



Shorter communication

## Conducting exposure treatment in multiple contexts can prevent relapse

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**Abstract**

The acquisition of anxiety disorders (e.g., phobias) is often thought to be mediated by classical conditioning processes (e.g., Wolpe, 1958, *Psychotherapy by reciprocal inhibition* Wolpe and Rowan, 1989, *Behaviour Research and Therapy*, 27, 583–585). Thus, the success of exposure therapy is possibly a consequence of extinction, and factors affecting extinction in Pavlovian conditioning are potentially relevant to clinicians who administer exposure therapy. The present experiments investigated the effects of conducting extinction in multiple contexts using rats as subjects in a conditioned suppression paradigm. In Experiment 1, subjects received conditioned stimulus (CS) and unconditioned stimulus (US) pairings in one context followed by extinction of that CS in one or three other contexts. When tested in an associatively neutral context (i.e., different from those of conditioning or extinction), rats that had received extinction in three contexts exhibited less responding to the CS than rats that had received extinction in one context. In Experiment 2, CS–US training occurred in either one or three contexts, followed by extinction of that CS in three other contexts. Testing in a neutral context revealed that rats conditioned in multiple contexts showed greater responding to the CS than rats trained in a single context. The results are discussed in the framework of memory retrieval, and the clinical implications are explored.

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*Key words:* Classical conditioning, Contextual associations, Exposure therapy, Extinction (learning), Phobias, Relapse, Renewal

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**1. Introduction**

Wolpe (1958; but see Rachman, 1977, for a critical review) first proposed that certain anxiety disorders (e.g. phobias) are at least in part acquired through the classical conditioning of

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initially neutral stimuli that were subsequently paired with a fear-inducing event. Consistent with this view, such learned fears are thought to be subject to extinction by exposing the individual to non-reinforced presentations of the feared stimulus (e.g. Marks, 1978). Such psychological (as opposed to pharmacological) therapies have been shown to be quite successful in the treatment of anxiety disorders. Margraf et al. (1993) reviewed the effectiveness of interoceptive exposure (i.e. exposure to bodily sensations typically experienced during fear situations, e.g. through hyperventilation or exercise), exteroceptive exposure (i.e. exposure to feared situations), and cognitive therapies (i.e. reattribution of anxiety symptoms), and found them collectively to be nearly as effective as contemporary pharmacological treatments (e.g. administration of benzodiazepines). Margraf et al. (1993) recommended further research aimed at investigating the factors involved in making such therapies successful. The present research explored the role of context in determining resistance to relapse following exteroceptive exposure treatment using rats as subjects.

Context (i.e. background cues) has long been known to play a vital role in modulating acquired behavior. Researchers in many psychological subfields (e.g. learning, memory, drug addiction) deem contextual cues to be important in their studies. The list of situations in which context has been shown to be relevant is long indeed. For instance, Smith et al. (1978) demonstrated that recall for word lists is best when testing is conducted in the same surroundings in which training took place. Similarly, with non-human animal Ss, Riccio and his colleagues have reported numerous instances in which performance was attenuated by a change of context between training and testing (see Riccio et al., 1984, for a review). Evidence for the effect of mood state on memory in humans (e.g. Bower, 1981; Schare et al., 1984; but see Bower and Mayer, 1985) indicates that differences in internal emotional state between training and testing can have dramatic effects on performance. Furthermore, studies of state-dependent retention have found that information acquired in one drug-induced state often does not transfer to a different drug-induced state (e.g. Overton, 1978, 1985). Thus, internal as well as external context appears to be critical to the retrieval and expression of acquired behavior in many situations.

Bouton and his colleagues have extensively studied the effects of external context upon the extinction of Pavlovian conditioning. Bouton and Bolles (1979) first demonstrated what is today termed the 'renewal effect'. They exposed rats to aversive excitatory conditioning with a conditioned stimulus (CS) and footshock unconditioned (US) in one context, and then gave their Ss extensive no-reinforced exposure to that CS (i.e. extinction) in a different context. Subsequent responding to the extinguished CS was strongly modulated by the context in which testing was conducted. Specifically, Ss showed excitatory (i.e. 'renewal of') conditioned responding to the CS when they were tested in the original training context, and poor conditioned responding to the stimulus when they were tested in the context that had been used for extinction. This effect has since been replicated within a variety of different experimental procedures, and has also been shown not to be a result of the summation of the associative value of the CS with the associative value of the training context (i.e. context-US associations; Bouton and King, 1983). The 'renewal effect' has been applied to a wide variety of situations from appetitive Pavlovian conditioning (Bouton and Peck, 1989) to the extinction of fear stimuli under the influence of benzodiazepine tranquilizers (Bouton et al., 1990). Thus, the effect

appears to be highly reliable across different procedures and the types of contexts that are used.

Most relevant to the present issue, Bouton (1988; see also Bouton and Swartzentruber, 1991) has also applied his findings concerning the importance of contextual information to the clinical setting (also see Kehoe and Macrae, 1997, for a review concerning the relevance of 'savings' in animal learning to the clinical setting). He contends that those therapists using extinction (i.e. exposure) techniques as a treatment for various psychological disorders (e.g. anxiety disorders and phobias) should be aware of the renewal effect and related contemporary findings in Pavlovian conditioning. For example, the renewal effect is known to arise from extinction being more context-specific than is excitatory conditioning which generalizes relatively easily to contexts other than the training context. After excitatory training of a CS in one context (denoted A), and extinction of that CS in a second context (denoted B), Bouton and Bolles (1979) tested the excitatory properties of the CS, not only in Contexts A and B, but also in a third, associatively neutral context (denoted C). They observed excitatory responding (i.e. renewal) in Context C, and concluded from this ABC procedure that excitation generalizes more readily to a neutral context than does extinction. An even more compelling demonstration of the context-specificity of extinction treatment was reported by Bouton and Ricker (1994). They exposed rats to excitation training with a stimulus in one context (i.e. A), and subsequently extinguished that stimulus in the same context (A). When that stimulus was subsequently tested in a second context (i.e. B), they again observed renewal of excitatory responding despite the absence of responding to the CS in Context A. This AAB renewal effect was obtained even when *Ss* were equally exposed to the two contexts, and when the contexts were equated for the overall probability of any CS being reinforced and non-reinforced within them.

