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Conducting extinction in multiple contexts does not necessarily attenuate the renewal of shock expectancy in a fear conditioning procedure with humans

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Abstract

The renewal of Pavlovian conditioned responses may provide a model for the relapse of fear following extinction-based treatments for anxiety disorders. Renewal can be observed if conditional stimulus (CS) and unconditional stimulus (US) pairings are given in one context, extinction trials of CS presentations in a second context, prior to test trials of CS presentations in the original acquisition context (ABA renewal). We examined ABA renewal in humans by using a fear conditioning procedure with an unpleasant shock US. A renewal of rated shock expectancy was demonstrated with this procedure. Conducting extinction treatment in multiple contexts was expected to attenuate the renewal effect. However, the renewal of shock expectancy persisted when extinction treatment was given across three or five different contexts. With the current renewal design, learning task, and measure of conditioned behaviour, extinction treatment does not appear to readily generalise to the test context. The use of multiple extinction treatments in a clinical setting may not necessarily reduce the likelihood of relapse via a renewal effect.

Keywords: Pavlovian conditioning, exposure therapy, context, relapse

1. Introduction

Contemporary conditioning accounts for specific phobia suggest that a conditional stimulus (CS) – unconditional stimulus (US) association underlies the development of fear (Davey, 2002). Fear of the CS can be reduced by extinction treatment in which the CS is presented repeatedly on its own. The clinical application of extinction treatment, typically called exposure therapy, requires that the phobic individual is exposed to the feared stimulus. Exposure therapy is efficacious in the treatment of specific phobias (Chambless & Ollendick, 2001). Moreover, the demonstrated benefit of exposure therapy in the treatment of other anxiety disorders, including panic disorder, post-traumatic stress disorder, social phobia, and obsessive-compulsive disorder (Chambless & Ollendick, 2001; Deacon & Abramowitz, 2004) extends the application of this treatment approach. Experimental research on the processes that underlie extinction suggest that the original CS-US association remains intact and can later influence behaviour given the right circumstances (Bouton, 2004). This advance in our understanding is significant because it has the potential to explain why some individuals show a relapse of anxiety symptoms, or return of fear (Rachman, 1989), following exposure therapy.

A compelling case has emerged to suggest that contextual cues play an important role in the return of fear following extinction (Bouton, 2004). The phenomenon of renewal illustrates this point. Experimental research has shown that if an animal is given acquisition fear conditioning trials of CS-shockUS pairings in one context, followed by extinction treatment of CS alone presentations in a second context, fear will return if the animal is exposed to the CS in the original acquisition context (termed “ABA” renewal; Bouton & Bolles, 1979; Bouton & King, 1983; Bouton & Peck, 1989; Bouton, 2004). Experimental studies with human participants using a fear conditioning paradigm have replicated the renewal effect observed in

the animal studies (Vansteenwegen, et al., 2005; Vervliet, Vansteenwegen, Baeyens, Hermans, & Helen, 2005; see also Hermans et al., 2005 for a demonstration of the related reinstatement effect). The renewal of extinguished conditioned behaviour cannot merely be attributed to the expression of a separate excitatory context-US association that is formed during acquisition (Bouton & King, 1983). Bouton (2004) has interpreted the renewal effect as reflecting that extinction creates new learning of a CS-noUS association, and not an unlearning of the CS-US association. Moreover, this new learning is highly context specific.

The renewal effect provides an elegant explanation for why individuals may show a return of fear following exposure therapy for anxiety disorders, at least in select cases. For instance, if a spider phobic individual acquires the phobia in one setting (e.g., home), but is given exposure therapy in a single different setting (e.g., clinic), fear may return if a spider is encountered in a context different to that present during exposure therapy. Several studies, which have demonstrated the renewal of fear in spider fearful individuals, confirm the plausibility of such a scenario (Mineka, Mystkowski, Hladek, & Rodriguez, 1999; Mystkowski, Craske, & Echiverri, 2002; Mystkowski, Mineka, Vernon, & Zinbarg, 2003; Rodriguez, Craske, Mineka, & Hladek, 1999). A simple solution to the renewal of fear would be to provide exposure therapy in contexts in which the feared object will later be encountered, a technique not unknown to clinicians. However, this may not necessarily be a viable or effective strategy. For instance, the number of potential future contexts in which the feared object will be encountered may be too numerous to render this strategy practical. An alternative solution could be to use a variety of examples of the feared stimulus during exposure therapy to aid in the generalisation of extinction learning to other encounters of the feared object (Rowe & Craske, 1998).

