

The renewal of extinguished conditioned fear with fear-relevant and fear-irrelevant stimuli by a context change after extinction

Author

Neumann, David L, Longbottom, Paula L

Published

2008

Journal Title

Behaviour Research and Therapy

DOI

[10.1016/j.brat.2007.12.004](https://doi.org/10.1016/j.brat.2007.12.004)

Rights statement

© 2008 Elsevier. This is the author-manuscript version of this paper. Reproduced in accordance with the copyright policy of the publisher. Please refer to the journal's website for access to the definitive, published version.

Downloaded from

<http://hdl.handle.net/10072/21645>

Link to published version

<http://www.elsevier.com/locate/brat>

Griffith Research Online

<https://research-repository.griffith.edu.au>

Running head: FEAR RENEWAL WITH FEAR-RELEVANT STIMULI

The renewal of extinguished conditioned fear with fear-relevant and fear-irrelevant stimuli by
a context change after extinction

David L. Neumann and Paula L. Longbottom

School of Psychology, Griffith University, Australia

Corresponding author and address: David Neumann, School of Psychology, Gold Coast Campus

GRIFFITH UNIVERSITY QLD, 4222, Queensland, Australia, E-mail

D.Neumann@griffith.edu.au, Facsimile +61(0)7 5552 8291, Telephone +61(0)7 5552 8052

Abstract

The acquisition, extinction, and subsequent recovery of conditioned fear can be influenced by the nature of the conditional stimulus (CS) and the context in which the CS is presented. The combined effects of these factors were examined in a differential fear conditioning procedure with humans. Fear-relevant or fear-irrelevant CSs were followed by a shock unconditional stimulus (US) during acquisition and presented alone during extinction. The CSs were images presented upon different background contexts. Half the participants received the same context during acquisition and extinction and the remaining received different contexts. All participants received test trials in the same context as acquisition. In Experiment 1 (N = 64), a renewal of shock expectancy and skin conductance responses was found during test for fear-relevant and fear-irrelevant CSs when extinction was given in a different context. In Experiment 2 (N = 72), renewal for fear-relevant stimuli was enhanced when acquisition and test was given in an indoor office context and extinction in an outdoor bush context. The opposite context configuration produced the strongest renewal for fear-irrelevant stimuli. The return of extinguished conditioned fear can occur to fear-relevant stimuli that are commonly associated with clinical fears and its strength may be enhanced when the stimuli are encountered in certain contexts after extinction.

Keywords: conditioned fear; fear renewal; extinction; context

1. Introduction

Pavlovian conditioning has provided a useful framework for understanding the origin and treatment of phobias (Field, 2006). This framework has continued to undergo revision ever since Watson and Rayner's (1920) demonstration that fear behavior to a white rat could be acquired by pairing it with an aversive loud noise. In this example, the white rat functioned as the conditional stimulus (CS) and was associated with an aversive unconditional stimulus (US). Although organisms are readily able to acquire conditioned fear, the extinction of fear behaviors appears to be more difficult. Extinction can be produced by repeatedly presenting the feared CS on its own. However, extinction can be retarded in certain stimuli that seem particularly potent to be associated with fear (Öhman & Mineka, 2001; Mineka & Öhman, 2002; Seligman, 1971). According to the notion of preparedness, humans have inherited a genetic predisposition to associate some CS-US combinations more readily than others (see Mineka & Öhman, 2002; Öhman & Mineka, 2001 for reviews). When applied to the acquisition of phobias, humans are more likely to associate certain *fear-relevant* stimuli with aversive stimuli. As such, fear-relevant stimuli that threatened our ancestors, such as predatory or poisonous animals, may explain why phobias to threatening organisms, such as spiders and snakes, are more common than phobias to modern stimuli, such as cars and electrical outlets (Hugdahl & Johnsen, 1989).