The results of Bouton and Bolles (1979) and Bouton and Ricker (1994) have important implications for clinicians who use exposure therapy in the treatment of various disorders (e.g. phobias). For instance, Bouton (1988) has suggested that in the ABC procedure, *Ss* do not learn that the stimulus is safe after the extinction manipulation, but rather they learn that the stimulus is safe only in Context B. Hence, relapse from extinction of a dysfunctional association can be expected outside the environment in which extinction occurred. Qualifying this expectation, we speculated that exposing *Ss* to non-reinforced presentations of the excitatory stimulus (i.e. extinction) in many contexts might provide the *S* with a more general knowledge that the CS will be non-reinforced not only in the extinction context, but in any context.

Beyond suggesting that therapeutic extinction manipulations are constrained to the context in which they are conducted, Bouton (1988; also see Bouton and Swartzentruber, 1991) made several suggestions concerning potential means of preventing relapse following extinction treatment. One such suggestion was that in order to minimize renewal of conditioned fear, therapists should conduct exposure therapy sessions in a context as similar as possible to the context in which the fear was acquired (see Bouton and King, 1983, for experimental evidence of this effect with rats as *Ss*). However, this invites the renewal of fear seen with the AAB design, as reported by Bouton and Ricker (1994). Thus, rather than give extinction treatment in a context similar to that in which the dysfunctional association was acquired, there may be greater efficacy in minimizing relapse by conducting exposure therapy sessions in multiple settings. This treatment might provide the client with the view that the fear-inducing stimulus is now safe 'everywhere'.

## 2. Experiment 1

This experiment sought to test our hypothesis that extinction in multiple contexts would prevent generalization of excitation (i.e. relapse, in clinical terms) to a neutral context. All *Ss* received excitatory conditioning with a stimulus (i.e. CS–US) in Context A. *Ss* were then assigned to one of three conditions with respect to the number of contexts in which they received extinction of the CS (i.e. CS alone). Group No Extinction (NE) received no extinction of the CS, Group Extinction-1 (E1) received extinction of the CS in one context (Context B), and Group Extinction-3 (E3) received extinction of the CS comparable in total number of extinction trials to that of Group E1 but divided among three distinct contexts (Contexts B, C and D). Finally, all *Ss* were tested for conditioned responding to the CS in a neutral context (Context E). We predicted that Group E3 would respond less to the CS in Context E than would either Group E1 or Group NE.

### 2.1. Method

#### 2.1.1. Subjects

The *Ss* were 36 naive, 80–120-day-old, male and female rats of Sprague-Dawley descent. The animals were bred in our colony from Holtzman stock. Body weight ranges were 185–245 g for females and 275–360 g for males. Each animal was assigned to one of three groups, counterbalanced for sex ( $ns = 12$ ). All animals were individually housed in wire-mesh cages in a vivarium that was maintained on a 16-hr light/8-hr dark cycle. Experimental manipulations occurred near the midpoint of the light portion of this cycle. Purina Laboratory Chow was freely available in the home cages. One week prior to the initiation of the study, access to water in the home cage was gradually reduced to 10 min/day, which occurred 18–22 hr prior to any treatment scheduled for the following day. All *Ss* were handled three times per week for 30 sec, from the time of weaning until the initiation of the study.

#### 2.1.2. Apparatus

Twenty-four experimental chambers, of three different types, were used. These chambers had clear Plexiglas side walls and ceilings, and sheet metal front and back walls. Type 1 chambers were roughly cubic and measured  $30.5 \times 27.5 \times 27.3$  cm ( $l \times w \times h$ ). The floor of these chambers consisted of 4-mm diameter stainless steel rods spaced 1.7 cm center-to-center, connected through NE-2 neon bulbs, which allowed constant-current footshock to be delivered by means of a high voltage AC circuit in series with a 1.0-MW resistor. A 25-W (nominal at 120 VAC) incandescent flashing light (operated at 50 VAC) was mounted above the clear ceiling of the chamber, 30 cm from the center of the chamber floor, and could be presented at a rate of 0.2 sec on/0.2 sec off. These chambers were otherwise dimly illuminated by a no. 1820 light bulb. This houselight bulb was mounted on an inside wall of the chamber approximately 14 cm from the center of the animal chamber floor. Each of 12 copies of Chamber 1 was enclosed in a separate sound- and light-attenuating environmental isolation chest.

Type 2 chambers were clear, narrow rectangular, Plexiglas cubicles  $22.75 \times 8.25 \times 13.0$  cm ( $l \times w \times h$ ) with a floor constructed of 4.8-mm diameter stainless steel rods spaced 1.5 cm center-to-center, connected by NE-2 neons, which allowed constant-current footshock to be deliv-

ered in the same manner as in Type 1 chambers. Type 2 chambers were dimly illuminated by a 2-W (nominal at 120 VAC) incandescent houselight bulb driven at 56 VAC, mounted on an inside wall of the isolation chest approximately 30 cm from the center of the floor of the animal enclosure. Each of six copies of Chamber 2 was enclosed in its own environmental enclosure.