The generalisation of extinction learning may also be beneficial in the specific case of the return of fear due to a renewal effect if there is a greater similarity between the extinction context and subsequent contexts. Gunther, Denniston, and Miller (1998) used a fear conditioning procedure with rats and found that the renewal of fear was attenuated when extinction was given in multiple contexts prior to test trials in a novel context. Chelonis, Calton, Hart, and Schachtman (1999) found a similar result using a taste aversion procedure with rats when the renewal of fear was examined upon return to the original learning context. The attenuation of renewal may occur because the use of multiple extinction contexts provides a larger number of contextual cues to be associated with extinction learning, thereby promoting the generalisation of learning to other contexts (Chelonis et al., 1999). The generalisation of contextual cues increases the likelihood that the CS-noUS association is recalled in another context, thus reducing conditioned responding in the presence of the CS. However, Bouton, García-Gutiérrez, Zilski, and Moody (in press) have recently been unable to replicate the attenuation of the renewal of fear in rats by conducting extinction in multiple contexts. The recent report by Bouton et al. suggests that conducting extinction treatment in multiple contexts does not necessarily attenuate the renewal effect.

Prior research on the effect of multiple extinction contexts on renewal has yielded inconsistent findings and it has been conducted in experiments with rats. For these reasons, further investigation with human participants seems warranted. It is plausible that an attenuation of renewal following extinction in multiple contexts will be found in a fear conditioning paradigm with humans. For instance, memory retrieval in people is enhanced when to-be-remembered information is presented in multiple contexts (Smith, 1982). However, in the absence of direct experimental evidence of the effects of extinction treatment in multiple

contexts in humans, the efficacy of this approach in reducing the return of fear remains unknown. The present research employed a fear conditioning procedure with humans to examine renewal of the expectancy of a shock US in an ABA renewal design. A differential conditioning procedure was employed by pairing a CS+ with a shock and presenting a control stimulus, CS-, alone. Three groups were used, a Control group that received no change of context during extinction, a Renewal 1 group that received extinction treatment in one context, and a Renewal 3 group that received extinction treatment in three different contexts. It was hypothesised that a renewal of shock expectancy would be observed only in the Renewal 1 group.

2. Experiment 1

2.1 Method

2.1.1 Participants

The participants were 29 female and 19 male first year psychology students with a mean age of 20.67 years (range 18 to 50 years). After providing informed consent, each participant was randomly allocated to one of three groups ($n = 16$ in each) such that each group had a similar proportion of male and females.

2.1.2 Apparatus

Expectancy of the shock US was recorded with a Grass Model 7D Polygraph running with a paper speed of 2.5mm/s. Participants operated a custom-built dial and pointer with their preferred hand. The dial had a rotation angle of 180° and the labels “certain the shock is NOT about to occur” and “certain the shock is about to occur” were placed on the left and right extremes respectively. The dial could record varying degrees of shock expectancy between the two extremes. The central position was labeled “uncertain”. Skin conductance responses were

also recorded and these measures generally confirmed the acquisition, extinction, and renewal and the effects of the multiple extinction contexts observed with the shock expectancy measure. However, as skin conductance was not measured in Experiment 2 and for brevity, only the shock expectancy data are reported in detail. A custom built apparatus that delivered pulsed shocks at a frequency of 50 Hz generated the electric shock US. It was applied to the volar surface of the participant's preferred forearm for 500 ms via a concentric electrode. The CSs consisted of pictures of geometric shapes that were back projected onto a projection area using a Leitz Pradovit 153 projector equipped with a tachistoscopic shutter (Gerbrand Model G1166CS). The projection area subtended $6.13^\circ \times 8.17^\circ$ visual angle at eye level, 1.5 m in front of the participant. The geometric shapes consisted of a trapezoid and a hexagon that were 3.25° visual angle in height and width when projected. Each presentation was for a duration of 8 s. Stimulus duration, sequencing, and intertrial intervals were controlled by an IBM (486) compatible computer.