Evidence in support of preparedness theory comes from laboratory research employing different types of stimuli as the CS. Such experiments have compared fear-relevant stimuli (e.g., images of spiders or snakes) with fear-irrelevant stimuli (e.g., images of flowers or mushrooms). A finding that corroborates preparedness theory is resistance to extinction in that fear-relevant stimuli show a slower rate in the extinction of conditioned fear than fear-irrelevant stimuli (Fredrikson, Hugdahl, & Öhman, 1976; Hugdahl, Fredrikson, & Öhman, 1977; Öhman, Fredrikson, Hugdahl, & Rimmö, 1976). The phenomenon of

resistance to extinction suggests that following acquisition, fear-relevant stimuli are slower to enter into an association that predicts the absence of the US than are fear-irrelevant stimuli. Even though complete extinction can still occur to both stimuli provided that a sufficient number of trials are made, the different rate of extinction in fear-relevant and fear-irrelevant stimuli potentially reflects different underlying processes of extinction. The fear-relevance of the CS may also influence other characteristics of extinction such as its permanency across contexts.

Research has shown that extinction does not necessarily result in a permanent loss of conditioned responses, but that it can return under certain circumstances (Bouton, Westbrook, Corcoran, & Maren, 2006). For instance, the renewal effect suggests that extinction learning is modulated by the context in which extinction treatment has been implemented. Bouton and Bolles (1979) demonstrated ABA renewal by exposing rats to pairings of a CS and a footshock US in one context (Context A), followed by extinction in a second context (Context B). Following extinction, the CS no longer evoked a conditioned fear response. When the rats were returned to the original learning context (Context A), they exhibited a renewal of conditioned fear to the CS. In comparison, low levels of conditioned fear were observed in rats that were tested in the same context that had been used for extinction (Bouton & Bolles, 1979; see also Bouton & King, 1983; Thomas & Ayres, 2004). Variations of the renewal procedure have indicated that extinction behavior is restricted to the environmental context in which it takes place (Bouton & Bolles, 1979; Bouton & Ricker, 1994). One explanation of renewal is that following extinction, the CS has become ambiguous because it is associated with the US in two ways, a CS-US and a CS-noUS association. The CS will elicit a conditioned response whenever the contextual cues do not match those experienced during extinction (Bouton, 2002; Bouton et al., 2006).

Renewal has clinical implications in that contextual cues may undermine the effectiveness of extinction-based behavioral treatments for fears and anxiety (Bouton, 2002). Phobic individuals may learn that the feared stimulus is safe only sometimes; that is, in the contexts in which the extinction treatment was implemented (Vansteenwegen et al., 2005). However, a return of fear may occur when the individual subsequently confronts the stimulus alone, in a different context. The observation of a renewal effect in a variety of human laboratory preparations, such as a conditioned suppression task (Havermans, Keuker, Lataster, & Jansen, 2005; Neumann, 2006, 2007) and a fear conditioning task (Alvarez, Johnson, & Grillon, 2007; Effting & Kindt, 2007; Neumann, Lipp, & Cory, 2007; Vansteenwegen et al., 2005; Vervliet, Vansteenwegen, Baeyens, Hermans, & Eelen, 2005) supports the relevance of renewal to clinical treatments. However, a notable aspect of this research has been the use of neutral CSs, such as images of geometric shapes (Neumann et al., 2007; Neumann, 2006; Vervliet et al., 2005). It is not known whether renewal can be observed for fear-relevant stimuli under the same conditions as when neutral stimuli are used. This question is particularly relevant given that clinical fears are typically found in response to fear-relevant stimuli such as spiders, snakes, and open spaces. Some research has demonstrated a return of fear within a clinical setting by examining spider fear (e.g., Mystkowski, Craske, & Echiverri, 2002; Mineka, Mystkowski, Hladek, & Rodriguez, 1999; Rodriguez, Craske, Mineka, & Hladek, 1999). However, as no direct comparisons between fear-relevant and fear-irrelevant stimuli were possible in these studies it remains to be specified whether the nature of the CS can impact upon the return of fear. The present research was conducted with the primary aim of examining this question.

2. Experiment 1

The aim of Experiment 1 was to examine the acquisition, extinction, and renewal of fear-related responses elicited by fear-relevant and fear-irrelevant CSs. A mild electric shock

was used as the US in four groups of participants formed by combining two levels of CS fear relevance (fear-relevant and fear-irrelevant) with two extinction contexts (ABA renewal design and AAA control design). Fear-relevant stimuli were images of snakes and spiders and fear-irrelevant stimuli were images of mushrooms and flowers. In keeping with the nature of the CSs that were used, the contexts were representative of different environments that people may encounter. An outdoor bush setting and an indoor office environment were selected. The final combination of CS and context thus consisted of photographic images of the CSs in one of the environments. The context used during the acquisition and test phases in the ABA design groups was the outdoor bush environment. The context used during extinction was an indoor office environment. This combination of contexts would represent the most simplistic example of renewal in a treatment application if it is supposed that conditioned fear to snakes or spiders is acquired by an individual in a natural environment, is extinguished in the therapists' office, only to return when the feared stimulus is encountered again in the original acquisition environment.