Type 3 chambers were 25.5 cm long boxes in the shape of a vertical truncated-V (28 cm high, 21 cm wide at top, 5.25 cm wide at bottom). The sloping walls were constructed of stainless steel plates, and the ceiling was made of clear Plexiglas. The floor consisted of two parallel stainless steel plates each 2 cm wide with a centered 1.25-cm gap between them. Constant-current footshock could be delivered to the floor and walls. Type 3 chambers were dimly illuminated by a 7-W (nominal at 120 VAC) bulb driven at 56 VAC mounted on an interior wall of the isolation chest approximately 30 cm from the center of the floor of the animal enclosure. Light entering the enclosure was primarily reflected from the roof of the environmental chest. Each of six copies of Chamber 3 was enclosed in its own environmental isolation chest.

Each copy of Chamber 1 could be equipped with a water-filled lick tube that protruded 1.5 cm forward from the rear of a cylindrical drinking niche at the bottom of one wall (axis perpendicular to the wall). Each niche was 5.5 cm in depth, 3.5 cm in diameter, and was centered on a short wall of the chamber, with its axis 6.5 cm above the chamber floor. An infrared photobeam was projected horizontally across the recess approximately 0.5 cm in front of the tip of the lick tube. Both Chambers 2 and 3 were also equipped with water-filled lick tubes. In both types of chambers, these projected forward 1 cm from the rear of a cylindrical niche that was 5.0 cm deep, 4.5 cm in diameter, and left–right centered with its bottom 1.75 cm above the floor of the apparatus. An infrared photobeam detector was projected horizontally 1 cm in front of the lick tube. In order to drink from the lick tube in any chamber type, Ss had to insert their heads into the niche, thereby interrupting the photobeam. Thus, the times during which the Ss accessed the lick tube could be recorded.

In all chambers, background noise, mostly from a ventilation fan, was 74 dB(C) re. SPL. A 45-W speaker mounted on the interior back side of each environmental chest could deliver a white noise stimulus approximately 8 dB(C) above the ambient background that served as the CS. The white noise CS was of 10 sec duration during training, and the US was a 1.0-mA footshock, 0.5 sec in duration, that occurred on reinforced trials during the last 0.5 sec of the CS.

Five physical contexts were used in this study, one for conditioning (Context A), three for extinction (Contexts B, C and D), and one for testing (Context E). Context A consisted of animals being placed into an instance of Chamber 1 with both the houselight and flashing light turned off. To further differentiate Context A from the other contexts, an odor cue was added. This was achieved by daily placing one drop of 98% methyl salicylate onto a small block of wood located inside the isolation chest. The physical contexts that served as Context B, C and D (the extinction contexts) were counterbalanced within groups. Thus, the three different contexts that constituted Contexts B, C and D were as follows: (1) a different instance of Chamber 1 than was used as Context A, but with the houselight on, flashing light off, and odor absent; (2) an instance of Chamber 2 or 3 with both the houselight and flashing light off and odor absent; and (3) an instance of Chamber 3 or 2 [the opposite type chamber from that used for (2) above] with the houselight on, flashing light off, and no odor cue present. Finally, Context E consisted of yet another instance of Chamber 1, but with the flashing light cycling throughout the session, the houselight off, and no odor cue present. Context E was further differen-

tiated from the other contexts by the insertion of a clear, Plexiglas floorplate that covered the grid floor.

### 2.1.3. Procedure

The design of Experiment 1 is illustrated in Table 1.

*2.1.3.1. Acclimation.* All Ss were acclimated to their versions of Contexts A, B, C, D and E on Days 1 or 2. Session durations were 30 min and all Ss had access to water-filled lick tubes in all contexts. On Day 1, half of the Ss in each group were exposed to Context A, then Context B, and finally Context C, while the remaining half of the Ss were exposed to Context B, then Context C, and finally Context A. On Day 2, half of the Ss in each group were exposed to Context D followed by exposure to Context E, while the remaining half of the Ss were exposed to Context E followed by exposure to Context D. The average intersession interval, which was spent in the home cage, was 60 min.

*2.1.3.2. Conditioning.* Prior to the conditioning phase, lick tubes were removed from all chambers. On Days 3 and 4, during a 60-min daily session, all Ss received four daily reinforced presentations of the 10-sec CS in Context A. Trials occurred at 5, 16, 26 and 42 min into each session.

*2.1.3.3. Extinction.* Group E3 received non-reinforced exposure to the CS (i.e. extinction treatment) in Contexts B, C and D; Group E1 received non-reinforced exposure to the CS in Context B only; and Group NE received no extinction of the CS. All Ss received equivalent exposure to each of Contexts B, C and D, and Ss in Groups E3 and E1 received the same total number (162) of extinction trials. Extinction sessions consisted of 54 10-sec, non-reinforced presentations of the CS per day in the appropriate context. Context exposure sessions consisted of simply providing the S with exposure to the appropriate context without presentation of the CS. All sessions were 2.25 hr in duration. Thus, the extinction phase was conducted as follows. Group NE received exposure to Context B on Days 5, 8 and 11, Context C on Days 6, 9 and 12, and Context D on Days 7, 10 and 13. Group E1 experienced extinction treatment with the CS in Context B on Days 5, 8 and 11, as well as comparable exposure to Context C on Days 6, 9 and 12, and comparable exposure to Context D on Days 7, 10 and 13 without any presentations of the CS. Group E3 experienced extinction treatment with the CS in Context B on

Table 1  
Design of Experiment 1

Group	Training	Extinction	Testing
NE	(CS-US) <sub>A</sub>	(—) <sub>B</sub> and (—) <sub>C</sub> and (—) <sub>D</sub>	(CS) <sub>E</sub>
E1	(CS-US) <sub>A</sub>	(CS) <sub>B</sub> and (—) <sub>C</sub> and (—) <sub>D</sub>	(CS) <sub>E</sub>
E3	(CS-US) <sub>A</sub>	(CS) <sub>B</sub> and (CS) <sub>C</sub> and (CS) <sub>D</sub>	(CS) <sub>E</sub>

*Note:* A, B, C, D and E were distinctive contexts, the CS was a white noise, US represents the footshock unconditioned stimulus, and — represents no stimulus presentations. Groups E1 and E3 received the same total number of non-reinforced CS (extinction) trials.