The context manipulations were produced by illuminating the room with different coloured lights and by playing different background sounds. The acoustic component consisted of musical instrument digital interface (MIDI) sounds produced via a Dell Latitude CP laptop (Model PPL) and presented via two Harman/Kardon speakers (Model HK 195) placed on either side of the participant's chair. Four MIDI sounds were selected from track 10 (percussion track): a bass drum (MIDI #35), ride cymbal (MIDI #51), hi wood block (MIDI #76), and short whistle (MIDI #71). Sounds were pulsed once every 1000 ms. The visual context manipulations used two red 50 Watt NEC Dichro Halogen Lamps, two green 50 Watt Phatan Tru-Aim EXN/C Halogen Lamps, two yellow 50 Watt Carona Australis Tekno EXN/Yellow Halogen Lamps, and two blue 50Watt Lux MR 16 Halogen Lamps. These lamps were positioned directly behind and

above the participant's chair. When switched on, they illuminated the walls of the experimental room in the chosen colour. The final contexts consisted of a random combination of one light and sound (final combinations were green light + bass drum, yellow light + ride cymbal, blue light + hi wood block, and red light + short whistle).

2.1.3 Procedure

The experiment was conducted in two adjacent rooms. Each participant sat in a semi-reclining chair in the participant's room while the experiment was monitored via a closed circuit video system from the adjoining room. After the participant provided informed consent, the experiment began with the shock work-up procedure. The 500 ms shock stimulus was presented in gradually increasing intensity until the participant reported the level to be "uncomfortable, but not painful". This final individual level was used for the remainder of the experiment. A 3-min acclimatization period followed the shock work-up procedure. Next, participants were provided with information on how to use the expectancy dial. Participants were instructed that they would be presented with pictures of shapes and the shock stimulus and that they should indicate to what extent they expected the shock stimulus to occur. Participants were instructed to indicate their expectation at all times during the experiment (including both during the CS presentations and the intervals in between) whenever their expectation changed.

Following the instructions, the first visual and acoustic context manipulations were instated (Context A) and the participants were pre-exposed to each CS. The acquisition phase immediately followed and consisted of 18 trials such that each CS was presented for 9 trials (labeled trials A1 to A9). One CS, the CS+, was followed immediately by the shock. The second CS, the CS-, was presented alone. The nature of which geometric shape served as the CS+ and CS- was counterbalanced between participants. At the conclusion of the acquisition

phase, the context was changed in the Renewal 1 and Renewal 3 groups (Context B).

Participants in the Control group remained in the same contextual environment. The extinction phase consisted of 18 trials, 9 each of the CS+ and CS- (labeled trials E1 to E9). No shock was presented during extinction. Participants in the Renewal 3 group also received a change of context immediately prior to trial E4 (Context C) and E7 (Context D) such that extinction treatment was evenly distributed across the three contexts. Following extinction, the context was returned to the original context established throughout acquisition for participants in the Renewal 1 and Renewal 3 groups. The test phase consisted of 6 presentations of the CSs, 3 each of the CS+ and CS- (labeled trials T1 to T3) and no presentations of the shock were made. In sum, the contexts used in the acquisition, extinction, and test phases of the experiment respectively were: Control group AAA, Renewal 1 group ABA, and Renewal 3 group A[BCD]A. The specific combination of light and sound that served as each context was randomised to avoid any potential bias. In all phases, the order of the CSs were also randomised with the restriction that the first CS presented in each phase was counterbalanced between participants and that there were no more than two presentations of the same CS in succession. The intertrial intervals were varied at random between 25, 30 and 35 s, with a mean of 30 s. Expectancy of the shock US was scored as the percentage difference between the level when the dial was set to “uncertain” to the level the participant had moved the dial at the end of the CS presentation. Expectancy values ranged from +100 (certain of shock), through zero (uncertain), to -100 (certain of no shock).

