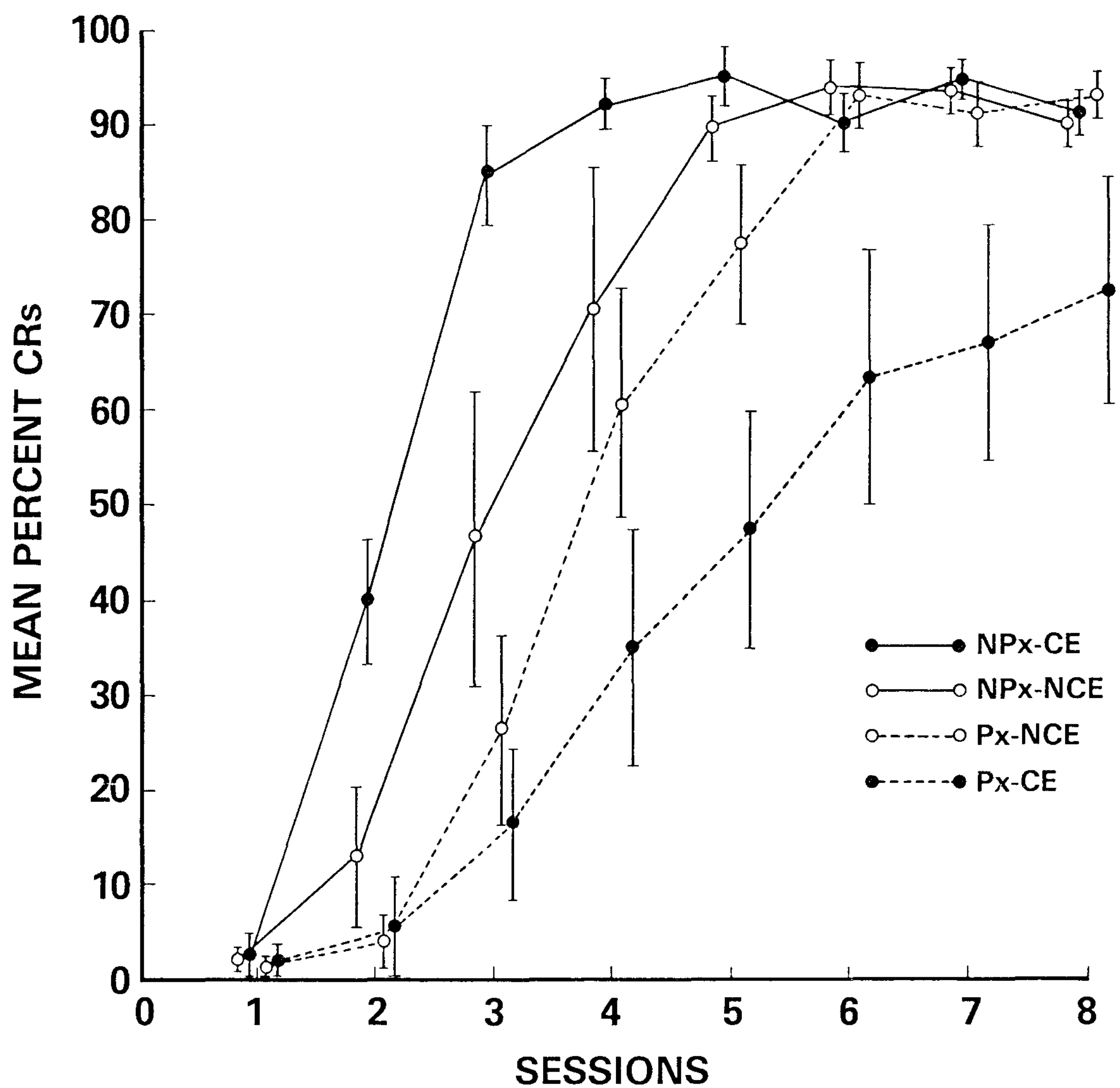
An eyeblink response was defined as a 1 mm deflection in the polygraph record from a baseline determined by the 500-msec period immediately previous to CS onset. During conditional eyelid training sessions, eyeblinks were scored during the 0.5-sec ISI for all subjects.

2.3 Results

Figure 1 presents the mean percentage ($\pm$ 1 SEM) of daily trials in which an eyelid response occurred during each of the eight daily sessions of conditional eyelid training. As can be seen in Figure 1, CR acquisition was slowest in the group which received UCS preexposure in the conditioning environment (Group Px-CE). It is also evident in Figure 1 that CR acquisition was fastest in the group which was simply restrained in the conditioning environment prior to the start of CS-UCS pairings (Group NPx-CE). Finally, from Figure 1, it is clear that the group which received UCS preexposure in the nonconditioning environment (Group Px-NCE), and the group which was simply restrained in the nonconditioning environment prior to the start of CS-UCS pairings (Group NPx-NCE), acquired the CR at about the same rate, with both of these groups being slower in CR acquisition than Group NPx-CE, and both faster than Group Px-CE.

The mean percentage ($\pm$ 1 SEM) of eyeblinks given over the total eight days of conditional eyelid training for each group was 38.7 $\pm$ 8.3, 55.9 $\pm$ 4.0, 62.4 $\pm$ 4.6, and 73.7 $\pm$ 1.9 for Groups Px-CE, Px-NCE,

Figure 1. Mean percentage ($\pm$ 1 SEM) of daily trials in which an eyeblink response occurred during each of the eight daily conditional eyelid training sessions in each of the different groups in Experiment 1.


MEAN PERCENT CRs
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
SESSIONS
NPx-CE
NPx-NCE
Px-NCE
Px-CE

NPx-NCE, and NPx-CE, respectively. A two factor (Px vs. NPx, and CE vs. NCE) design analysis of variance[2] of these mean percentage total CR data for each group revealed a significant main effect of the different UCS preconditioning treatments [(Px vs. NPx); (F=14.21, df=1,37, p < .001)], and a significant interaction between the different preconditioning treatments and the different preconditioning environments [(CE vs. NCE); (F=6.47, df=1,37, p < .025)]. Examination of Figure 1 suggests that the interaction results from the fact that UCS preexposure had a larger detrimental effect on CR acquisition when given in the CE compared to the NCE (compare the difference between Groups Px-CE and NPx-CE to that between Groups Px-NCE and NPx-NCE). Separate one-way analyses of variance of the different preexposure treatment (Px vs. NPx) effects in the different contexts (CE vs. NCE)

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[2] Although all the experiments reported in the present thesis involved a within-subjects repeated measure (i.e., experimental sessions), repeated-measures ANOVA's were not used to analyze data from any experiment. The decision to not use repeated-measures ANOVA's was dictated by the nonhomogeneity of variance occurring on the within-subjects measure in all experiments. (Such nonhomogeneity of variance is a typical problem encountered in learning curves when the response measures used is categorical, i.e., the only characteristic of the response recorded is its occurrence or nonoccurrence. Such categorical response measures contrast with other response measures, such as running speed in a maze, which typically always assume nonzero values.) The violation of the assumption of homogeneity is particularly problematic with regard to within-subjects measures, and is exacerbated in some of the experiments reported in the present thesis by the widely divergent sample sizes of some of the groups. When the data for each subject in a group are, however, collapsed across the within-subjects measure (to produce the overall mean percent of CRs for each subject), these overall response distributions are fairly homogeneous in variance. Thus, the results of all experiments reported in the present thesis were collapsed, for each subject, over experimental sessions to yield a measure of responding on which appropriate factorial, or one-way, ANOVA's could be performed. The results of each experiment are, however, still graphically presented as learning curves showing mean response rates for each experimental session for each group in an experiment.

supported this impression: There was a significant effect of preexposure treatment in the conditioning context (F=14.34, df=1,20, p<.001), but no significant effect of preexposure treatment in the nonconditioning context (F<1).

Further analyses of portions of the data summarized in Figure 1 were conducted to determine if the pre-asymptotic performance of the groups differed. The choice of these subsequent analyses was based on two considerations: First, it is possible that differences in pre-asymptotic CR acquisition performance between groups may be masked by collapsing the data over all conditioning sessions since some groups attain asymptote prior to the final conditioning session, thus only a restricted portion of the learning curve was analyzed; Second, a factorial analysis of variance of the data summarized in Figure 1 does not permit *a posterori* pairwise comparisons of the different groups' CR acquisition performance because of considerations involving degrees of freedom. Thus, a one-way analysis of variance of the CR acquisition performance of all groups over the first 5 conditioning sessions was computed, and *a posterori* pairwise comparisons were conducted using Newman-Keuls' Multiple-Range tests. The mean percentage ($\pm$ 1 SEM) of eyeblinks given over the first 5 days of conditioning for each group was 21.4 $\pm$ 7.0, 34.0 $\pm$ 5.7, 44.4 $\pm$ 7.0, and 62.8 $\pm$ 2.4 for Groups Px-CE, Px-NCE, NPx-NCE, and NPx-CE, respectively. Analysis of these CR data for the first 5 conditioning sessions revealed a significant effect of the different treatments given the different groups (F=9.13, df=3,37, p<.01), and subsequent pairwise comparison analyses indicated the following groups differed from each other (all p's<.05): Group

Px-CE from both Groups NPx-NCE and NPx-CE, Group Px-NCE from Group NPx-CE, and Group NPx-NCE from Group NPx-CE.

2.4 Discussion

2.4.1. The UCS Preexposure Effect and Contextual Stimuli. The finding in the present experiment that UCS preexposure retards subsequent CR acquisition confirms previous reports of a UCS preexposure effect in the rabbit eyelid conditioning preparation (Mis and Moore, 1973; Siegel and Domjan, 1971, Experiment 2). It is obvious, however, from the data summarized in Figure 1, that the magnitude of the UCS preexposure effect in rabbit eyelid conditioning is modulated by the similarity between the contextual stimuli present during UCS preexposure and the contextual stimuli present during CS-UCS pairings. If the contextual stimuli present during UCS preexposure and CS-UCS pairings were identical, CR acquisition was slower than if no UCS preexposure was given (compare Group Px-CE to Group NPx-CE). However, if the contextual stimuli were altered between UCS preexposure and the start of CS-UCS pairings, there was a significant reduction in the degree to which CR acquisition was retarded (compare Group Px-NCE to Group Px-CE).