Day 5, in Context C on Day 8, and in Context D on Day 11. Group E3 also received comparable exposure to Context B on Days 9 and 13, Context C on Days 6 and 12, and Context D on Days 7 and 10, all without presentations of the CS.

*2.1.3.4. Reacclimation.* Following the extinction phase, lick tubes were reinserted into the experimental chambers. On Day 14, all *Ss* were reacclimated to Context E during a 60-min session to reestablish a steady rate of drinking prior to testing in this associatively neutral context.

*2.1.3.5. Testing.* On Day 15, all *Ss* were tested for conditioned suppression of ongoing drinking behavior in the presence of the CS in Context E. Each *S* was placed into the appropriate experimental chamber and, immediately upon completion of 5 cumulative seconds of licking, the CS was presented to each *S* for 15 min. Thus, each *S* was drinking at the time of CS onset. The time to complete an additional 5 sec of licking in the presence of the CS was recorded, with a 15-min maximum time being imposed.

Suppression times of this sort ordinarily yield within-group distributions with strong positive skewness. In order to better approximate a normal distribution and thereby justify the use of parametric statistics, a log (base 10) transformation was performed on each suppression score. An alpha level of 0.05 was adopted for all tests of statistical significance. One *S* from Group NE was eliminated from the subsequent analyses due to experimental error during testing.

## 2.2. Results and discussion

The present experiment demonstrated that *Ss* exposed to extinction treatment in three contexts are more likely to show behavior indicative of extinction when tested in a neutral context than are *Ss* given a comparable number of extinction trials in a single context.

First, the times to complete an initial 5 cumulative seconds of drinking prior to CS onset on Day 15 were analyzed. A one-way analysis of variance (Group: NE, E1 or E3) detected no effect of group,  $F < 1$ . Moreover, no *S* took more than 60 sec to complete its initial 5 cumulative seconds of drinking. Thus, the groups showed little and equivalent fear of the test context.

Next, the times to complete 5 cumulative seconds of drinking after CS onset on Day 15 were analyzed. These suppression times revealed an effect of Group,  $F(2,32) = 32.88$ ,  $P < 0.001$ . Planned comparisons were then conducted to assess specific group differences. Group E1 suppressed more to the CS than did Group E3,  $F(1,32) = 27.24$ ,  $P < 0.001$ , demonstrating that behavior indicative of extinction generalized to the neutral test context more readily for Group E3 than for Group E1 (Fig. 1). Moreover, Group NE suppressed more to the CS than did Group E1,  $F(1,32) = 8.18$ ,  $P < 0.01$ , suggesting that although excitatory responding was seen to the CS in Group E1, there was some reduction in responding to the CS as a result of the extinction treatment (i.e. 'renewal' of conditioned responding in a neutral context after training in one context and extinction in a second context was not complete). Prior research with similar parameters found that rats tested in the context in which extinction treatment occurred yielded a mean score of approximately 0.85 log sec (Grahame et al., 1990). Thus, to the extent that cross-experiment comparisons are meaningful, compared to such a control (which was absent in the present study), we see that Group E3 displayed a tendency toward more suppression. This suggests that, although extinction in three contexts greatly reduced the renewal effect

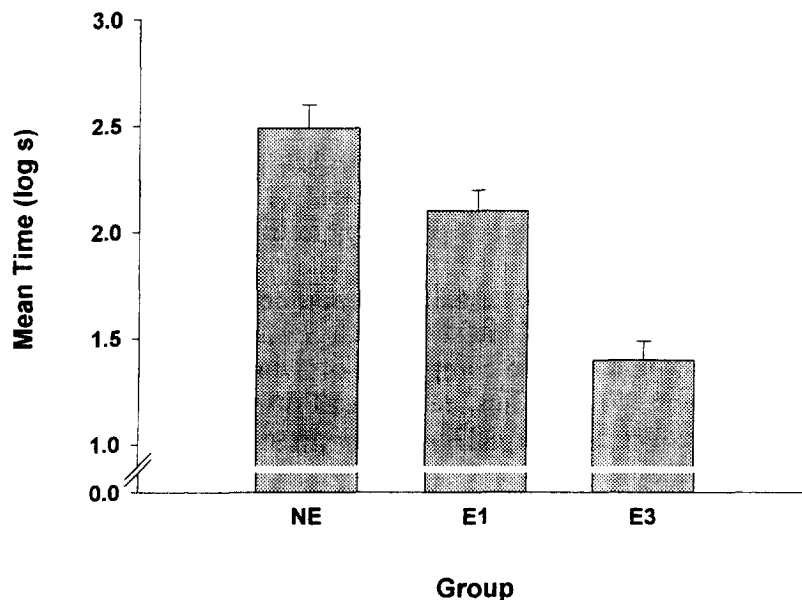


Fig. 1. Mean times in Experiment 1 to complete 5 cumulative seconds of licking in the presence of the CS in Context E. Error bars denote standard errors of means.

relative to Group E1, it did not fully eliminate it in that it failed to lower responding down to the level that would have been expected had testing occurred in the extinction context. Whether more extinction trials would have fully eliminated renewal is an open question, that is not answerable based on the present data.