2.2 Results and Discussion

The mean percent shock expectancy for the Control, Renewal 1, and Renewal 3 groups are shown in Figure 1. ANOVAs were conducted using the Greenhouse Geisser adjustment for within-subjects factors of more than two levels to correct for violations of the sphericity

assumption (the epsilon used in the correction is reported). In the acquisition phase, learning was evident across trials by an increasing shock expectancy during the CS+ and a decreasing shock expectancy during the CS-. A $3 \times 2 \times 9$ (Group $\times$ CS $\times$ Trial) ANOVA for the acquisition trials confirmed these impressions with a main effect for CS, $F(1, 45) = 244.65, p < .001$, a main effect for Trial, $F(8, 360) = 6.16, \epsilon = .65, p < .001$, and a CS $\times$ Trial interaction, $F(8, 360) = 41.81, \epsilon = .52, p < .001$. As can be seen in Figure 1, there was a clear differentiation between the CS+ and CS- in all groups by the last trial of acquisition.

In the extinction phase, all groups showed a loss of shock expectancy during the CS+. A $3 \times 2 \times 9$ (Group $\times$ CS $\times$ Trial) ANOVA for the extinction trials yielded a main effect for CS, $F(1, 45) = 14.84, p < .001$, a main effect for Trial, $F(8, 360) = 57.64, \epsilon = .59, p < .001$, and a CS $\times$ Trial interaction, $F(8, 360) = 11.23, \epsilon = .49, p < .001$. In addition, the groups differed across trials, as reflected in a Group $\times$ Trial interaction, $F(16, 360) = 3.97, \epsilon = .59, p < .001$. A feature of the extinction phase was the extinction was relatively steady for the Control and Renewal 1 groups, but was less stable in the Renewal 3 groups. Post hoc analyses to examine this trend across trials were conducted with t tests that were adjusted for the accumulation of Type I error by using Šidák's multiplicative inequality (Games, 1977). Additional analysis showed that the Control group and the Renewal 1 group exhibited a consistent decrease in shock expectancy across trials, with the decrease across some trials being statistically significant (Control: Trial E2 vs. E3, $t = 3.41, p < .05$; Renewal 1: Trial E1 vs. E2 and Trial E2 vs. E3, both $ts > 4.19, p < .01$; all other $ts < 1.80$). In contrast, the Renewal 3 group showed both decreasing and increasing shock expectancy across trials. Shock expectancy decreased from Trial E1 to E2, and Trial E2 to E3, increased from Trial E3 to E4, decreased from Trial E4 to E5, did not change significantly from Trial E5 to E6, increased from Trial E6 to E7, and decreased from Trial E7 to E8, all

significant $t_s > 2.75, p < .05$. In sum, the increases in shock expectancy in the Renewal 3 group occurred on Trials E4 and E7, the same trials in which a new extinction context was implemented.

A second feature of the extinction phase was that there was a change in expectancy ratings following the switch in context between acquisition to extinction. To confirm that the extinction procedure was responsible for the change in expectancy across trials, it needs to be confirmed that there was differentiation between the CS+ and CS- on the first extinction trial. Otherwise the apparent extinction might reflect a loss of generalisation from the acquisition to the extinction phases, particularly in the renewal groups. Further post hoc analyses were conducted to confirm that extinction occurred during the extinction phase. Expectancy of the shock US was significantly greater during the CS+ than during the CS- in all groups on the first extinction trial, all $t > 5.43, p < .01$. There were no differences between the CS+ and CS- on the last extinction trial in any group, all $t_s < 1.67, p > .05$. In sum, while there appeared to be some loss of generalisation of learning from acquisition following the switch in contexts between acquisition and extinction, this was not substantial enough to eliminate the differences between the CS+ and CS-. The lack of differentiation between the CS+ and CS- on the last extinction trial, however, shows that the extinction manipulation was effective.