The results of the present experiment demonstrate that the UCS preexposure effect in rabbit eyelid conditioning is attenuated by altering contextual stimuli between preexposure and the initiation of CS-UCS pairings. The results of several recent studies involving taste aversion learning (Batson and Best, 1979; Willner, 1978) CER conditioning (Chambers and Szakmary, Note 1), and autoshaping of the pigeon's keypeck (Tomie, Murphy, and Fath, 1980) also demonstrate that the UCS preexposure effect is attenuated if CS-UCS pairings occur in a context other than the one in which UCS preexposure occurs.

2.4.2 Conditioning to contextual stimuli and CR acquisition in the two nonpreexposed groups. Although the final asymptotic level of CR performance was comparable in the two nonpreexposed groups of the present experiment (NPx-CE and NPx-NCE), the rate of CR acquisition was faster in Group NPx-CE, which was restrained in the conditioning environment prior to CS-UCS pairings, than in Group NPx-NCE, which was restrained in the nonconditioning environment prior to the start of conditional eyelid training. This difference in CR acquisition performance of the two nonpreexposed groups was unexpected. Although we would caution that the replicability of a difference in CR acquisition performance between nonpreexposed groups treated identically to those of the present experiment should not be considered established on the basis of the results of the present experiment, there are theoretical reasons to believe that such a difference might occur. Thus, it has been suggested that the amount of conditioning to one stimulus (e.g., the nominal CS) is inversely related to the total amount of conditioning to all stimuli (e.g., contextual stimuli) concurrently present at the time of UCS presentation (Rescorla and Wagner,1972). It follows from this suggestion that conditioning to the nominal CS should be reduced during CS-UCS pairings to the extent that contextual stimuli concurrently present are simultaneously established as signals of the UCS (e.g., McAllister, McAllister, Weldin, and Cohen, 1974; Rescorla and Wagner, 1972). However, if contextual stimuli present during CS-UCS pairings are rendered less capable of serving as signals of the UCS than normal, then conditioning to the nominal CS should be more rapid than normal.

One procedure that reduces the conditionability of a to-be-conditioned stimulus is repeated presentations of that stimulus alone prior to its pairing with the UCS. The reduced degree of conditioning occurring to a preexposed CS is termed "latent inhibition" (Lubow and Moore, 1959). Since subjects in Group NPx-CE were restrained for 10 daily 60-min sessions in the presence of the contextual stimuli present when the nominal CS was subsequently paired with the UCS during the conditional eyelid training phase of the experiment, it might be expected that when the nominal CS was paired with the UCS in the presence of these "preexposed" contextual stimuli, conditioning to the nominal CS would be faster than if the contextual stimuli were relatively more novel. This is because nonpreexposed contextual stimuil should "compete" with conditioning to the nominal CS more than familiar, "latently inhibited", contextual stimuli. The finding in the present experiment that CR acquisition tended to be faster in Group NPx-CE, in which the nominal CS was paired with the UCS in a familiar context, than in Group NPx-NCE, in which the nominal CS was paired with the UCS in a novel environment, is consistent with this "latent inhibition" analysis. Lubow, Rifkin, and Alek (1976) have reported a finding similar to the difference in CR acquisition between Groups NPx-CE and NPx-NCE in the present experiment. In both a perceptual learning task involving children, and an olfactory discrimination task using rats, Lubow et. al. (1976) found that learning was more rapid when the learning tasks were presented in a familiar, preexposed environment rather than in a novel, nonpreexposeed environment. Lubow et. al. (1976) suggested that one factor that may contribute to this finding is latent inhibition of environmental stimuli.

CHAPTER 3

EXPERIMENT 2. THE LATENT INHIBITION STUDY

3.1 Reduced Conditioning to Contextual Stimuli and Attenuation of the UCS Preexposure Effect

According to the context blocking analysis, the UCS preexposure effect occurs because conditioning to contextual stimuli during the period of UCS preexposure blocks subsequent conditioning to the nominal CS. Based on this analysis, it would be expected that the UCS preexposure effect would be attenuated if conditioning to contextual stimuli during the period of UCS preexposure were reduced.

One procedure which reduces conditioning to a stimulus is experience with the stimulus prior to its pairing with the UCS, i.e., latent inhibition (Lubow and Moore, 1959). Latent inhibition has frequently been demonstrated using discrete stimulus events (for a review, see Lubow, 1973). Latent inhibition has also been demonstrated to occur with contextual stimuli in a study by Blanchard, Deilman, and Blanchard (1968). In the Blanchard et al. (1968) study, conditioning to contextual stimuli was indexed by the amount of time a rat spent crouching when placed in a distinctive box where it had previously been shocked, with more crouching assumed to indicate more conditioned fear to box cues. Rats given 24 hr exposure to the shock-box cues prior to receiving shocks crouched less (i.e., evidenced less conditioning) following a series of seven shocks in the box than rats given only 0.5 hr exposure to the box cues. Blanchard et al. (1968) discussed several interpretations of this finding, one of which involved the possibility that experience with "the apparatus cues of the shock situation may have produced a deficit in the development of a conditioned response in the situation" (p. 372)--that is, latent inhibition. Thus, there is evidence to suggest that conditioning which occurs to contextual stimuli is reduced by prior nonreinforced presentations of the contextual stimuli.

The indication that conditioning to contextual stimuli is subject to latent inhibition suggests a further test of the context blocking interpretation of the UCS preexposure effect. Namely, the UCS preexposure effect should be attenuated by latently inhibiting contextual stimuli prior to the start of UCS preexposure. That is, experience with the contextual stimuli of the UCS preexposure environment prior to the start of UCS-alone presentations should reduce conditioning to contextual stimuli, and thus attenuate the UCS preexposure effect. The purpose of Experiment 2 was to determine whether animals given experience with the contextual stimuli of the UCS preexposure environment, prior to the start of UCS preexposure, show less of a UCS preexposure effect than animals without such prior experience with the contextual stimuli.

3.2 Method

3.2.1 Design. The experiment involved three independent groups of rabbits. Rabbits in one group were given UCS preexposure prior to the start of CS-UCS pairings (Group Px). Rabbits in a second group were treated identically to rabbits in Group Px, except that they were restrained on several occasions prior to the period of UCS preexposure in the presence of the contextual stimuli present during UCS preexposure (Group Li-Px). This manipulation was designed to correspond to a latent inhibition procedure for contextual stimuli of the UCS preexposure environment. Finally, a third group of rabbits received no UCS preexposure prior to the initiation of CS-UCS pairings (Group NPx).

Originally, ten rabbits were assigned to each of Groups Px and Li-Px, and eight rabbits were assigned to Group NPx. However, one rabbit in Group NPx had to be discarded due to illness, leaving seven rabbits in this group.

3.2.2 Subjects. The subjects were 28 experimentally naive rabbits of the same sex, strain, weight, and age as those used in the previous experiment.

3.2.3 Apparatus. Details of the recording apparatus, shock UCS, and auditory CS were identical to those of the previous experiment.

3.2.4 Procedure. Each rabbit participated in the experiment for each of 32 daily, 60-min sessions. During each session, each rabbit was restrained in a clear Plexiglas box (18 x 14 x 41 cm) located in one of six, identical sound-attenuated, darkened chambers, with an ambient noise level of approximately 60 db A above 20 $\mu N/m^2$.

As in the previous experiment, each rabbit was first systematically adapted to the restraint box and eyelid recording apparatus during each of two daily sessions. Following this adaptation period, for each of the next 10 days (Days 3-12), rabbits in Group NPx and Group Li-Px were restrained in the conditioning chambers for 60 min. Rabbits in Group Px were left undisturbed in their home cages during this time. No UCS presentations were given to rabbits in any group during this phase of the experiment.

Next, rabbits in Groups Li-Px and Px received 10 daily sessions (Days 13-22) of 20 UCS presentations. The interval between UCS presentations was either 1.5, 3.0, or 4.5 min (mean: 3.0 min), with the different intervals occurring according to a predetermined irregular sequence. Rabbits in Group NPx received no UCS presentations, and were simply restrained in the conditioning chambers for 10 daily, 60-min sessions during this time.

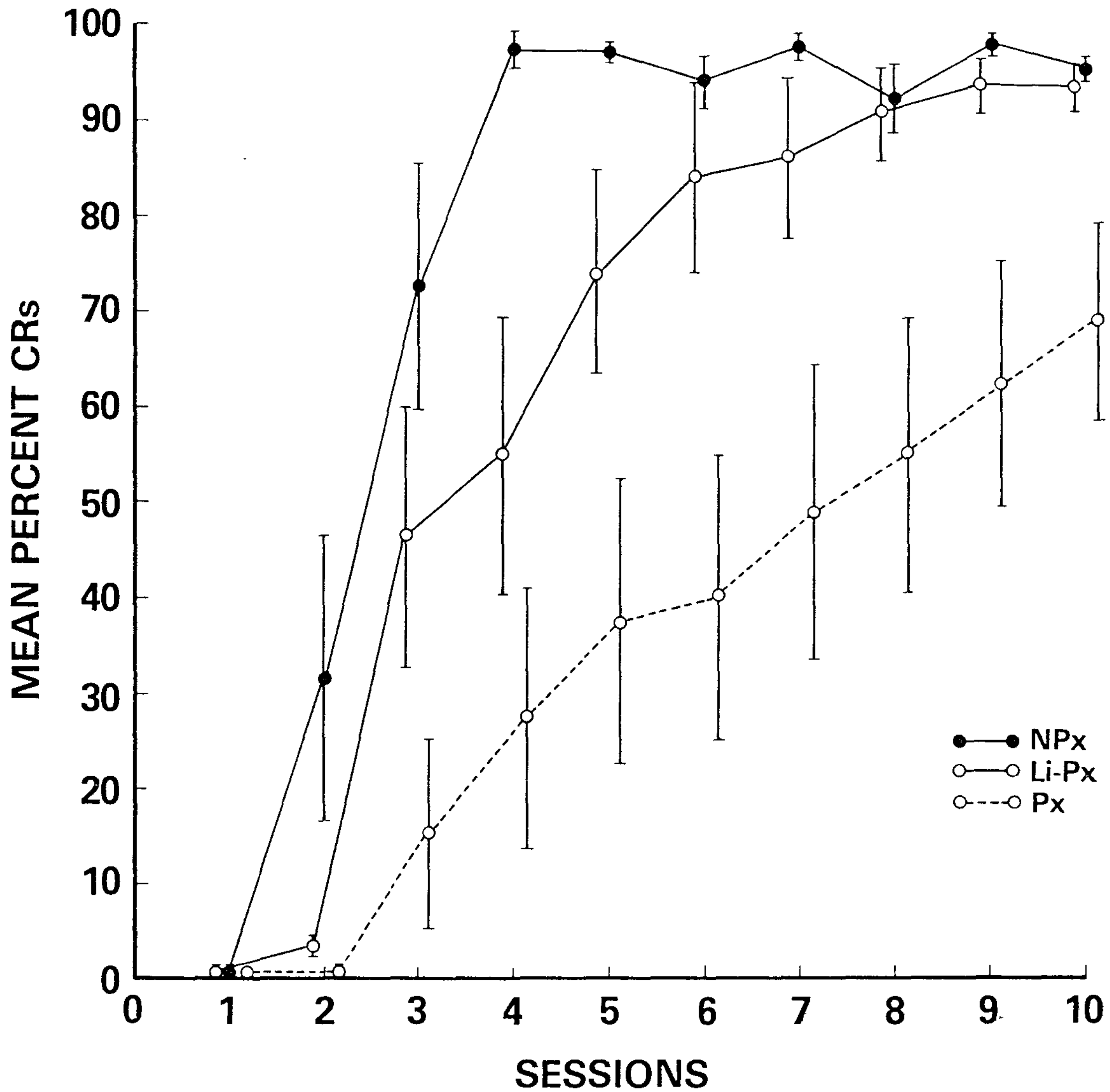
Finally, all rabbits received conditional eyelid training during each of 10 daily sessions (Days 23-32) commencing 24 hr after the last UCS preexposure session. Conditional eyelid training, which was the same for all rabbits, was conducted in a manner identical to that previously described in Experiment 1.