### 3. Experiment 2

Experiment 1 found that renewal of conditioned responding in a neutral context can be appreciably reduced if extinction is conducted in multiple contexts. From a therapeutic perspective, one might infer from these results that relapse following clinical extinction of a phobia could be greatly reduced if the therapist were to conduct the extinction treatments in a variety of different contexts. However, for many reasons inferences from the laboratory to clinical settings must be made with caution. For instance, the development of phobias has been shown to be quite complex, arising from vicarious and instructional factors as well as from direct experience (e.g. Ollendick and King, 1991). Thus, phobic reactions likely stem from a variety of different sources, or situations. For example, a fear of flying may develop gradually through exposure to media-presented material regarding plane crashes (i.e. an instructional factor), being close to someone who shares a fear of flying (i.e. a vicarious factor), and/or experiencing a fearful event while flying (i.e. a direct experience). Notably, each of these learning trials differ greatly with respect to context.

Experiment 2 sought to examine renewal after extinction in several different contexts following fear conditioning in either one or several different training contexts. Group Train-1 (T1) received treatment similar to that received by Group E3 in Experiment 1 (i.e. conditioning of the CS in one context, and extinction of the CS in three other distinctive contexts). Group Train-3 (T3) received conditioning of the CS in three contexts, and extinction of the CS in three other distinctive contexts. Finally, all Ss were tested for suppression to the CS in an associatively neutral context.

### 3.1. Method

#### 3.1.1. Subjects

The Ss were 24 naive, 80–120-day-old, male and female rats of Sprague-Dawley descent. Body weight ranges were 180–240 g for females and 290–410 g for males. Subjects were randomly assigned to one of two groups ( $n_s = 12$ ), counterbalanced for sex. Subjects were housed and maintained as in Experiment 1.

#### 3.1.2. Apparatus

The apparatus used was the same as in Experiment 1 except for the addition of Chamber 4. Chamber 4 was a rectangular compartment, 21.5 × 10.0 × 11.5 cm (l × w × h), constructed with wooden walls and ceiling and with a wire-mesh floor. Chamber 4 was dimly illuminated by a 2-W (nominal at 120 VAC) bulb driven at 56 VAC mounted outside the chamber approximately 30 cm from the center of the floor of the animal enclosure; light entered only by reflection from the sawdust below the wire-mesh floor. Each of 12 copies of Chamber 4 was enclosed in its own environmental isolation chest. In each chamber, background noise, mostly from a ventilation fan, was 74 dB(C) re. SPL. The white noise stimulus was delivered in the same manner as in Experiment 1. Subjects did not have access to lick tubes in Chamber 4.

Seven different physical contexts were used in Experiment 2. Three physical contexts were counterbalanced within groups with respect to which served as Context A, B and C (the training contexts). These contexts were identified (using the nomenclature of Experiment 1) as follows: (1) an instance of Chamber 1 with the houselight on, flashing light off, and odor absent; (2) an instance of Chamber 2 or 3 (counterbalanced within groups) with both the houselight and flashing light turned off, and odor absent; and (3) an instance of Chamber 3 or 2 [counterbalanced against (2) within groups] with both the houselight and flashing light off, and the methyl salicylate odor cue present. Contexts D, E and F served as the extinction contexts. Context D consisted of an instance of Chamber 2 or 3 (counterbalanced within groups) with the house light on, the flashing light off, and odor cue absent; Context E consisted of an instance of Chamber 1 [other than (1) above] with the flashing light on, houselight off, Plexiglas floorplates present, and odor absent; and Context F consisted of an instance of Chamber 4 with the houselight on, flashing light off, and odor absent. Context G, the test context for all Ss, consisted of an instance of Chamber 2 [other than (2) or (3) above] with both the houselight and flashing light off, Plexiglas floorplates present, and a banana odor (Artificial Ripe Banana no. 112, Virginia Dare Extract Co., Inc., applied in the same manner as was used with the methyl salicylate odor cue) present.

### 3.1.3. Procedure

The group treatments are illustrated in Table 2. The details of the procedure for Experiment 2 are the same as in Experiment 1 except where noted.

**3.1.3.1. Acclimation.** All *Ss* received acclimation to all of the contexts on Days 1, 2 or 3 during 60-min daily sessions. On Day 1, all *Ss* were exposed to their versions of Contexts A, B and C; on Day 2, all *Ss* were exposed to Contexts D, E and F; on Day 3, all *Ss* were exposed to Context G. Animals had access to water-filled lick tubes only in Context G, which later served as the test context.

**3.1.3.2. Conditioning.** Group T1 received conditioning with the CS in one context (A), while Group T3 received conditioning with the CS in three contexts (A, B and C). These groups received equivalent exposure to each of these conditioning contexts, and also received the same total number of CS-US trials. Specifically, Group T1 received three daily reinforced presentations of the CS on Days 4, 7 and 10 in Context A. Group T3 received three daily reinforced presentations of the CS in Context A on Day 4, in Context B on Day 7, and in Context C on Day 10. Reinforced trials occurred at 14, 25 and 38 min into each 60-min conditioning session. In order to equate for exposure to each of the conditioning contexts, 60-min context exposure sessions were conducted with no stimuli programmed to occur. Group T1 received exposure to Context B on Days 5, 8 and 11, and to Context C on Days 6, 9 and 12. Group T3 received exposure to Context A on Days 8 and 12, to Context B on Days 5 and 11, and to Context C on Days 6 and 9.