Skin conductance responses (SCRs) and subjective expectancy of the US were used to measure conditioned responses (Mineka & Öhman, 2002). The SCR provides a measure of the anticipatory emotional response and expectancy of the US reflects a cognitive self-report measure of conditioning. Together, these measures provided a means to compare the pattern of acquisition, extinction, and renewal of conditioned responses between fear-relevant and fear-irrelevant stimuli. It was hypothesized that fear-relevant stimuli would be associated with slower extinction of conditioned responses than fear-irrelevant stimuli. The associations learnt during extinction was not expected to transfer following a change of context (i.e., change from extinction to test) as is consistent with a renewal effect for both fear-relevant and fear-irrelevant stimuli. However, the use of different CSs will indicate whether the magnitude of the renewal effect will differ between fear-relevant and fear-irrelevant stimuli.

2.1 Method

2.1.1 Participants. The participants were 54 female and 10 male first year psychology students from Griffith University with a mean age of 21.8 years (range 17 - 51 years). Participants volunteered in return for partial course credit. Informed consent was obtained prior to participation in an experimental protocol approved by the Human Research Ethics Committee of Griffith University. Participants were randomly assigned to one of four groups such that there were the same number in each group and that the ratio of males to females was similar.

2.1.2 Apparatus. The participants' perceived aversiveness of the fear-relevant stimuli was determined using the Spider Questionnaire (SPQ) and the Snake Questionnaire (SNAQ) developed by Klorman, Weerts, Hastings, Melamed and Lang (1974). The experiment used equipment described in detail elsewhere (Boschen, Parker, & Neumann, 2007; Neumann & Waters, 2006). A PowerLab Model 4/20 data acquisition system (ADInstruments, Sydney) in conjunction with a Dell Optiplex GX260 computer was used to record responses. Expectancy of the US was obtained via a custom built dial-and-pointer that could be moved about 270° with the extreme left labeled "certain shock will occur", the middle position labeled "uncertain", and the extreme right position labeled "certain shock will not occur". Skin conductance responses were measured with an ADInstruments Model ML116 GSR Amp and MLT116F electrodes attached to the distal phalanges of the first and second finger of the nonpreferred hand. Respiration was recorded via an ADInstruments Model MLT1132 Piezo Respiratory Belt Transducer to monitor for respiratory influences (e.g., sneezes) on skin conductance responses.

The CSs were custom produced color digital photographs of a spider and snake (fear-relevant) and of flowers and a mushroom (fear-irrelevant). The spider was a female *Nephila plumipes* (coastal golden orb-weaver), with a body length (excluding legs) measuring 21 mm.

The snake was a 1.8 m rubber model of a *Pseudechis porphyriacus* (red-bellied black snake). The mushroom was a *Chlorophyllum molybdite* (green-spored parasol) with a 10 cm diameter cap and the flowers were selected from the *Tibouchinas* (jazzie) plant. All these organisms can be found in the region in which the experiment was conducted. There were two different contexts in which the stimuli were photographed: an outdoor bush environment containing grass, leaves, rocks, and soil, and an indoor office environment containing a desk, shelves, books, and carpet. All fear-relevant and fear-irrelevant CSs were photographed in each of these contexts. Eight digital photographs were obtained for each combination of CS and context as well as for the contexts alone in order to maintain variety in the images that were shown. The resulting images were projected onto the white screen situated 1.5 m from the participant using a Panasonic Model PT-L557E LCD projector and were 1.8 m wide x 1.2 m high. The shock US was a 200 ms electrotactile stimulus delivered by an IWORX SI100 stimulus isolator via two disposable ADInstruments MLA1010B Ag/AgCl electrodes applied to the inside of the participants preferred forearm. The intensity was set at an individual level for each participant. Starting at an intensity of zero, 200 ms presentations of the electro-tactile stimulus were delivered while gradually increasing the intensity, until the participant reported that the stimulus was “unpleasant, but not painful”.