In unspecified details, the procedures of Experiment 2 were identical to those of Experiment 1.

3.3 Results

Figure 2 shows the mean percentage ($\pm$ 1 SEM) of daily trials in which an eyelid response occurred during each of the 10 daily

Figure 2. Mean percentage ($\pm$ 1 SEM) of daily trials in which an eyeblink response occurred during each of the ten daily conditional eyelid training sessions in each of the different groups of Experiment 2.


MEAN PERCENT CRs
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
SESSIONS
NPx
Li-Px
Px

conditional eyelid training sessions.

The results presented in Figure 2 reveal that rabbits given UCS preexposure (Groups Px and Li-Px) were slower to acquire the conditional eyeblink response than rabbits which received no preconditioning UCS presentations (Group NPx). It is also evident from the results presented in Figure 2, however, that the magnitude of the UCS preexposure effect was not equal in Groups Li-Px and Px: Rabbits restrained in the UCS preexposure environment prior to the start of UCS-alone presentations (Group Li-Px) acquired the eyeblink CR faster (i.e., showed less of a UCS preexposure effect) than rabbits simply left undisturbed in their home cages prior to the start of UCS-alone presentations (Group Px).

The mean percentage ($\pm$ 1 SEM) of eyeblinks given over the total 10 days of conditional eyelid training for each group was 35.8 $\pm$ 9.3, 62.6 $\pm$ 5.4, and 77.6 $\pm$ 2.2 for Groups Px, Li-Px, and NPx, respectively. A one-way analysis of variance of these mean percent total CR data indicated a significant overall effect of the different experimental treatments ($F \doteq 8.84$, $df=2, 24$, $p < .005$). Subsequent pairwise comparison analyses (Newman-Keuls' Multiple Range Tests) indicated that the CR acquisition performance of Group Px was significantly different from that of both Group Li-Px and Group NPx (both p's $< .05$), but that the difference between Groups Li-Px and NPx was not significant.

An additional analysis of a portion of the data summarized in Figure 2 was conducted to determine if the pre-asymptotic CR performance of the groups differed. As was the case for Experiment 1, a one-way analysis of variance of the CR acquisition performance of all groups over the first 5 conditioning sessions was computed, and *a posterori* pairwise comparisons were conducted using Newman-Keuls' Multiple Range Tests. The mean percentage ($\pm$ 1 SEM) of eyeblinks given over the first 5 days of conditioning for each group was 16.3 $\pm$ 7.3, 35.8 $\pm$ 7.7, and 59.6 $\pm$ 5.4 for Groups Px, Li-Px and NPx, respectively. Analysis of these mean percentage total CR data for the first 5 conditioning sessions revealed a significant groups effect (F=8.18, df=2,24, p<.005), and subsequent pairwise comparison analyses indicated that Group NPx differed from both Groups Li-Px and Px (p<.05), but that the latter two groups did not differ.

3.4 Discussion

The finding in the present experiment that UCS preexposure retards CR acquisition replicates previous demonstrations of a UCS preexposure effect in rabbit eyelid conditioning (e.g., Mis and Moore, 1973). However, as was the case in Experiment 1, the results of the present experiment demonstrate that the magnitude of the UCS preexposure effect is modulated by manipulation of contextual stimuli present at the time of UCS preexposure. In the present experiment, rabbits exposed to the contextual stimuli in which UCS-alone presentations were administered (Group Li-Px) evidenced less-retarded CR acquisition performance than rabbits, with the same preconditioning experience with the UCS, but without experience with the contextual stimuli alone (Group Px).

There is also some evidence in the present experiment that the latent inhibition procedure did not totally eliminate the detrimental effect of UCS preexposure on excitatory learning: Rabbits in Group Li-Px evidenced fewer eyeblink CRs during the first 5 conditioning sessions than rabbits in Group NPx. This residual decremental effect of UCS preexposure on CR acquisition in Group Li-Px may have resulted simply from insufficient latent inhibition training to contextual stimuli. Furthermore, it should also be pointed out that latent inhibition does not prevent conditioning to the preexposed stimulus, but rather only slows the rate of learning (e.g., Siegel, 1972). Thus, it is possible that some conditioning between contextual stimuli and the UCS could have occurred in rabbits in Group Li-Px following the latent inhibition procedure with contextual stimuli. Any such contextual conditioning in Group Li-Px during UCS preexposure should then retard CR acquisition at the start of training. Finally, it should also be recognized that the residual decremental effect of UCS preexposure observed in Group Li-Px may indicate that some degree of the UCS preexposure effect on excitatory conditioning is not determined by associative processes. Thus, it is possible that nonassociative factors (e.g., habituation, loss of reactivity) may play a role in UCS preexposure. However, it should be noted that the much greater retarded CR acquisition performance of Group Px in comparison to Group Li-Px in the present experiment suggests that, at least with regard to rabbit eyelid conditioning, associative factors play a larger role than nonassociative factors in producing the detrimental effect of UCS preexposure on excitatory learning.

CHAPTER 4

EXPERIMENT 3. THE EXTINCTION STUDY

4.1 Extinction of Contextual Conditioning and Attenuation of the UCS Preexposure Effect

If, as suggested by the context blocking analysis, the UCS preexposure effect results from interference with conditioning to the nominal CS by prior conditioning to contextual stimuli, it should be possible to attenuate the UCS preexposure effect by reducing the strength of the contextual conditioning prior to the initiation of CS-UCS pairings. Perhaps the most common procedure for attenuating conditioning is extinction. Extinction involves presenting the CS a number of times without the UCS following a period in which conditioning has occurred (see Mackintosh, 1974, p. 13, for a review).

It should be possible to extinguish conditioning which occurs to contextual stimuli during a period of UCS-alone presentations. That is, repeated presentations of contextual stimuli present during UCS preexposure, but now presented without the UCS, should weaken conditioning to contextual stimuli.

The possibility that contextual conditioning may be extinguished suggests a further test of the context blocking analysis of the UCS preexposure effect. Namely, the UCS preexposure effect should be attenuated by returning subjects to the experimental situation in which UCS preexposure is administered following the period of UCS presentations, but now not presenting the UCS.

4.2 Method

4.2.1 Design. The experiment involved a 2 x 2 factorial design. One factor on which subjects were differentiated involved whether or not they were given UCS preexposure. Some rabbits received UCS preexposure (designated "Px"), and some rabbits were simply restrained in the experimental environment without any UCS presentations (designated "NPx"). The second factor on which subjects were differentiated concerned their treatment following the period of UCS preexposure, or restraint, just described. Half the rabbits receiving UCS preexposure, and half the rabbits restrained without any UCS presentations, were simply left undisturbed in their home cages unitl the start of conditional eyelid training (designated "REST"). The remaining half of the rabbits receiving UCS preexposure, or restraint, were returned to the UCS preexposure environment, but now no UCS presentations occurred (designated "EXT"). The treatment given the "extinguished" (EXT) subjects was intended to reduce any conditioning which may have occurred to contextual stimuli in subjects given UCS preexposure. Thus, four independent groups of rabbits were formed: (1) UCS preexposure followed by restraint in the preexposure environment, Px-EXT; (2) UCS preexposure followed by being left undisturbed in the home cage, Px-REST; (3) No UCS preexposure followed by restraint in the experimental chambers, NPx-EXT; and (4) No UCS preexposure followed by being left undisturbed in the home cage, NPx-REST.

Twelve rabbits were assigned to each of Groups Px-EXT and Px-REST, and six rabbits were assigned to each of Groups NPx-EXT and NPx-REST.

4.2.2 Subjects. The subjects were 36 experimentally naive rabbits of the same sex, strain, weight, and age as those used in the previous experiments.

4.2.3 Apparatus. Details of the recording apparatus, shock UCS, and auditory CS were identical to those of the previous experiments.

4.2.4 Procedure. Each subject participated in the experiment for each of 25, daily 60-min sessions. All experimental sessions were conducted while each rabbit was restrained in a clear Plexiglas box (18 x 14 x 41 cm) located in one of six, identical, darkened, sound-attenuated, ventilated chambers with an ambient noise level of 60 db A above 20 $\mu N/m^2$.