**3.1.3.3. Extinction.** All *Ss* received an extinction treatment similar to that of Group E3 in Experiment 1 (i.e. all *Ss* received non-reinforced exposure to the CS in each of three contexts, in this case in Contexts D, E and F). All *Ss* were exposed to 54 non-reinforced CS trials per day in each of Contexts D (on Day 13), E (on Day 14), and F (on Day 15) during 2.25-hr sessions. Unlike Experiment 1, during extinction treatment there were no days of exposure to these contexts other than those in which the non-reinforced CS was presented.

**3.1.3.4. Reacclimation.** Prior to this phase, lick tubes were reinserted into Context G. On Days 16 and 17, all *Ss* were reacclimated to Context G (the test context) during 60-min daily sessions in order to restabilize baseline drinking.

Table 2  
Design of Experiment 2

Group	Training	Extinction	Testing
T1	(CS-US) <sub>A</sub> and (—) <sub>B</sub> and (—) <sub>C</sub>	(CS) <sub>D</sub> and (CS) <sub>E</sub> and (CS) <sub>F</sub>	(CS) <sub>G</sub>
T3	(CS-US) <sub>A</sub> and (CS-US) <sub>B</sub> and (CS-US) <sub>C</sub>	(CS) <sub>D</sub> and (CS) <sub>E</sub> and (CS) <sub>F</sub>	(CS) <sub>G</sub>

*Note:* A, B, C, D, E, F and G were distinctive contexts, the CS was a white noise, US represents the footshock unconditioned stimulus, and — represents no stimulus presentations. Both groups received the same total number of CS-US pairings and the same total number of non-reinforced CS (extinction) trials.

**3.1.3.5. Testing.** On Day 18, Ss were tested in Context G for suppression to the CS during a 15-min presentation that began with the completion of 5 cumulative seconds of drinking. Testing was conducted in the same manner as in Experiment 1. The time to complete 5 cumulative seconds of drinking in the presence of the CS was recorded.

One S from Group T1 was eliminated from the study due to illness.

### 3.2. Results and discussion

The results of Experiment 2 indicated that Ss that received conditioning with the CS in multiple contexts (A, B and C) followed by extinction of the CS in multiple contexts (D, E and F) exhibited greater conditioned suppression to the CS when tested in a neutral context (G), relative to Ss that were conditioned with the CS in a single context (A) followed by extinction treatment with the CS in multiple contexts (D, E and F). Thus, extinction does not appear to generalize as readily to a neutral context if training and extinction are conducted in an equivalent number of separate contexts. The following analysis supports this conclusion.

As in Experiment 1, no differences between groups in time to complete an initial 5 cumulative seconds of licking (i.e. prior to CS onset) on Day 18 was detected,  $F < 1$ , and no S took more than 60 sec to complete its initial 5 cumulative seconds of drinking. A one-way analysis of variance conducted on the suppression scores from Day 18 found an effect of Group (T1 vs T3),  $F(1,21) = 58.95$ ,  $P < 0.001$ . Inspection of Fig. 2 reveals that Group T3 responded more vigorously to X in the neutral test context (G) than did Group T1.

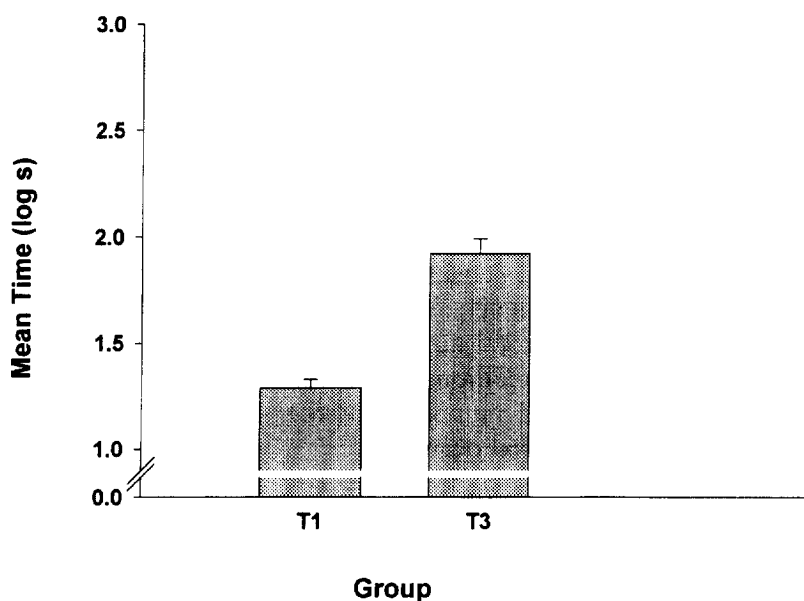


Fig. 2. Mean times in Experiment 2 to complete 5 cumulative seconds of licking in the presence of the CS in Context G. Error bars denote standard errors of means.

Bouton (1988) has suggested as an explanation for the clinical observation of relapse after exposure therapy that dysfunctional associative training in a single context generalized more broadly to a novel context than did extinction treatment. Experiment 1 constrained this view by demonstrating that extinction treatment did generalize to a neutral test context when it had been given in several different contexts. Experiment 2 then sought to determine if this means of reducing relapse would prove to be effective after acquisition of the association in the same number of multiple contexts as would later be used for extinction treatment. Under these circumstances, relapse was observed despite extinction treatment in multiple contexts. That is, Group T3 did not show behavior indicative of extinction in Context G; in fact, renewal behavior (i.e. indicative of relapse) was observed. However, Group T1 in the present experiment (as well as Group E3 of Experiment 1) did show behavior indicative of extinction, suggesting that relapse could be prevented by giving extinction treatment in multiple contexts, provided that training had occurred in a single context and testing was conducted in a neutral context.