2.1.3 Procedure. After providing informed consent, participants were guided into a sound-attenuated room and the experiment was monitored via a closed circuit video camera in an adjoining room. Participants next completed the SPQ and the SNAQ after which the electrodes were applied. The intensity of the shock US was next set. Participants rested quietly for three minutes to provide for a stable baseline for the physiological responses. Participants were informed that they will be shown pictures on the screen in front of them, and that their bodily reactions will be recorded. They were also instructed that they would

receive a shock stimulus at various times throughout the experiment and that they should use the dial-and-pointer to indicate their expectation of the shock.

A differential conditioning paradigm (Öhman et al., 1976) was used whereby participants in the fear-relevant groups were given presentations of one stimulus (e.g., snake) followed by an aversive US (CS+), whereas another equally fear-relevant stimulus (e.g., spider) was not followed by the aversive US (CS-) during acquisition. Similarly, participants in the fear-irrelevant groups were presented with different fear-irrelevant stimuli as the CS+ and CS- (e.g., images of flowers and mushrooms). The nature of which CS served as the CS+ and CS- in each fear-relevance group was counterbalanced. The differential conditioning design controls for the fact that fear-relevant stimuli are more prepotent than fear-irrelevant stimuli (Mineka & Öhman, 2002). The conditioning procedure is shown in Table 1 for each of the four groups. Initially, participants were pre-exposed to the CS+ and CS- without the US in context A. The second phase, acquisition, was also completed in context A. The next phase was extinction. The Fear-relevant AAA and Fear-irrelevant AAA groups received the CS+ and CS- alone in Context A. The Fear-relevant ABA and Fear-irrelevant ABA groups received the same trial presentations in Context B. Participants also received exposures to the context alone, without presentations of the CS or US to control for the possibility that the context can serve as a cue for the US to produce renewal in an ABA design. The extinction and context exposure trials were also intermixed such that there were four periods of extinction and four periods of context exposure. Following extinction and context exposure, the test phase was undertaken. Throughout all phases of the experiment, the outdoor bush environment was used as Context A and the indoor office environment was used as Context B. In addition, the order of the CS+ and CS- presentations were randomized with the restriction that the first two presentations in each phase was a CS+ and CS- trial, and that the nature of the first stimulus presented in each phase (CS+ or CS-) was counterbalanced. The

CS lasted 8 s, and the US onset coincided with the CS offset. The intertrial interval (CS offset to CS onset) was randomly varied between 20, 25, and 30 s.

 Insert Table 1 about here

2.1.4 Response quantification. The number of spontaneous phasic skin conductance responses, defined as responses that exceed 0.05 μ S, elicited during the rest period were counted. A one-way ANOVA confirmed that there were no significant differences between the four groups, $F(3, 60) = 1.31, p = .28$. Expectancy of the US was scored as the deflection from the middle “uncertain” level at the end of the CS presentation. The deflections were converted to a percentage change from the uncertain baseline such that -100% indicated “*certain of no shock*”, 0% indicated “*uncertain*”, and +100% indicated “*certain of shock*”. Skin conductance response magnitude was quantified as those responses that began within a latency window of 1 to 4 s after CS onset. Response magnitude was measured as the difference between trough and apex of the curve. Responses containing respiratory artifact were scored as missing and subsequently replaced with estimates based on the mean of the response of the trial preceding and following the missing trial to enable a trial-by-trial analysis of skin conductance responses. Less than 2.5% of responses were replaced. The skin conductance responses were square root transformed in order to normalize the distributions prior to statistical analysis (Venables & Christie, 1980).

2.2 Results

There were no differences between the groups in the scores for the SPQ and SNAQ or the final shock level selected, as assessed by separate one-way ANOVAs, all $F_s < 2.0, p > .05$. The mean shock expectancy and SCRs for the acquisition, extinction, and test phases are shown in Figures 1 and 2, respectively. Statistical analyses were conducted separately for

each phase of the experiment and to examine the transfer of learning from extinction to test¹. Pairwise comparisons were used for further investigation of significant effects by using *t*-tests that were adjusted for the accumulation of Type I error by using Šidák's multiplicative inequality (Games, 1977).