Two strategies were used to determine the extent to which shock expectancy was renewed on the test trials. The first compared the differences between the CS+ and CS- during the test trials in each group. Renewal would be observed if there is greater shock expectancy during the CS+ (the CS paired with the US in acquisition) than during the CS- (the control CS). The second strategy recognised that renewal can be defined as a change in conditioned responding from the last extinction trial to the first test trial. Renewal would be evidenced by an

increase in shock expectancy from the last extinction trial to the first test trial for the CS+. The second strategy thus compared shock expectancy between the last extinction trial and first test trial in each group.

A 3 x 2 x 3 (Group x CS x Trial) ANOVA conducted to examine conditioned suppression during the test trials showed a main effect for CS, $F(1, 45) = 25.07, p < .001$, a main effect for Trial, $F(2, 90) = 26.26, \epsilon = .95, p < .001$, a Group x Trial interaction, $F(4, 90) = 8.50, \epsilon = .95, p < .001$, a CS x Trial interaction, $F(2, 90) = 8.15, \epsilon = .86, p < .01$, and a Group x CS x Trial interaction, $F(4, 90) = 2.10, \epsilon = .86, p = .09$, that approached significance. It is clear from Figure 1, that a renewal of shock expectancy was observed in the two renewal groups, but not in the control group, and that the renewal was strongest on the first test trial due to unreinforced presentations of the CS+ across trials. Pairwise comparisons confirmed that there were no differences between the CS+ and CS- in the Control group on any test trial, all $ts < 2.07, p > .05$. In the Renewal 1 group, shock expectancy was greater during the CS+ than during the CS- on Trial 1, $t = 6.23, p < .01$, but not on subsequent trials, both $ts < 1.26, p > .05$. This pattern of results is consistent with a renewal effect. In the Renewal 3 group, shock expectancy was greater during the CS+ than during the CS- on Trial 1, $t = 6.23, p < .01$, Trial 2, $t = 4.03, p < .01$, but not on Trial 3, $t(90) = 2.70, p > .05$. Contrary to expectations, this analysis indicated that a renewal effect was observed even though the Renewal 3 group received multiple contexts during extinction treatment.

The second test for renewal employed a 3 x 2 x 2 (Group x CS x Trial) ANOVA to compare shock expectancy between the last extinction trial and first test trial in each group. The outcome of these analyses supported the conclusions from the analysis during the test phase. The ANOVA resulted in a Main effect for CS, $F(1, 45) = 22.57, p < .001$, a Main effect for

Trial, $F(1, 45) = 61.23, p < .001$, Main effect for Group, $F(1, 45) = 3.05, p = .06$, a CS x Trial interaction, $F(1, 45) = 22.98, p < .001$, a Trial x Group interaction, $F(1, 45) = 17.24, p < .001$, and a CS x Trial x Group interaction, $F(2, 45) = 2.48, p = .09$. Comparisons between the last extinction trial and first test trial in each group showed that there was no difference between trials for the CS+ in the Control group, both $t_s < 1$. However, shock expectancy during the CS+ was higher on the first test trial than on the last extinction trial in both the Renewal 1 group, $t(45) = 8.76, p < .01$, and Renewal 3 group, $t(45) = 7.32, p < .01$. The increase in shock expectancy from the extinction to the test phase confirms that the renewal of shock expectancy occurred in both the Renewal 1 and Renewal 3 groups.

Inspection of Figure 1 suggests that although renewal was observed in the Renewal 3 group, the level of shock expectancy for the CS+ was slightly lower than that in the Renewal 1 group. Any potential between group differences for the CS+ were thus examined with a one-way ANOVA conducted for the first test trial using all three groups in the analysis. The ANOVA was significant, $F(1, 45) = 9.48, p < .001$, reflecting the between-group differences. Post hoc analyses confirmed that shock expectancy was higher in the Renewal 1 group than in the Control group, $t = 4.16, p < .01$, and higher in the Renewal 3 group than in the Control group, $t = 3.18, p < .01$. However, the difference between the Renewal 1 and Renewal 3 groups was not significant. The analyses thus confirm that the renewal effect was not significantly different in magnitude between the Renewal 1 and Renewal 3 groups.