It may be worthwhile to note the difference in the ratio of the number of training contexts used to the number of extinction contexts used for Groups T1 and T3 in Experiment 2. We observed generalization of extinction in a neutral context (i.e. prevention of relapse) for Group T1 for which there was a 1:3 (1 training context: 3 extinction contexts) ratio; however, we observed generalization of excitation (i.e. renewal) for Group T3 for which there was a 1:1 (3 training contexts: 3 extinction contexts) ratio (see Group E1 in Experiment 1 for another 1:1 ratio that yielded renewal). This ratio of the number of training contexts to extinction contexts may be useful in predicting when renewal as opposed to non-responding indicative of extinction will be observed. There are numerous reports demonstrating that excitation generalizes from a single training context more readily to a neutral context than does extinction following extinction treatment in a single context (e.g. Bouton and Bolles, 1979; Bouton and Ricker, 1994; Pavlov, 1927). Perhaps if we had maintained a 1:3 (e.g. 3 training contexts: 9 extinction contexts) for Group T3, we might have observed behavior indicative of extinction in the neutral test context (i.e. we might have been successful at attenuating relapse). While this idea would be interesting to pursue, it is likely to be problematic procedurally because of the difficulties inherent in establishing 13 distinctive contexts.

The present experiment thus served to demonstrate two important findings. First, we replicated the finding of Experiment 1 that conditioning a stimulus in one context, followed by extinction treatment of that stimulus in three other contexts results in behavior indicative of extinction when testing is conducted in a neutral context (i.e. extinction treatment in multiple contexts can prevent renewal). This was achieved despite our equating the *Ss*' overall exposure to each context, and our equating the total number of extinction trials conducted with the CS). Second, we demonstrated that when conditioning and extinction treatments are each conducted in several, separate contexts (an equal number of each), behavior indicative of excitation is observed in a neutral context (i.e. renewal occurs).

#### **4. General discussion**

Experiment 1 demonstrated that, after conditioning a stimulus in one context and extinguishing that stimulus in multiple other contexts, generalization of extinction behavior is observed

when testing is conducted in an associatively neutral context. Experiment 2 replicated this finding, but also revealed that, if conditioning is conducted in multiple contexts and extinction is conducted in the same number of multiple other contexts, generalization of excitation behavior is seen during subsequent testing in an associatively neutral context.

The results of Experiment 1 (i.e. Group E1) are consistent with the findings of Bouton and Bolles (1979; the ABC design), who suggested that excitation generalizes more readily to novel contexts than does extinction. Bouton (1988) has since proposed that the *S* learns that the stimulus is 'safe' only in the context in which the prior excitatory training is countered by extinction treatment. However, if *Ss* are given extinction training in several different contexts (i.e. Group E3; an A[BCD]E design) following training in a single context, *Ss* apparently learn that the stimulus is safe when tested in a neutral context, in that generalization of extinction behavior was seen in the neutral context. This result has important implications for therapists who use exposure therapy techniques. For such techniques to be successful during later 'tests' in novel contexts, therapy sessions in a variety of contexts appear to be desirable. Otherwise, patients might behave as if they learned that the fear-evoking stimulus is 'safe' only when encountered in the context associated with the therapy session (e.g. the therapist's office). Thus, when testing consists of encountering the fear-evoking stimulus in a novel setting, relapse is more likely when exposure therapy has been conducted in only one context than when it has been conducted in several distinct contexts.

Brooks and Bouton (1994) offered further evidence for the importance of contextual information as a factor in determining relapse. Subjects were exposed to CS-US training in one context followed by exposure to the CS alone in a second context. During the exposure (i.e. extinction) phase, *Ss* were also given a few brief presentations of an auditory stimulus in addition to the non-reinforced CS presentations. When testing was subsequently conducted with the CS in the original training context and in the presence of the auditory stimulus that had occurred during exposure treatment, *Ss* showed little conditioned fear to the CS. Recall, that such a procedure (when performed without the brief auditory stimulus) results in renewal of conditioned fear to the CS (i.e. relapse). However, Brooks and Bouton maintained that the presentation during testing of the auditory stimulus that had been experienced during exposure treatment acted as a reminder stimulus for the extinction context, thereby reducing the extent of relapse.

While the physical aspects of context have not (to our knowledge) been extensively manipulated in the clinical settings, several clinical findings lend support for the importance of the impact of context on the effectiveness of exposure treatment. For example, agoraphobic patients have been found to be less prone to relapse following exposure therapy when additional sessions were conducted in their homes, or with the patient's spouse assisting in the sessions (e.g. Barlow et al., 1984). These results are consistent with both the results of our Experiment 1 and with those of Brooks and Bouton (1994). Specifically, extending the therapy sessions to include the home setting increases the number of contexts in which exposure was conducted (consistent with our Experiment 1), and conducting therapy sessions with the spouse may expedite therapeutic success due to the spouse coming to act as a 'reminder cue' for the exposure therapy sessions (consistent with Brooks and Bouton). In other words, if the spouse is present during subsequent exposure to the fear-invoking stimulus, relapse is less likely to occur if the spouse had also been a salient cue during exposure therapy. This result is further

supported by the finding that agoraphobic patients often use 'safety signals' (Rachman, 1983) when attempting to confront feared situations. In Rachman's experience, patients often rely on the spouse (or some other stimulus that signals safety in fear-inducing situations) to accompany him or her when venturing out of the home. When the spouse is involved in the exposure sessions, the likelihood is that she or he would be used as a safety signal.