As previously described, the first two sessions involved adaptation to the restraint. Following the adaptation period, during each of the next 10 daily sessions (Days 3-12), rabbits in groups receiving UCS preexposure (Groups Px-EXT and Px-REST) were presented 20 UCSs occurring at intervals of either 1.5, 3.0, or 4.5 min (mean: 3.0 min), with the different intervals occurring according to a predetermined irregular sequence. During this time, rabbits in groups not designated to receive UCS preexposure (Groups NPx-EXT and NPx-REST) were simply restrained in the experimental chambers for 10 daily 60-min sessions.

Following the treatment phase of the experiment just described, rabbits in Groups Px-REST and NPx-REST were left undisturbed in their home cages for the next five days (Days 13-17). During this time, rabbits in Groups Px-EXT and NPx-EXT were placed in the experimental chambers for 60 min during each of five daily sessions. No UCS presentations were given to rabbits in any group during this phase of the experiment. Placement in the experimental chambers during this five-day period was designed to serve as an extinction procedure for rabbits previously given UCS preexposure (Group Px-EXT).

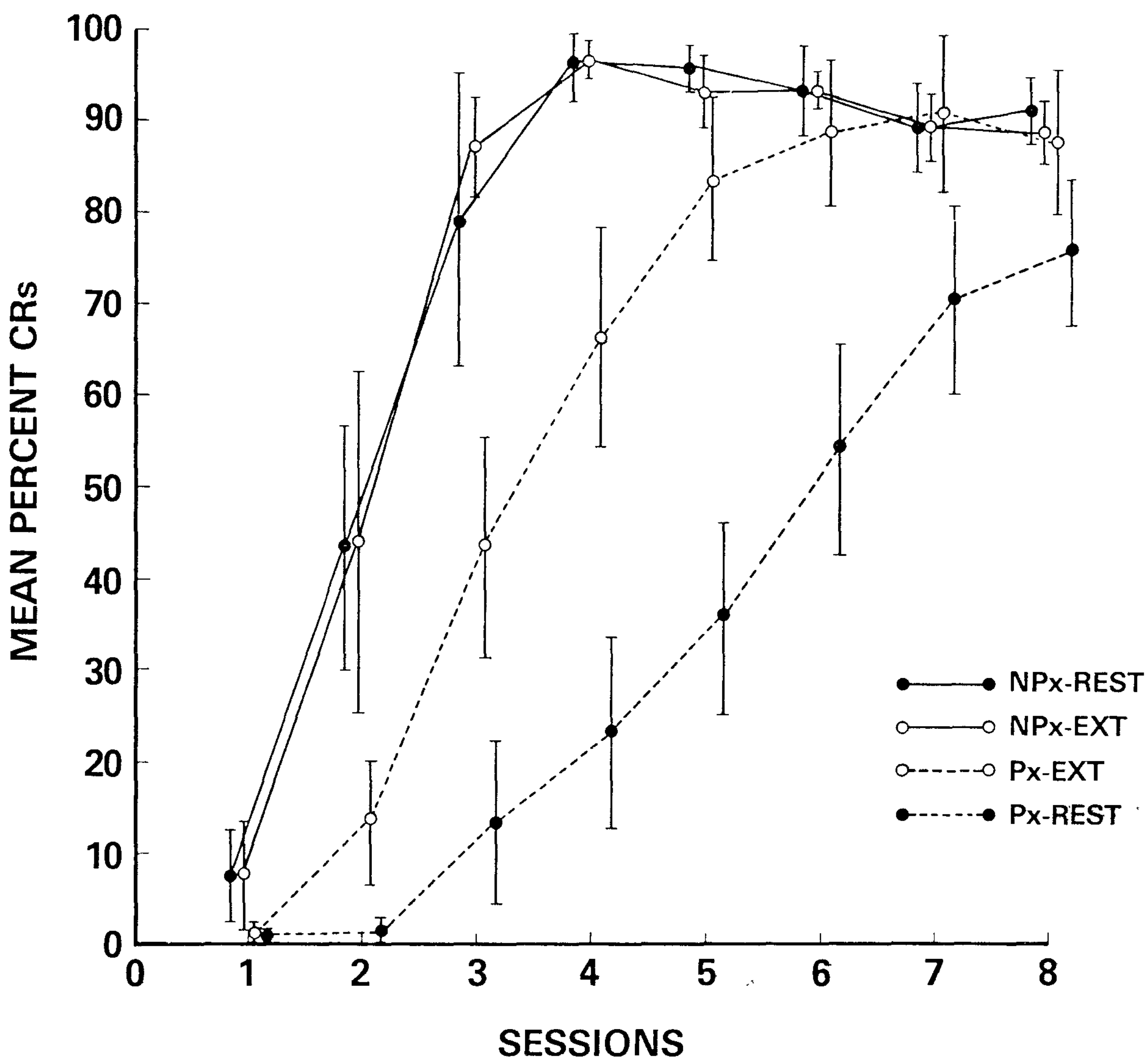
Following the five-day treatment phase of the experiment just described, all rabbits received identical conditional eyelid training sessions during each of the final eight days of the experiment (Days 18-25). These conditional eyelid training sessions were conducted in a manner identical to those previously described in Experiments 1 and 2.

In unspecified details, the procedures of Experiment 3 were identical to those of Experiments 1 and 2.

4.3 Results

Shown in Figure 3 is the mean percentage of daily trials ($\pm$ 1 SEM) in which an eyelid response occurred during each of the eight daily sessions of conditional eyelid training. As can be seen in Figure 3, CR acquisition was retarded in both groups which received UCS preexposure (Groups Px-EXT and Px-REST), relative to the groups which were not exposed to the UCS prior to the start of CS-UCS pairings

Figure 3. Mean percentage ($\pm$ 1 SEM) of daily trials in which an eyeblink response occurred during each of the eight daily conditional eyelid training sessions in each of the different groups of Experiment 3.


MEAN PERCENT CRs
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
SESSIONS
NPx-REST
NPx-EXT
Px-EXT
Px-REST

(Groups NPx-EXT and NPx-REST). However, it is also evident in Figure 3 that CR acquisition was faster in rabbits which were returned to the UCS preexposure environment for five days following UCS preexposure prior to the start of conditional eyelid training (Group Px-EXT), than in rabbits which were simply left undisturbed in their home cages between UCS preexposure and the start of conditional eyelid training (Group Px-REST). Finally, it is clear from Figure 3 that the two groups which were not given preconditioning experience with the UCS (Groups NPx-EXT and NPx-REST) acquired the CR at about the same rate.

The mean percentage ($\pm$ 1 SEM) of eyeblinks given over the total eight days of conditional eyelid training for each group was 34.4 $\pm$ 6.1, 59.3 $\pm$ 6.4, 74.5 $\pm$ 3.7, and 74.9 $\pm$ 2.7 for groups Px-REST, Px-EXT, NPx-REST, and NPx-EXT, respectively. A two factor (Px vs. NPx, and REST vs. EXT) design analysis of variance of these mean percentage total CR data for each group revealed a significant main effect of the different preconditioning UCS treatments [(Px vs. NPx); (F=17.93, df=1, 32, $p < .001$)], a significant main effect of whether subjects received the REST or EXT treatment (F=4.20, df=1, 32, $p < .05$), and a significant interaction between these two factors (F=6.54, df=1, 32, $p < .025$). Examination of Figure 3 suggests that the interaction results from the fact that the extinction treatment had a greater effect in rabbits receiving UCS preexposure (compare Groups Px-EXT and Px-REST) than in rabbits given no UCS pretreatment (compare Groups NPx-EXT and NPx-REST). Two separate one-way analyses of variance conducted on the two levels of UCS preconditioning treatment (Px vs. NPx) confirmed this impression: There was a significant effect of treatment (EXT vs. REST) in animals receiving UCS preexposure (F=7.8, df=1,22, p<.025), but no differential effect of extinction versus rest treatment for rabbits which were simply restrained, without UCS preexposure, prior to the initiation of CS-UCS pairings (F < 1).

A one-way analysis of variance of the mean total percent CRs for all groups over the first 5 conditioning sessions was conducted to determine if the groups differed in preasymptotic CR acquisition performance. The mean percentage (± 1 SEM) of CRs for each group over the first 5 conditioning sessions was 15 ± 5.8, 41.5 ± 6.9, 64.4 ± 6.1, and 65.8 ± 3.4 for Groups Px-REST, Px-EXT, NPx-REST, and NPx-EXT, respectively. Analysis of these data revealed a significant effect of the different treatments given the various groups (F=13.36, df=3,32, p<.001). Subsequent pairwise comparison analyses (Newman-Keuls' Multiple Range tests, p's < .05) indicated that Group Px-REST differed from all other groups, and that Group Px-EXT differed from the two nonpreexposed groups.

4.4 Discussion

4.4.1 Attenuation of the UCS Preexposure Effect by Extinction.

The results of Experiment 3 demonstrate, once again, that UCS preexposure retards subsequent acquisition of the excitatory CR in the rabbit eyelid conditioning preparation: Groups Px-REST and Px-EXT were slower to acquire the eyeblink CR than either of the groups which did not experience the UCS prior to the start of CS-UCS pairings (Groups NPx-EXT and NPx-REST). The results of Experiment 3 further demonstrate that the UCS preexposure effect is significantly attenuated if, following the period of UCS preexposure, the contextual stimuli of the preexposure environment are presented on several occasions without the UCS prior to start of conditional eyelid training: Although subjects in Groups Px-EXT and Px-REST had identical preconditioning experience with the UCS, CR acquisition was significantly faster in Group Px-EXT than in Group Px-REST.

If, as suggested by most traditional accounts, the UCS preexposure effect results mainly from a reduction in the organism's reactivity to the UCS, it would be expected that animals which receive identical preconditioning experience with the UCS should evidence the same magnitude of UCS preexposure effect. Thus, the difference in CR acquisition performance between Groups Px-EXT and Px-REST in the present experiment is not accounted for by traditional, nonassociative analyses of the UCS preexposure effect (e.g., Taylor, 1946; Macdonald, 1956; Randich and LoLordo, 1979a). However, the difference in CR acquisition performance between Groups Px-EXT and Px-REST in the present experiment is anticipated by the context blocking analysis which assigns a crucial role to contextual stimuli of the preexposure environment in mediating the UCS preexposure effect.