2.2.1 Pre-exposure phase. The pre-exposure phase was examined with separate 2 x 2 x 2 x 2 (Fear relevance x Design x CS x Trial) ANOVAs for the two measures. Expectancy of the shock was greater for the fear-relevant stimuli than for fear-irrelevant stimuli, main effect for Fear relevance, $F(1, 60) = 38.21, p < .0005, \eta_p^2 = .39$, and Fear relevance x Design x CS interaction, $F(1, 60) = 6.58, p = .013, \eta_p^2 = .10$. The interaction reflected that expectancy of the shock during the CS- was lower than during the CS+ for the fear-irrelevant group that received the AAA design, $t = 3.08, p < .05$, whereas the difference between the CSs was not significant for any other groups, all $t_s < 1.49, p > .05$. The apparent difference between the CSs in the fear-irrelevant AAA group, however, was not present by the first acquisition trial as shown by little difference between the CS+ and CS- on trial A1 in Figure 1. The analyses for the SCRs yielded a main effect for Trial, $F(1, 60) = 72.95, p < .0005, \eta_p^2 = .55$, indicating that responses declined across trials.

2.2.2 Acquisition phase. The shock expectancy and SCRs during the acquisition trials were examined with separate 2 x 2 x 2 x 8 (Fear relevance x Design x CS x Trial) ANOVAs. As shown in Figure 1, expectancy of the US developed during the CS+, whereas expectancy of no US developed during the CS- across the acquisition trials, as confirmed by a CS x Trial interaction, $F(7, 420) = 70.33, \epsilon = .67, p < .001, \eta_p^2 = .54$. The fear-relevant groups also differed from the fear-irrelevant groups, as supported by a main effect for Fear Relevance, $F(1, 60) = 7.22, p = .01, \eta_p^2 = .11$, and a Fear Relevance x CS x Trial interaction, $F(7, 420) = 2.50, \epsilon = .67, p = .03, \eta_p^2 = .04$. Post hoc analyses showed that the fear-relevant groups had a higher expectancy of the US than the fear-irrelevant groups for the CS+ on the first

acquisition trial, $t = 4.29, p < .01$, and for the CS- on acquisition trials 1 to 5 inclusive, all $ts > 3.17, p < .05$, whereas no other trials differed, $ts < 1.65, p > .05$.

 Insert Figures 1 and 2 about here

The mean SCRs during the acquisition phase were larger during the CS+ than during the CS- as shown by a CS x Trial interaction, $F(7, 420) = 5.48, \varepsilon = .77, p < .001, \eta_p^2 = .08$, to support the acquisition of conditioned responses. Unlike the US expectancy measure, the fear-relevant and fear-irrelevant groups did not differ in SCR magnitude, all $F_s < 1.26, p > .05$.

2.2.3 Extinction phase. During the extinction trials, expectancy of no US developed during the CS+. A $2 \times 2 \times 2 \times 8$ (Fear relevance x Design x CS x Trial) ANOVA confirmed this impression with a CS x Trial interaction, $F(7, 420) = 17.55, \varepsilon = .67, p < .001, \eta_p^2 = .23$. The difference between the CS+ and CS- also varied as a function of extinction context, as shown by a Design x CS interaction, $F(1, 60) = 13.20, p < .001, \eta_p^2 = .18$. Post hoc analyses showed that US expectancy was lower in the groups that received a change of context during extinction (ABA design) than in the groups that did not receive a change of context (AAA design), for the CS+, $t(60) = 3.49, p < .05$, but not for the CS-, $t = 1.42, p > .05$. In addition, there was a Fear Relevance x Design interaction, $F(1, 60) = 6.78, p = .01, \eta_p^2 = .10$. The interaction suggested that the higher expectancy of shock during fear-relevant stimuli was present only when there was a context change during extinction (i.e., the ABA design groups), $t = 3.35, p < .05$. There were no differences between fear-relevant and fear-irrelevant stimuli when the extinction context was unchanged (i.e., the AAA design groups), $t = 0.39, p > .05$. The SCRs during extinction were examined with a $2 \times 2 \times 2 \times 8$ (Fear relevance x Design x CS x Trial) ANOVA. The analyses yielded a main effect for CS, $F(1, 60) = 26.52,$

$p < .001$, $\eta_p^2 = .31$, and a main effect for Trial, $F(7, 420) = 4.14$, $\epsilon = .73$, $p = .001$, $\eta_p^2 = .07$. However, no differences were found as a function of fear relevance or context change, all F s < 1.30 , $p > .05$.