Experiment 2 demonstrated that if CS-US conditioning is conducted in multiple (3) contexts and extinction is conducted in multiple (3) other contexts, excitatory responding to the CS is observed in the neutral test context. Bouton's (1988) explanation for extinction being more context-sensitive than excitation centered on the fact that ambiguity concerning the associative status of the stimulus was created in the extinction context (i.e. the stimulus was unambiguously associated with reinforcement in Context A, and was then associated with non-reinforcement in Context B, thereby creating ambiguity). Disambiguation of the meaning of the stimulus is possible only through consideration of the context in which testing occurs. Bouton assumes that the treatment that introduced ambiguity (i.e. uncertainty about reinforcement of the stimulus) will be specific to the context in which ambiguity arose (i.e. Context B). In our Experiment 1, Group E3 seemingly learned that the stimulus was 'dangerous' in Context A, and safe in enough other contexts that it is effectively 'safe everywhere else', as is suggested by the lack of conditioned fear we observed to the CS in the neutral test context. However, in Experiment 2 the *S* likely learned that the stimulus was 'dangerous' in Contexts A, B and C, and 'safe' in Contexts D, E and F. In this case, there was not a preponderance of contexts in which the stimulus was safe. Consequently, when the *S* was tested in the neutral context, it encountered an ambiguous situation (one that could not be disambiguated by the test context), and therefore from Bouton's viewpoint predicts behavior indicative of excitation (i.e. when in an ambiguous situation, excitation ought to generalize more readily than extinction). Although this type of analysis adequately addresses the present data, it fails to explain the strong responding observed by Bouton and Ricker (1994) in a neutral context after training and extinction in a common context despite weak responding in the training/extinction context (i.e. the AAB design).

The context specificity of extinction may also be viewed as a retrieval failure. For example, Smith (1982) presented human participants with a list of words in either a single context, or distributed among more than one context (2 or 4). Participants demonstrated enhanced performance on a subsequent free recall test conducted in a novel experimental room if they had been presented with the word lists in more than one room. However, Smith observed no such effect on a recognition test, and proposed a retrieval explanation (rather than an acquisition explanation) for his pattern of results. Smith concluded that training in multiple contexts "immunizes learned material against the negative effects of a changed testing context" (p. 412).

Bouton (1993) has also suggested a retrieval explanation for his context effects. He states that, in his renewal procedure, ambiguity in outcome arises from *Ss*' learning both an excitatory (during conditioning) and inhibitory (during extinction) relationship between the CS and the US, and that performance at test will depend on which relationship is activated by the background retrieval cues available in the test context. In our Experiment 1, *Ss* from Group E3 (and Group T1 in Experiment 2) showed behavior indicative of extinction during testing in the associatively neutral context. Perhaps by extinguishing the stimulus in multiple contexts (after conditioning in a single context), we increased the likelihood that when the *S* was placed

in the neutral context, it encountered contextual stimulus elements similar to those of the extinction context. As previously described, Brooks and Bouton (1994) reported a study in which a retrieval cue for extinction (i.e. a cue present during extinction training) was presented during testing. These Ss showed generalization of extinction even when they were tested in the original conditioning context [i.e. they did not show renewal of responding (relapse) in the training context]. In our Experiment 2, Ss in Group T3 showed generalization of excitation to the neutral test context despite extinction in multiple (3) contexts after conditioning had been conducted in multiple (3) contexts. Presumably, there were a similar number of potential retrieval cue elements in the test context that had been present in the conditioning contexts and in the extinction contexts, thereby creating a situation that could not be disambiguated by the contextual cues of the test context. However, since excitation generalizes more readily than does extinction (Pavlov, 1927), the retrieved excitatory associations were stronger, so Ss showed conditioned fear to the CS in the neutral context.

Given the assumption that excitation generalizes across eliciting stimuli more readily than does inhibition (or at least extinction), the present data are fully explicable in terms of contexts being composed of stimulus elements with each context sharing some fraction of its constituent elements with each other context. Presumably context modulates behavior both through its direct excitatory and inhibitory effects upon activation of the US representation and through its action as an occasion setter (i.e. a retrieval cue for the CS–US or CS–no US association). After excitatory training in one context, extinction treatment in a second context, and testing in a third (neutral) context, the number of elements from the training context and from the extinction context that are also part of the test context should, on average, be equal. Consequently, generalization of an excitatory response tendency to the neutral test context ought to be greater than generalization of an inhibitory response tendency because excitation generalizes more readily than inhibition. However, with excitatory training in one context and extinction treatment in three other contexts, collectively generalization of inhibition from the three extinction contexts might well be expected to exceed generalization of excitation from the single excitatory training context. This outcome is anticipated because the test context will, on average, have three times the number of elements in common with the extinction context than with the training context, and this factor might well be expected to more than compensate for the stronger generalization of excitation than inhibition. Finally, concerning the results of Experiment 2 (Group T3) with excitatory training in three different contexts, once again the number of stimulus elements from each of these three contexts that are to be found in the neutral test context should on average be equal, and the greater generalization of excitation than inhibition should prevail.

The results of the present studies, combined with those of Bouton and Bolles (1979; also see Bouton and King, 1983; Bouton and Ricker, 1994; Smith, 1982) have important implications for clinicians who conduct exposure therapy, and who hope to prevent relapse of conditioned fears. First, from the results of Experiment 1, we conclude that therapists should attempt to conduct exposure sessions in a variety of settings in order to prevent relapse in novel settings (Bouton and Bolles, 1979). Second, if this proves unsuccessful, we may suspect that the phobia was acquired in multiple settings, and that it would be wise to further increase the number of settings in which the exposure treatments are to be conducted (Experiment 2). Third, although reaching beyond the present data, we suggest that the therapist might consider incorporating

some type of reminder technique that the client could use in novel (or fear-originating) contexts (Brooks and Bouton, 1994). For example, if the clients are able to carry with them a component of the extinction context (e.g. a pendant the *S* had been instructed to grasp during exposure sessions), relapse might be prevented by a 'return to the extinction context', using that component as a reminder cue for extinction treatment.

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