Attenuation of the UCS preexposure effect by extinction of contextual stimuli has also recently been reported by Batson and Best (1979) and Willner (1978) in the taste aversion paradigm, and by Tomie (1976a) in the autoshaping procedure.

4.4.2 Residual UCS Preexposure Effect and Failure to Extinguish Contextual Conditioning. If conditioning to contextual stimuli were all that were involved in the UCS preexposure effect, it would be expected that the UCS preexposure effect should be totally eliminated by totally extinguishing all conditioning to contextual stimuli. In the present experiment, CR acquisition was retarded in Group Px-EXT relative to the two nonpreexposed groups (NPx-EXT and NPx-REST), indicating that the UCS preexposure effect was not totally eliminated by the present extinction procedure. The UCS preexposure effect still in evidence following the extinction procedure applied to contextual stimuli in Group Px-EXT may simply be due to an insufficient number of extinction trials. Alternatively, the finding that extinction of contextual stimuli may not totally eliminate the UCS preexposure effect may indicate that nonassociative factors, not subject to associative extinction, contribute to the UCS preexposure effect.

CHAPTER 5

EXPERIMENT 4. THE EFFECT OF UCS PREEXPOSURE ON CONDITIONAL INHIBITION

5.1 UCS Preexposure and Inhibitory Conditioning

The previous experiments have examined the effects of various associative manipulations of contextual stimuli (e.g., extinction, latent inhibition, altering contextual stimuli) on the UCS preexposure effect in excitatory conditioning. The results of these experiments provide evidence that UCS preexposure retards excitatory conditioning largely because of an excitatory association between contextual stimuli and the UCS.

In addition to excitatory conditioning, Pavlov (1927) discussed at some length a second form of conditioning--namely, inhibitory conditioning. The effect of UCS preexposure on inhibitory conditioning in a situation where UCS preexposure retards excitatory conditioning has not been previously reported (see, however, Baker & Mackintosh, 1977). However, any complete theoretical account of the processes involved during UCS preexposure should allow prediction of the effect of UCS preexposure on inhibitory, as well as excitatory, conditioning. Thus, in the present experiment, the effect of UCS preexposure on inhibitory conditioning was investigated with respect to expectations based on the associative, context blocking analysis and several of the traditional nonassociative analyses of UCS preexposure (e.g., Macdonald, 1946; Taylor, 1956; Randich and LoLordo, 1979a).

5.2 Inhibitory Conditioning

A conditional inhibitory CS is defined as a stimulus "that has become capable, through experience, of interfering with the production of a response by a conditional excitatory stimulus" (Rescorla, 1975, p. 20). Several procedures have been described for producing a conditional inhibitory CS (see review by Rescorla, 1969).

One conditional inhibitory training procedure involves backward pairings of the UCS and CS. That is, whereas in conditional excitatory training, the CS precedes the UCS, in the backward conditioning procedure, the CS follows the UCS. Backward-paired presentations of the UCS and CS are an effective conditional inhibitory training procedure in a variety of conditioning preparations (Heth, 1976; Moscovitch and LoLordo, 1968; Siegel and Domjan, 1971, Expermient 1, 1974), including rabbit eyelid conditioning (Plotkin and Oakley, 1975; Siegel and Domjan, 1971, Experiment 2, 1974).

It has been suggested (e.g., Wagner and Rescorla, 1972) that the acquisition of conditional inhibition in the backward conditioning procedure may, in part, be mediated by excitatory conditioning to contextual stimuli. That is, normally during the course of UCS-CS backward pairings, contextual stimuli may acquire conditional excitatory strength. Support for the proposal that contextual stimuli acquire conditional excitatory strength during the course of UCS-CS backward pairings is provided by the results of an experiment by McAllister and McAllister (1962). After a number of UCS-CS backward pairings sufficient to produce conditional excitation to contextual stimuli, the backward CS (which follows UCS presentation) is presented nonreinforced in an excitatory context. It has been suggested (e.g., Pavlov, 1927; p. 67-87; Wagner and Rescorla, 1972) that nonreinforcement of a CS in the presence of excitatory stimuli is a particularly effective conditional inhibitory training procedure.

The acquisition of conditional inhibition by the procedure of nonreinforcement of a stimulus in an excitatory context is conceptualized in a model of classical conditioning suggested by Rescorla and Wagner [(1972); see also Rescorla, 1975; Wagner and Rescorla, 1972)]. According to this model of conditioning, the trial by trial changes in the conditional properties of a stimulus are represented by the formula

$$\Delta Va = \alpha a \beta \chi (\lambda x - V) \qquad (1)$$

where ΔV_a is the change in the conditional properties of stimulus "a" on the conditioning trial; α_a and β_x are learning rate parameters (which assume positive values ≤ 1) associated with the CS and UCS, respectively; λ_x is the asymptotic degree of conditioning supportable by the UCS (which also assumes positive values ≤ 1); and, $\overline{V}$ is the total amount of conditioning to all stimuli present during the conditioning trial. There are two important assumptions of the Rescorla/Wagner model for the acquisition of conditional inhibition by the procedure of nonreinforcement of a stimulus in an excitatory context: (1) Conditional excitation is represented by positive values of V, and, conversely, conditional inhibition is represented by negative values of V, and (2) λ_x associated with nonreinforcement is zero (0). Given these two assumptions, it is obvious from examining equation 1 that in order for V_a to become negative (i.e., in order for stimulus "a" to acquire conditional inhibition), $(\lambda_x - \overline{V})$ must be negative, and thus $\overline{V}$ must be positive (i.e., excitatory). If a stimulus is nonreinforced in the presence of excitatory stimuli (i.e., stimuli which contribute to a positive value of $\overline{V}$), then $(\lambda_x - V)$ will be negative since the λ value associated with nonreinforcement is 0, and thus the stimulus will acquire conditional inhibitory properties.

One prediction of the Rescorla/Wagner model of conditioning is that the acquisition of conditional inhibition should be faster the greater the positive value of $\overline{V}$ [i.e., the greater the excitatory strength of other stimuli (e.g., contextual stimuli) present when the nominal CS is presented nonreinforced]. This is because, the greater the positive value (i.e., excitatory strength) of $\overline{V}$ when stimulus "a" is presented nonreinforced, the greater the negative value of $(\lambda_x - \overline{V})$. Support for the prediction that the acquisition of conditional inhibition by a stimulus is directly related to the net excitatory strength of all the stimuli present on the conditioning trial has been reported by Wagner (1971) in the rabbit eyelid conditioning preparation. Briefly, two stimuli were pretrained to have either high (Stimulus A) or low (Stimulus B) excitatory strength. Subsequently, these stimuli were combined with another stimulus (C) and nonreinforced, while stimulus A and stimulus B continued to be presented and reinforced. The compound AC nonreinforced trials would be expected to produce conditional inhibition to stimulus C (e.g., Pavlov, 1927, pp. 67-87). However, according to the Rescorla/Wagner model of conditioning, stimulus C should acquire greater conditional inhibitory properties when nonreinforced in compound with the more highly excitatory stimulus A, than when nonreinforced in compound with the more weakly excitatory stimulus B. The results, in fact, demonstrated that stimulus C acquired greater conditional inhibitory properties by virtue of the AC training than by the identical amount of training in the BC compound.

5.3 Predicted Effect of UCS Preexposure on Inhibitory Conditioning

5.3.1 The Associative, Context Blocking Analysis. If the acquisition of conditional inhibition in the backward conditioning procedure depends, in part, upon contextual stimuli acquiring excitatory strength, then it would be expected that if contextual stimuli are made excitatory prior to the start of UCS-CS pairings, acquisition of conditional inhibition by the backward CS should be more rapid than if the contextual stimuli acquire conditional excitation only during the normal course of UCS-CS backward pairings.

According to the associative, context blocking interpretation of the UCS preexposure effect in excitatory conditioning, contextual stimuli acquire conditional excitation during UCS preexposure. Based on the foregoing analysis, it would be expected that UCS preexposure would facilitate the acquisition of conditional inhibition in the backward conditioning procedure. This is because, UCS-CS backward pairings administered following UCS preexposure would occur in a context already rendered excitatory by virtue of the period of

UCS-alone presentations. Thus, the backward CS would be presented nonreinforced in an excitatory context from the outset of backward training, and would not have to await the acquisition of conditional excitation by contextual stimuli, as would normally occur during UCS-CS backward inhibitory training.

5.3.2 Nonassociative Analyses. It is unclear what effect UCS preexposure would be expected to have on the acquisition of conditional inhibition on the basis of any of the traditional, nonassociative accounts of UCS preexposure (e.g., Macdonald, 1946; Taylor, 1956). As discussed previously, all of the traditional, nonassociative interpretations of UCS preexposure suggest that preexposing the UCS renders it functionally less aversive, intense, and/or emotional. It might be argued that such a functionally "weaker" UCS, should result in slower learning, whether involving conditional excitation or conditional inhibition. Several experiments have demonstrated a direct relationship between UCS intensity and the acquisition of conditional excitation (see Mackintosh, 1974, pp. 70-71, for a review). Although there have been no reports of the relationship between UCS intensity and the acquisition of conditional inhibition, it seems likely that traditional, nonassociative accounts of UCS preexposure would also anticipate a decremental effect of UCS preexposure on the acquisition of conditional inhibition. In any event, it is difficult to conceive how any of the traditional, nonassociative accounts of UCS preexposure would anticipate a facilitatory effect of UCS preexposure on conditional inhibitory acquisition. Thus, the prediction of enhanced acquisition of conditional inhibition following UCS preexposure would appear to be unique to the associative, context blocking interpretation of UCS preexposure.

5.4 Retardation of Acquisition as a Measure of Conditional Inhibition

In the present experiment, a retardation-of-acquisition test was used to assess the extent to which a backward-conditioned CS acquired conditional inhibitory properties, when UCS-CS backward pairings were administered either subsequent to UCS preexposure, prior to UCS preexposure, or without any UCS preexposure. In the retardation-of-acquisition test, the conditional inhibitory properties of a stimulus are assessed by subjecting the suspected inhibitory CS to a known excitatory training procedure (i.e., forward CS-UCS pairings) following the period in which the putative conditional inhibitory training procedure is administered (see Rescorla, 1969). Since a conditional inhibitory CS is defined by its opposing action to the effects of a conditional excitatory CS, evidence for conditional inhibition in the retardation-of-acquisition test would consist of slower acquisition of the excitatory CR. Furthermore, a stimulus with stronger conditional inhibitory properties would be expected to acquire conditional excitation more slowly than a stimulus with weaker conditional inhibitory properties.