The failure to find a complete elimination of the ABA renewal effect when extinction treatment was conducted across multiple contexts in the present experiment may reflect the relatively low power of the manipulation used. Chelonis et al. (1999) observed an attenuation of ABA renewal when extinction treatment was given across three contexts, as was done here,

although their experiment examined conditioned taste aversion in rats. It may be necessary with the present experimental task and subject group to use a larger number of extinction contexts to reliably observe an attenuation. To examine this notion a supplementary experiment was conducted. A Renewal 5 group was tested by conducting extinction treatment across five different contexts (i.e., the design was A[BCDEF]A).

3. Experiment 2

3.1 Method

3.1.1 Participants

A total of 6 males and 10 females (mean age = 20.3 years, range 17 to 29) participated. No participants had previously participated in Experiment 1 and all were assigned to the Renewal 5 group.

3.1.2 Apparatus and Procedure

Minor changes to the apparatus and procedure were made and skin conductance responses were not recorded. Only a Renewal 5 group was tested. To ensure that there was an even number of extinction trials conducted in each context, the number of acquisition and extinction trials were both increased to 10 trials each for the CS+ and CS-. The number of different coloured lights and the nature of the sounds used were also increased. The six contexts used were a green light + bass drum sound (MIDI #35), amber light + ride cymbal (MIDI #51), blue light + high wood block (MIDI #76), red light + short whistle (MIDI #71), white light + open triangle (MIDI #81), and purple light + claves (MIDI #75). Contexts were assigned at random without replacement for each phase of the experiment to result in an A[BCDEF]A design in which the 10 extinction trials were distributed evenly across five different contexts. During

extinction, context changes were made at the start of extinction (Context B) and thereafter following every two trials of the CS+ and CS-.

Results and Discussion

The mean percent expectancy of the shock US for the Renewal 5 group is shown in Figure 2. Participants showed a strong trend of increasing shock expectancy during the CS+ and decreasing shock expectancy during the CS- in the acquisition phase. A 2 x 10 (CS x Trial) ANOVA yielded a main effect for CS, $F(1, 15) = 433.88, p < .001$, and a CS x Trial interaction, $F(9, 135) = 44.59, \epsilon = .23, p < .001$. The difference in shock expectancy between the CS+ and CS- was lost during the extinction phase. A 2 x 10 (CS x Trial) ANOVA confirmed this impression with a main effect for CS, $F(1, 15) = 16.92, p < .001$, main effect for Trial, $F(9, 135) = 23.48, \epsilon = .42, p < .001$, and a CS x Trial interaction, $F(9, 135) = 2.69, \epsilon = .48, p = .036$. Similar to Experiment 1 there was some loss of generalisation of the learning from acquisition following the context switch in the extinction phase. Post hoc analysis, however, confirmed that there was greater expectancy of the shock during the CS+ than during the CS- on the first extinction trial, $t = 4.59, p < .01$, whereas there were no difference on the last extinction trial, $t = .50, p > .05$. As observed in the Renewal 3 group in the previous experiment, extinction proceeded in a somewhat irregular manner. Shock expectancy significantly decreased from E1 to E2, did not change significantly from E2 to E3, E3 to E4 or E4 to E5, but significantly decreased from E5 to E6, significantly increased from E6 to E7, significantly decreased from E7 to E8, did not change from E8 to E9, and significantly decreased from E9 to E10, all significant $ts > 3.12, p < .01$, all others $ts < 2.45, p < .05$. The irregular progression of extinction again seems to reflect the effects of the context switch across the trials.