2.2.4 Transfer from extinction phase to test phase. Two tests were conducted to examine the amount of renewal observed in the test phase. The first compared Trials E8 and T1 with $2 \times 2 \times 2 \times 2$ (Fear relevance \times Design \times CS \times Trial) ANOVAs. The analyses for US expectancy yielded a Design \times CS \times Trial interaction, $F(1, 60) = 20.92$, $p < .001$, $\eta_p^2 = .26$. Expectancy of the US during the CS+ significantly increased in the transition from trial E8 to T1 in the ABA design groups, $t(60) = 9.05$, $p < .05$, but not during the CS+ for the AAA design group or during the CS- for any group, all t s < 0.85 , $p > .05$. The analyses also indicated that the fear relevance of the CSs had a marginal effect as shown by a Fear relevance \times Design \times Trial interaction, $F(1, 60) = 3.70$, $p = .07$, $\eta_p^2 = .05$.

The examination of SCRs between trials E8 and T1 resulted in Design \times CS \times Trial interaction, $F(1, 60) = 12.59$, $p = .001$, $\eta_p^2 = .17$. Comparisons revealed significantly larger SCRs during the CS+ on trial T1 than on trial E8 in the ABA renewal groups, $t(60) = 7.03$, $p < .05$. No significant differences between trials were found for the CS- for the ABA renewal groups or for the CS+ and CS- for the AAA control groups, all t s $< .62$, $p > .05$. The fear-relevance of the CS also produced a marginal effect as shown by the Fear Relevance \times Design \times CS interaction, $F(1, 60) = 2.88$, $p = .09$, $\eta_p^2 = .046$.

2.2.5 Test phase. The second test for renewal compared between the CSs across the three test trials with a $2 \times 2 \times 2 \times 3$ (Fear relevance \times Design \times CS \times Trial) ANOVA. Expectancy of the US varied as a function of the context change, as indicated by a Design \times CS interaction, $F(1, 60) = 10.38$, $p = .002$, $\eta_p^2 = .15$. Post hoc analyses confirmed the renewal effect in that that US expectancy was greater for the ABA design groups than for the AAA design groups for the CS+, $t(60) = 6.18$, $p < .05$, but not for the CS-, $t = 1.62$, $p < .05$.

A marginal Fear-relevance x CS interaction, $F(1, 60) = 3.54, p = .06, \eta_p^2 = .056$, was also found.

The magnitude of SCRs during the test phase yielded a Design x CS x Trial interaction, $F(1, 120) = 6.66, p = .002, \eta_p^2 = .10$. Post hoc analyses confirmed that responses in the ABA design groups were larger during the CS+ than during the CS- for the first test trial, $t = 6.51, p < .01$, but not on subsequent trials, both $ts < 0.52, p > .05$. The differences between the CS+ and CS- for the AAA design groups were not significant for any trial, all $ts < 1.10, p > .05$. All effects involving the Fear-relevance factor failed to reach significance, all $F_s < 1, p > .05$.

2.3 Discussion

The aim of the present experiment was to examine the effects of context changes during the extinction and subsequent renewal test for fear-relevant and fear-irrelevant CSs. The fear relevance of the CSs was shown to influence expectancy of the shock in that there was a higher expectancy for fear-relevant stimuli than for fear-irrelevant stimuli during pre-exposure and early during acquisition. In addition, the context changes influenced conditioned responses during extinction and during the transition from extinction to test. The latter effects show that the way in which context was manipulated in the present experiment, by using different background scenes upon which the CSs were photographed, was successful. A renewal of extinguished conditioned responses was observed as an increase in conditioned responses to the CS+ on the first test trial compared to the last extinction trial and larger conditioned responses to the CS+ than to the CS- during the test trials. The present results show that a renewal of conditioned fear responses can be observed when fear-relevant organisms are used as the CSs.