5.5 Method

5.5.1 Design. The experiment involved four independent groups of rabbits. During the final phase of the experiment, subjects in all four groups were given identical CS-UCS excitatory training trials. Subjects differed in their treatment prior to receiving CS-UCS excitatory training. Rabbits in one group (Group N) received only the CS-UCS excitatory training trials during the final phase of the experiment. Rabbits in a second group (Group BCK) received UCS-CS backward conditioning trials during each of several daily sessions prior to receiving the CS-UCS excitatory training trials. Since UCS-CS backward pairings are an effective inhibitory training procedure (e.g., Siegel and Domjan, 1971), it would be expected that rabbits in Group BCK would be slower to acquire the excitatory CR during the CS-UCS training period than rabbits in Group N. Rabbits in a third group (Group UCS-BCK) first received several daily sessions of UCS-alone presentations, then received the identical UCS-CS backward training as subjects in Group BCK prior to finally receiving CS-UCS excitatory training trials. It would be expected that during the UCS-alone presentations administered rabbits in Group UCS-BCK, an excitatory association would be formed between contextual stimuli and the UCS. Consequently, the UCS-CS backward conditioning trials administered rabbits in Group UCS-BCK would occur in an excitatory context. Based on the Rescorla/Wagner model of conditioning, inhibitory training given in an excitatory context should result in the acquisition of greater conditional inhibitory properties by the backward CS than if inhibitory training were adminstered in a nonexcitatory context (i.e., UCS-CS backward trials administered rabbits in Group BCK). Thus, it would be expected that rabbits in Group UCS-BCK would be slower to acquire the excitatory CR during the CS-UCS excitatory training trials than rabbits in Group BCK.

Both UCS preexposure and UCS-CS backward trials retard excitatory CR acquisition (e.g., Siegel and Domjan, 1971). Thus, it is possible that any additional retardation of excitatory conditioning evidenced by rabbits in Group UCS-BCK, compared to rabbits in Group BCK, might be due simply to the summation, or "pooling", of the independent decremental effects of UCS preexposure and UCS-CS training on excitatory conditioning. Thus, the design of the experiment included a fourth group of rabbits which received the identical number of UCS-CS backward conditioning trials and UCS prexposure sessions as rabbits in Group UCS-BCK, but in the reversed order. That is, rabbits in this fourth group (Group BCK-UCS) first received several daily sessions of UCS-CS backward conditioning trials, then received several daily sessions of UCS-alone presentations prior to finally receiving CS-UCS excitatory training trials. Since UCS-alone presentations are administered subsequent to UCS-CS backward conditioning trials to rabbits in Group BCK-UCS, any excitatory conditioning to contextual stimuli occurring during UCS preexposure in this group would not be expected to enhance inhibitory conditioning to the backward CS. Thus, the CR acquisition performance of rabbits in Group BCK-UCS during the CS-UCS excitatory training sessions of the experiment may serve to represent the combined decremental effects of both UCS preexposure and UCS-CS trials on excitatory acquisition. If, as suggested by the associative context conditioning analysis, UCS preexposure facilitates inhibitory conditioning, rabbits in Groups UCS-BCK would be expected to be slower in acquiring the excitatory CR during the CS-UCS training trials than rabbits in Group BCK-UCS.

Originally, 12 rabbits were assigned to each of the four groups in the experiment. However, one rabbit in each of Groups BCK, BCK-UCS, and UCS-BCK had to be discarded from the experiment due to illness, leaving 11 rabbits in each of these three groups.

5.5.2 Subjects. The subjects were 48 experimentally naive rabbits of the same sex, strain, weight, and age as those used in the previous experiments.

5.5.3 Apparatus. Details of the recording apparatus, shock UCS, and auditory CS were identical to those of the previous experiments.

5.5.4 Procedure. Each rabbit participated in the experiment for each of 27, daily, 60-min sessions. All experimental sessions were conducted while rabbits were individually restrained in darkened, sound-attenuated, ventilated chambers with an ambient noise level of 60 db A above 20 $\mu N/m^2$.

In the present experiment, as in the previous experiments, all rabbits were first systematically adapted to the restraint and eyelid recording apparatus during two, 60-min sessions.

For each of the 15 daily sessions following this initial adaptation period, rabbits were presented either UCS preexposure sessions, UCS-CS backward conditioning sessions, or were left undisturbed in their home cages, according to their group designation.

As described in the previous experiments, UCS preexposure sessions involved 20 UCS presentations (presented at intervals of 1.5, 3.0, or 4.5 min according to a predetermined irregular sequence, with an average interval of 3 min) during each of 10 sessions. UCS-CS backward conditioning sessions involved trials in which onset of the 600-msec CS occurred simultaneously with offset of the 100-msec shock UCS (see Siegel and Domjan, 1971, Experiment 2, 1974). There were 20 such backward conditioning trials presented during each of five daily sessions, with ITIs of 1.5, 3.0, and 4.5 min (mean: 3.0 min). Thus, rabbits in Group UCS-BCK first received 10 daily UCS preexposure sessions followed by five daily backward conditioning sessions, while rabbits in Group BCK-UCS received the five backward conditioning sessions followed by the 10 UCS preexposure sessions. During the first 10 days following the 2-day adaptation period, rabbits in Group BCK remained undisturbed in their home cages. Rabbits in Group BCK then received the five daily UCS-CS backward conditioning sessions. Finally, rabbits in Group N, which received neither UCS preexposure sessions nor UCS-CS backward conditioning sessions, were left undisturbed in their home cages for the 15-day period required for administration of UCS preexposure and backward conditioning to rabbits in Group UCS-BCK and BCK-UCS.

During the final 10 days of the experiment, all rabbits received identical, daily conditional excitatory eyelid training sessions. These conditional excitatory eyelid training sessions were conducted in a manner identical to those described for all the previous experiments: There were 20 daily trials, at an average ITI of 3 min, in which the 100-msec UCS overlapped the last 0.1 sec of the 600-msec CS.

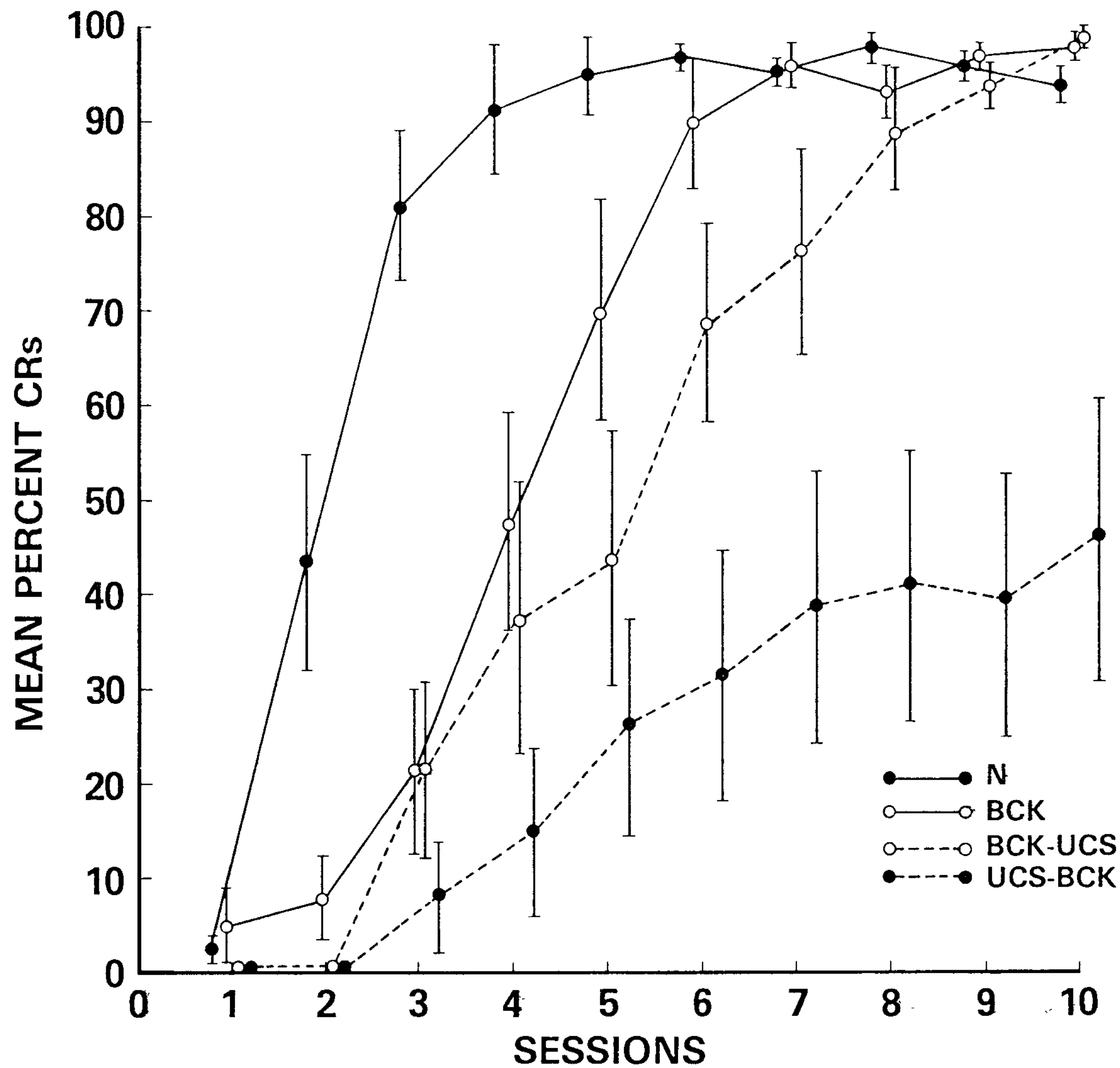
In unspecified details, the procedures of Experiment 4 were identical to those of the previous experiments.