The first test for renewal used a 2 x 3 (CS x Trial) ANOVA to examine shock expectancy during the test trials. The analysis confirmed the presence of renewal by a main effect for CS, $F(1, 15) = 20.02, p < .001$, a main effect for Trial, $F(2, 30) = 9.23, \varepsilon = .69, p = .003$, and a CS x Trial interaction, $F(2, 30) = 3.24, \varepsilon = .55, p = .087$. Expectancy of shock was significantly greater during the CS+ than during the CS- on the first test trial, $t = 3.57, p < .01$, but not on subsequent trials, both $ts > 1.89, p > .05$. Similar to Experiment 1, the renewal of shock expectancy was strongest on the first test trial due to the fact that the CS+ was not reinforced on the test trials.

The second test for renewal used a 2 x 2 (CS x Trial) ANOVA to compare between the last extinction trial and first test trial. The analyses yielded a main effect for CS, $F(1, 15) = 13.84, p < .01$, main effect for Trial, $F(1, 15) = 30.16, p < .001$, and a CS x Trial interaction, $F(1, 15) = 10.06, p < .01$. Post hoc analysis confirmed that shock expectancy significantly increased from the last extinction trial to the first test trial for the CS+, $t = 5.42, p < .01$. These analysis again support the comparisons during the test phase and the conclusion of Experiment 1. Conducting extinction treatment across multiple contexts did not attenuate the renewal effect in a fear conditioning procedure with humans.

Although the present experiment found the presence of a renewal effect even when extinction treatment was conducted across five contexts, an examination of the data across this and the previous experiment appears to show a trend. Shock expectancy during the CS+ appears to decrease as the number of extinction contexts increase from one (Renewal 1 $M = 46.15\%$, $SD = 64.68$), to three (Renewal 3 $M = 21.53\%$, $SD = 75.89$) to five (Renewal 5 $M = 5.75\%$, $SD = 81.13$). A one-way ANOVA was used to determine whether this trend was statistically significant. The outcome indicated that it was not, $F(2, 45) = 1.20, p = .309$. Rather, the

apparent trend may be better explained by reflecting different overall levels of shock expectancy between the groups. This factor can be taken into account by calculating the difference in shock expectancy between the CS+ and CS- on the first test trial. The results are very similar between the Renewal 1 ($M = 86.47$, $SD = 91.71$), Renewal 3 ($M = 78.02$, $SD = 78.54$), and Renewal 5 ($M = 85.06$, $SD = 97.37$) groups, as confirmed by a one-way ANOVA, $F(2, 45) = .041$, $p = .96$. It would appear that there is no evidence for an attenuation of the renewal effect as the number of extinction contexts is increased.

4. General Discussion

The main finding of the present experiment was that with the current ABA renewal design, fear conditioning preparation, and measure of conditioned behaviour, conducting extinction treatment in a number of different contexts did not significantly attenuate the renewal effect. It might be argued that even more extinction contexts than used here would produce a complete elimination of the renewal effect. Although this is possible, the present results did not show any substantial trend to support this suggestion. For instance, the difference in shock expectancy between the CS+ and CS- on the first test trial was very similar regardless of whether one, three, or five extinction contexts were used. It might also be argued that the context manipulations were not effective and that participants were not able to discriminate between the different contexts. However, during extinction for the Renewal 3 and Renewal 5 groups, each context change resulted in a significant renewal of shock expectancy. This observation suggests that the context manipulation was effective and extinction was conducted across distinctly different contexts from the participant's point of view.

It was expected that multiple extinction treatments would result in a greater number of contextual cues to be shared between the extinction contexts and the subsequent test context and

result in an attenuation of renewal. The present results suggest that this generalisation did not take place. An alternative explanation for the failure to observe an attenuation of renewal might be that the acquisition context maintained a separate excitatory association with the shock US. It was this excitatory association that was expressed in behaviour because the test trials were conducted following a return to the acquisition context. This could have resulted in an increase in shock expectancy independent of any associative link between the CS and US. However, this explanation cannot account for the low expectation of the shock US during the control stimulus, the CS-. If there was a separate context-US association that renewed shock expectancy, it should have resulted in a similar increase in expectancy for the CS+ and the CS-. However, the increased shock expectancy was clearly largest for the CS+.