5.6 Results

Shown in Figure 4 is the mean percentage ($\pm$ 1 SEM) of daily trials in which an eyelid response occurred during each of the 10 sessions of conditional excitatory eyelid training for all groups. As can be seen in Figure 4, subjects given experience with the conditional stimuli prior to the start of conditional excitatory eyelid training (Groups BCK, UCS-BCK, and BCK-UCS) were retarded in acquiring the conditional eyeblink response compared to subjects left undisturbed in their home cages prior to the start of CS-UCS pairings (Group N). However, it is evident from the results shown in Figure 4 that CR acquisition performance was more retarded when UCS preexposure was given prior to UCS-CS backward conditioning trials (Group UCS-BCK) than when either UCS preexposure was given subsequent to UCS-CS backward conditioning trials (Group BCK-UCS), or when only UCS-CS backward conditioning trials were administered (Group BCK).

The mean percentage ($\pm$ 1 SEM) of eyeblinks given over the total 10 days of conditional eyelid training for each group was 24.8 $\pm$ 8.9, 52.9 $\pm$ 5.8, 62.2 $\pm$ 3.7, and 80.5 $\pm$ 2.6 for Groups UCS-BCK, BCK-UCS, BCK, and N, respectively. A one-way analysis of variance of these mean percent total CR data indicated a significant overall effect of the different treatments given subjects in the different groups ($\underline{F}$=17.1,

Figure 4. Mean percentage ($\pm$ 1 SEM) of daily trials in which an eyeblink response occurred during each of the ten daily conditional eyelid training sessions in each of the different groups in Experiment 4.


100
90
80
70
60
50
40
30
20
10
0
MEAN PERCENT CRs
0
1
2
3
4
5
6
7
8
9
10
SESSIONS
N
BCK
BCK-UCS
UCS-BCK

df=3, 41, *p* < .001). Subsequent pairwise comparison analyses (Newman-Keuls' Multiple Range Tests) indicated that the CR acquisition performance of all groups was different (all *p*'s < .05), except for the performance of Groups BCK and BCK-UCS.*

Additional analyses of the results of the present experiment were not conducted, as they were for all the previous experiments, since the analysis of the CR acquisition performance of all groups over the total 10 conditioning sessions did not appear to mask differences in pre-asymptotic CR acquisition performance between groups as was the case in Experiments 1, 2, and 3 (this is accounted for in the present experiment by the fact that those groups which did reach a high level of CR performance did not do so until near the end of training).

5.7 Discussion

5.7.1 Backward Conditioning as an Inhibitory Procedure. The finding in the present experiment that excitatory CR acquisition was retarded in rabbits given preconditioning experience with the UCS and CS in a backward conditioning manner (Group BCK) replicates previous findings in the rabbit eyelid conditioning preparation (Plotkin and Oakley, 1975; Siegel and Domjan, 1971, Experiment 2, 1974), and a variety of

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* The overall analysis did not indicate a difference between Groups BCK and BCK-UCS. However, since the mean daily CR acquisition performance of Group BCK-UCS was lower than that of Group BCK over all 10 conditioning sessions, an analysis (t-test) of these two groups' overall CR data was conducted to ensure that any difference between these two groups was not being obscured in the reported analysis. The results of this analysis, which is liberal with regard to false positives, did not indicate a difference. Thus, it is safe to conclude that the CR acquisition performance of Groups BCK and BCK-UCS is, in fact, not different.

other conditioning preparations (Heth, 1976; Siegel and Domjan, 1971, Experiment 1, 1974).

5.7.2 UCS Preexposure, Backward Conditioning and Excitatory CR Acquisition. The results of the present experiment also demonstrate that UCS preexposure in combination with UCS-CS backward conditioning trials retards excitatory CR acquisition more than UCS-CS backward conditioning trials alone if UCS preexposure is administered prior to UCS-CS backward training: Group UCS-BCK was slower to acquire the conditional eyeblink response than Group BCK. However, if UCS preexposure is administered sbusequent to UCS-CS backward training, CR acquisition is not significantly slower than if only UCS-CS backward training is given: Group BCK-UCS was not significantly slower to acquire the conditional eyelid response than Group BCK. Since both UCS preexposure and UCS-CS backward training independently retard excitatory CR acquisition, it might have been expected that Group BCK-UCS would have been slower to acquire the excitatory CR than Group BCK. The failure to find a significant difference in the CR acquisition performance of Groups BCK and BCK-UCS in the present experment may indicate that the independent decremental effects of UCS preexposure and UCS-CS backward training on excitatory conditioning do not summate in a simple linear fashion, but instead interact in such a way as to produce less of an effect when combined than would be anticipated on the basis of the independent effects of each procedure alone. However, the difference in CR acquisition performance between Groups UCS-BCK and BCK-UCS in the present experiment demonstrates that under certain conditions (i.e., when UCS preexposure precedes UCS-CS backward training), UCS preexposure can enhance the inhibitory effect of backward conditioning.

5.7.3 UCS Preexposure and Facilitation of Inhibitory Conditioning: Implications for Theories of UCS Preexposure. The finding that Group UCS-BCK was more retarded in CR acquisition than either Group BCK-UCS or Group BCK is expected on the basis of the associative, context blocking interpretation of UCS preexposure. According to the context blocking analysis, the backward-paired CS acquires greater conditional inhibitory properties in Group UCS-BCK than in either Group BCK-UCS or Group BCK because UCS preexposure prior to the start of UCS-CS backward pairings makes the contextual stimuli in which UCS-CS backward pairings occur excitatory (see Rescorla, 1970, p. 370). The greater retardation of excitatory CR acquisition obtained in Group UCS-BCK compared to Groups BCK-UCS and BCK suggests that greater conditional inhibitory properties were, in fact, acquired by the backward CS in the former group than in either of the latter two groups. Thus, the finding in the present experiment that UCS preexposure may facilitate the acquisition of conditional inhibition in a backward conditioning procedure provides additional evidence in support of the proposal that during a period of UCS preexposure an excitatory association is formed between contextual stimuli and the UCS. Whereas, in the case where excitatory training trials are administered subsequent to the period of UCS preexposure, learning is retarded, in the present experiment, where inhibitory training trials are administered subsequent to UCS preexposure, learning is facilitated. This asymmetry in the effects of UCS preexposure on subsequent learning is expected on the basis of the associative, context conditioning analysis of UCS preexposure, but is difficult to reconcile with any of the traditional nonassociative accounts of UCS preexposure (e.g., Macdonald, 1946; Taylor, 1956).

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Modulation of the UCS Preexposure Effect in Excitatory Conditioning by Manipulations of Contextual Stimuli

Experience with the UCS prior to its pairing with the CS retards CR acquisition in a variety of excitatory conditioning preparations--the phenomenon being termed the UCS preexposure effect. The results of experiments 1, 2, and 3 of the present thesis demonstrate that the UCS preexposure effect is modulated by manipulations of contextual stimuli of the preexposure environment. The results of Experiment 1 demonstrate that the UCS preexposure effect is most pronounced when CS-UCS excitatory training trials are administered in the same context in which UCS preexposure occurs. The results of Experiment 2 demonstrate that the UCS preexposure effect is attenuated if the preexposure environment is presented without the UCS on several occasions prior to the start of UCS preexposure sessions. And the results of Experiment 3 demonstrate that the UCS preexposure effect is reduced if the preexposure environment is presented nonreinforced by the UCS on several occasions following the period of UCS preexposure.

6.2 The Effect of UCS Preexposure on Inhibitory Conditioning.

Although the decremental effect of UCS preexposure on excitatory conditioning is well-documented (see Randich and LoLordo, 1979b, for a review), there are no reports of the effect of UCS preexposure on inhibitory conditioning. In Experiment 4, the effect of UCS preexposure on the acquisition of conditional inhibition in the backward conditioning procedure was examined. The results of Experiment 4 demonstrate that UCS preexposure administered prior to UCS-CS backward conditioning trials facilitates the acquisition of conditional inhibition by the backward CS.

6.3 Implications of the Present Results for Theories of UCS Preexposure

6.3.1 Traditional, Nonassociative Theories.

Traditional, non-associative theories of UCS preexposure (e.g., Macdonald, 1946; Taylor, 1956; Randich and LoLordo, 1979a) suggest that the relevant effect of preconditioning experience with the UCS is to reduce the organism's reactivity to the UCS. All such nonassociative theories are similar in stipulating that such reduced reactivity to the UCS is solely the result of the number of UCS presentations. The results of Experiments 1, 2, and 3 of the present thesis, however, demonstate that animals given identical UCS preexposure experience do not evidence the same magnitude UCS preexposure effect. Instead, the results of these experiments demonstrate that contextual stimuli of the UCS preexposure environment play a crucial role in determining the magnitude of the UCS preexposure effect in excitatory conditioning. Traditional, nonassociative accounts of UCS preexposure, which assign no role to contextual stimuli, offer no explanation for the influence of contextual stimuli in mediating the UCS preexposure effect demonstrated in these experiments.

If the relevant effect of UCS preexposure were simply to reduce the organism's reactivity to the UCS, it would be expected that UCS preexposure should have a similar effect on both excitatory and inhibitory learning. The results of Experiment 4 demonstrate, however, that, in contrast to the decremental effect that UCS preexposure has on excitatory learning, UCS preexposure exerts a facilitatory effect on inhibitory learning. This asymmetry in the effect of UCS preexposure on excitatory and inhibitory learning is not accounted for by traditional, nonassociative interpretations of UCS preexposure.

6.3.2 The Associative, Context Conditioning Theory. Recently, an associative theory of UCS preexposure has been suggested (e.g., Batson and Best, 1979; Mis and Moore, 1973; Tomie, 1976 a,b; Willner, 1978; Tomie, Murphy, and Fath, 1980). According to this associative interpretation of UCS preexposure, an excitatory association is formed between the UCS and contextual stimuli of the preexposure environment during UCS preexposure. This excitatory association is hypothesized to mediate the effects of UCS preexposure on subsequent learning.

In the case of excitatory learning, the excitatory association to contextual stimuli would be expected to retard CR acquisition by "blocking" conditioning to the nominal CS in a manner similar to that which occurs in the typical blocking procedure (e.g., Kamin, 1968, 1969). Furthermore, it would be expected that the degree to which UCS preexposure retards excitatory learning would be modulated by the strength of the excitatory association to contextual stimuli. The results of the first three experiments of the present thesis are consistent with this expectation, demonstrating that the decremental effect of UCS preexposure on excitatory conditioning is attenuated by several associative manipulations of contextual stimuli designed to reduce the strength of any excitatory association to contextual stimuli formed during UCS preexposure.

Although an excitatory association to contextual stimuli would be expected to retard excitatory learning, the opposite effect would be predicted in the case of inhibitory learning. That is, it has been suggested that inhibitory learning occurs more rapidly in an excitatory context. Based on the associative account of UCS preexposure, UCS preexposure would be expected to facilitate inhibitory learning. The results of Experiment 4 confirm the predicted facilitatory effect of UCS preexposure on inhibitory learning.

6.3.3 UCS Preexposure: Associative and Nonassociative Influences.

The results of the present experiments clearly demonstrate that associative factors play an important role in the effects of UCS preexposure on excitatory and inhibitory rabbit eyelid conditioning. However, some results of the present experiments may indicate that other factors [e.g., nonassociative processes (see Randich & LoLordo, 1979b), learned helplessness (Maier & Seligman, 1976)] also contribute to the effects of preconditioning UCS experience on subsequent learning. Thus, in Experiments 1, 2, and 3 the associative manipulations of contextual stimuli, although attenuating to a great extent the effects of UCS preexposure, did not totally eliminate the effects of UCS preexposure. It is possible that the effects of UCS preexposure surviving the associative procedures employed in these experiments results simply from insufficient training with the associative manipulations (e.g., not enough extinction trials in Experiment 3). Alternatively, the effects of UCS prexposure still evident following the associative manipulations used in Experiment 1, 2, and 3 to attenuate contextual conditioning may indicate that factors other than associative processes contribute to UCS preexposure effects. The results of some studies (e.g., Randich & LoLordo, 1979a; Cannon, Berman, Baker, and Atkinson, 1975) do, in fact, suggest that nonassociative factors may contribute to the effects of UCS preexposure in other preparations. Thus, it is possible that both associative and nonassociative factors contribute to the effects of UCS preexposure in rabbit eyelid conditioning.

6.4 The Role of Contextual Stimuli in Other Preconditioning Procedures which Retard Excitatory Conditioning.

The results of the present experiments, indicating a crucial role of contextual stimuli in mediating the UCS preexposure effect, are consistent with an emerging body of empirical and theoretical literature emphasising the importance of contextual stimuli in mediating a variety of learning phenomena. The results of several experiments demonstrate that contextual stimuli play a crucial role in other preconditioning stimulus exposure operations that, like UCS preexposure, retard subsequent learning.

6.4.1 The Role of Contextual Stimuli in Latent Inhibition.

Preexposure to the CS prior to its pairings with the UCS retards subsequent conditioning (see Lubow, 1973, and Siegel, 1972, for reviews) -- the effect being termed "latent inhibition" (Lubow and Moore, 1959). Consistent with the results of Experiment 1 of the present thesis, the results of several studies (Anderson, Merrill, Dexter, and Alleman, Note 4; Anderson, O'Farrell, Fomica, and Caponigri, 1969; Anderson, Wolf, and Sullivan, 1969; Lantz, 1973; Lubow, Rifkin, and Alek, 1976) demonstrate that latent inhibition is significantly less pronounced when CS preexposure is administered in a context different from the one in which CS-UCS pairings are administered. It has been suggested (Wagner, 1975) that the context specificity of the CS preexposure effect may result from factors similar to those suggested by the associative, context conditioning analysis to underlie the context specificity of the UCS preexposure effect--namely, a conditional association between the preexposed stimulus and contextual stimuli. If the decremental effect of CS preexposure on subsequent learning is mediated by a contextual association, it should be possible to attenuate the CS preexposure effect by the manipulations used to attenuate the UCS preexposure effect in Experiments 2 and 3 of the present thesis, i.e., preexposure to contextual stimuli, and extinction of contextual stimuli. There are, at present, no data available concerning the attenuation of latent inhibition by these associative manipulations of contextual stimuli.

6.4.2 Truly Random Presentations of the CS and UCS. Another preconditioning stimulus exposure operation which retards subsequent conditioning involves "truly random" presentations of the CS and UCS (see Rescorla, 1967, 1969). In the truly random procedure, the CS and UCS are presented independently of each other, such that the probability of UCS occurrence conditionalized on CS presence is equal to the probability of UCS occurrence conditionalized on CS absence. Preconditioning exposure to the CS and UCS in a truly random procedure retards subsequent CR acquisition in a variety of conditioning preparations (Baker and Mackintosh, 1979; Benedict and Ayres, 1972; Kremer, 1971, 1974; Kremer and Kamin, 1971; Mackintosh, 1973; Quinsey, 1971; Siegel and Domjan, 1971; Tomie, 1976 a,b). As originally formulated (Rescorla, 1967, 1969), conditioning to contextual stimuli was envisioned to play a crucial role in the effect of truly random presentations of the CS and UCS (see Rescorla and Wagner, 1972). The results of several experiments, in fact, provide evidence that conditioning to contextual stimuli is involved in the decremental effect of preconditioning random CS/UCS presentations on subsequent conditioning. Like the decremental effect of UCS, and CS, preexposure on subsequent conditioning, the decremental effect of random CS/UCS preexposure is attenuated if contextual stimuli are altered between preexposure and the initiation of CS-UCS pairings (Tomie, 1976a, Experiment 1, 1976b; Tomie, Murphy, and Fath, 1980). It has been suggested (Tomie, 1976 a,b) that the context specificity of the decremental effect of random CS/UCS preexposure indicates that a contextual association may, in part, underlie the phenomenon. The results of other experiments provide further evidence in support of the proposal that the decremental effect of random CS/UCS preexposure is dependent on contextual conditioning. These experiments demonstrate that the decremental effect of preconditioning random experience with the conditioning stimuli is extinguishable (Dweck and Wanger, 1970; Tomie, 1976, Experiment 2; see also Sheafor, 1975, Experiment 2). Although other factors may be involved in the decremental effect of preconditioning random experience with the CS and UCS (e.g., Baker and Mackintosh, 1979; Baker and Mackintosh, 1977; Mackintosh, 1973) the finding that the effect is (1) context specific and (2) extinguishable, clearly indicates a role for associative processes involving contextual stimuli in mediating the phenomenon.

6.5 Conditioning to Contextual Stimuli and UCS Exposure Subsequent to Conditioning

With the exception of Experiment 4, the experiments of this thesis have examined the effect of UCS exposure administered prior to the initiation of excitatory, CS-UCS pairings. Recently, studies have appeared concerned with the effect of UCS exposure administered subsequent to a period of CS-UCS pairings. Results of some of these experiments suggest that conditioning to contextual stimuli plays a role in the effects of postconditioning UCS exposure similar to the role of contextual conditioning in the effects of preconditioning UCS exposure demonstrated in the present experiments.

One of the effects of UCS postconditioning exposure involves what is termed the "reinstatement" of fear (Rescorla and Heth, 1975). In the reinstatement experiment, animals first receive CS-UCS pairings resulting in CR acquisition. Following this CR acquisition training, animals receive CS-alone extinction trials sufficient to eliminate conditional responding. Next, some animals receive UCS-alone presentations, while other animals receive no treatment. Finally, all animals are presented the CS to test for conditional responding. The important outcome of the reinstatement experiment is that animals given UCS exposure subsequent to extinction trials evidence a recovery, or "reinstatement", of the previously extinguished response. However, animals given no UCS exposure subsequent to extinction trials, continue to show no conditional responding. The recovery of extinguished conditional responding by post-extinction UCS exposure has been attributed to a "revitilization" of the UCS memory which is presumably weakened during extinction trials (e.g., Rescorla and Heth, 1975). Although processes such as revitilization of the UCS memory may play a role in the reinstatement phenomenon, the results of a recent series of experiments (Bouton and Bolles, 1979) demonstrate that conditioning to contextual stimuli during the period of post-extinction UCS exposure is also involved. In these experiments, reinstatement of conditional responding was effected only if post-extinction UCS exposure was administered in the same context in which testing for recovery of conditional responding was subsequently administered. Furthermore, the ability of post-extinction UCS exposure to promote a recovery of extinguished conditional responding was abolished by nonreinforced exposure of contextual stimuli following such UCS exposure--that is, the reinstatement effect was extinguishable. These results demonstrate the importance of contextual stmiuli in the reinstatement effect, and suggest a role of contextual conditioning in the effects of post-conditioning UCS exposure similar to the role of contextual conditioning in preconditioning UCS exposure demonstrated in the experiments of the present thesis.

6.6 Conclusion

The purpose of the present thesis was to determine whether the effects of UCS preexposure in rabbit eyelid conditioning result, at least in part, from associative processes involving contextual stimuli. To this end, Experiments 1, 2, and 3 investigated the effects of various associative manipulations of contextual stimuli on the UCS preexposure effect in excitatory conditioning. The results of these experiments clearly demonstrate an associative influence involving contextual stimuli on the UCS preexposure effect in rabbit eyelid conditioning. A final experiment then provided further evidence for the associative basis of UCS preexposure by confirming the prediction, derived uniquely from a contextual conditioning analysis, that UCS preexposure should facilitate inhibitory learning. The results of the experiments comprising the present thesis thus clearly establish that associative processes involving conditioning to contextual stimuli influence the effect of UCS preexposure in rabbit eyelid conditioning.

Results of other studies have also been discussed which demonstrate that conditioning to contextual stimuli plays a role in the effects of UCS preexposure in other conditioning preparations, in other preconditioning stimulus exposure procedures that, like UCS preexposure, retard excitatory conditioning, and in the effects of UCS postconditioning exposure, an area of contemporary research interest. These results serve to highlight the generality of contextual conditioning, and to emphasize the potential role of such conditioning in mediating a variety of effects in classical conditioning involving exposure to the CS and/or UCS.

It should also be recalled, however, that results of studies were discussed which suggest that nonassociative processes are also involved in the effects of UCS exposure under certain conditions and in certain learning situations. These findings, taken in conjunction with findings indicating a role of associative processes in the effects of UCS exposure, point out the need for further studies designed to elucidate the conditions under which the relative influence of associative and nonassociative processes vary.

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