The failure to find an attenuation of the renewal effect following extinction treatment in multiple contexts contrasts with the outcomes two prior studies with animals (Chelonis et al., 1999; Gunther et al., 1998). However, the failure to replicate this effect in the present experiments cannot be attributed merely to differences between human and animal subjects. Bouton et al. (in press) used a fear conditioning preparation with rats and reported a similar failure to find an attenuation of renewal following extinction treatment in multiple contexts. As noted by Bouton et al., the discrepant results may reflect that one or more variables impact upon whether or not multiple extinction treatment will successfully attenuate renewal. One potentially important variable could be the types of distinct cues that a context is composed of. Thomas, Larsen, and Ayres (2003) showed that the renewal effect was larger when the extinction and test contexts differed on a larger number of contextual cues. The implication here is that the larger the number of shared cues between extinction and test, the greater the generalisation of extinction learning to the test context, and the smaller the renewal. In the context of the present

problem, this would suggest that using multiple extinction contexts of a blue light + bell sound and red light + drum sound would produce a smaller renewal effect if test was conducted in the context that combined one feature of each context (e.g., blue light + drum sound) than in a completely novel context (e.g., yellow light + cymbal sound). The overall number of distinct contextual cues might also be important. For instance, conducting extinction across several contexts that are all uniquely different across five different components (e.g., sight, background sound, smell, touch, and temperature) might increase the chances that extinction treatment can generalise to a test context than if extinction treatment is conducted across several extinction contexts that are different on only one component (e.g., background sound). The greater the number of distinct cues in a context, the greater will be the chance that some of these cues will be shared with a future test context. Finally, the type of conditioning paradigm might be important, at least for human participants. It might be the case that the renewal of fear learning is more persistent and difficult to abolish than the renewal of behaviour is a conditioning procedure that does not use an aversive US, such as the task used by Havermans, Keuker, Lataster, and Jansen (2005).

The present results have a number of implications for our understanding of the renewal effect and the application of exposure therapy in the treatment of anxiety disorders. It would appear that at least some factors that underlie the renewal effect in humans and animals and its possible attenuation by multiple extinction treatments remain unknown. Further research will aid in delineating these factors and assist in generalising the prior animal research to humans. In terms of the clinical applications, it would appear that giving extinction-based treatments for anxiety disorders in multiple contexts has two implications. First, as shown by the irregular progression of extinction in the Renewal 3 and Renewal 5 groups, each switch to a new context

for a further additional exposure therapy session may lead to some amount of a return of fear. This return of fear is akin to the renewal effect in the ABC renewal procedure where the extinction learning does not readily generalise to a novel context. Second, as shown by the renewal effects found in the Renewal 3 and Renewal 5 groups, conducting exposure therapy in multiple contexts does not necessarily guarantee an attenuation of the return of fear due to a renewal effect. This is not to say that extinction conducted in multiple contexts is not going to be effective; rather it highlights that there is still much that we need to understand about the conditions under which multiple extinction treatment contexts could prove to be effective. This understanding has the potential to improve future therapeutic applications of extinction-based treatments by possibly designing procedures that are even more effective in reducing the potential for relapse.

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Figures

Figure 1. Mean percent expectancy of the shock unconditional stimulus (US) during the CS+ and CS- across the three experimental phases for the Control Group and Renewal 1 Group and Renewal 3 Group. Trials A1 to A9 are the nine trials in the Acquisition phase, Trials E1 to E9 are the nine trials in the Extinction phase, and Trials T1 to T3 are the three trials in the Test phase.

Figure 2. Mean percent expectancy of the shock unconditional stimulus (US) during the CS+ and CS- across the three experimental phases for the Renewal 5 group. Trials A1 to A10 are the 10 trials in the Acquisition phase, Trials E1 to E10 are the 10 trials in the Extinction phase, and Trials T1 to T3 are the 3 trials in the Test phase.