The effect of the CS fear-relevance during the context change from extinction to test was more limited. Visual inspection of Figure 1 and 2 suggests that the renewal effect was

larger in the ABA design that used fear-irrelevant stimuli than in the ABA design that used fear-relevant stimuli. Supporting this comparison of the means is an evaluation of the effect size for the difference between the CS+ and CS- on the first test trial. For example, the effect size (η_p^2) for the difference in SCRs on the first test trial was .53 for the fear-irrelevant stimuli, but only .26 for the fear-relevant stimuli. However, the interactions involving the required factors of fear-relevance and context change just fell short of statistical significance. The effect of fear-relevance on the renewal effect may have been artificially reduced because the extinction treatment was not sufficiently extensive. During extinction, fear-relevant stimuli were associated with an overall higher expectancy of shock than fear-irrelevant stimuli in the ABA design groups. Importantly, this effect did not interact with trials such that by the end of extinction, the fear-relevant stimuli may have been associated with a greater expectation of shock than fear-irrelevant stimuli, though both had reduced relative to that at the end of acquisition. A similar complication emerges with the SCRs, although no overall effect of fear-relevance during extinction was observed. Taking the results together, it would seem that eight extinction trials may not have been sufficient to produce equivalent and complete extinction of conditioned fear for the fear-relevant and fear-irrelevant stimuli. The next experiment thus aimed to provide a more complete extinction of conditioned fear.

3. Experiment 2

The present experiment extended the methods of Experiment 1 in two ways. First, 12 extinction trials were used, in comparison to the 8 extinction trials used in Experiment 1. It was expected that the longer extinction training would result in the complete extinction of conditioned fear responses to both fear-relevant and fear-irrelevant CSs prior to the renewal test. Second, the combination of CS and context used in each phase of the experiment was varied. In Experiment 1, the nature of the context used in the acquisition, extinction, and test phases was kept constant for all participants in the ABA design groups. That is, the context

used during the acquisition and test phases in these groups was the outdoor bush environment. The context used during extinction was an indoor office environment. The nature of the contexts used in the different phases was orthogonally manipulated in Experiment 2 to test whether the renewal effect could be influenced by the combination of the CS and context that is used. The present experiment thus tested the effects of different combinations of CS and context by using both fear-relevant and fear-irrelevant CSs presented in an outdoor bush setting or an indoor office setting during different phases of an AAA and an ABA renewal design.

3.1 Method

3.1.1 Participants. Fifteen male and 59 female first year students from Griffith University participated. The participant's ages ranged from 17 to 48 years ($M = 23.8$ years) and none had participated in Experiment 1. The data from one male and one female participant was unavailable due to equipment error. The participants were randomly allocated to one of eight groups with a similar number of males and females in each group.

3.1.2 Apparatus and Procedure. The apparatus and procedure replicated that used in Experiment 1 except in the type of participant groups, the nature of the CSs and contexts that were used, and the number of trials presented during the extinction and context exposure phases. Like Experiment 1, there were 2 presentations each of the CS+ and CS- in pre-exposure and 8 presentations each of the CS+ and CS- during acquisition. In extinction, however, there were 12 presentations each of the CS+ and CS- intermixed with 12 presentations of a context alone. Similar to Experiment 1, the CS and context alone presentations were intermixed by presenting them in groups of four.

There were eight groups formed by the crossing of CS type (fear-relevant and fear-irrelevant), context design (AAA and ABA), and the type of context (outdoor bush context or indoor office context) used in the different phases of the design. Half the participants were

presented with fear-relevant stimuli (spider and snake) as the CS+ and CS- and the remaining participants were presented with fear-irrelevant stimuli (flowers and mushroom). Half the participants in each fear-relevance group were presented with the ABA context design, whereas the remaining half received the AAA context design. Similar to Experiment 1, all groups received equivalent exposure to the two extinction contexts used in each group. Finally, half the participants in each of the four resulting combinations of fear relevance and context design received the CS presentations upon an outdoor bush context for the pre-exposure, acquisition, and test phases (i.e., context A). The remaining participants received the CS presentations upon an indoor office context for these three phases. The context upon which the CSs were presented in extinction depended on the design of the group. The AAA design received the CSs presented upon the same context as the acquisition and test contexts. The ABA design received presentations of the CSs in the alternative context as the acquisition and test contexts. For instance, those that received the outdoor bush context in acquisition and test received the indoor office context in extinction.

3.2 Results

The groups did not differ in the final shock level, scores on the SPQ and SNAQ, and the number of spontaneous skin conductance responses during the rest period, all $F_s < 1.66$, $p > .05$. Preliminary analyses indicated that two participants did not develop expectancy of the shock during the CS+ in acquisition. These participants were removed from all further analyses. The mean shock expectancy and skin conductance responses during each phase of the experiment in each group are shown in Figures 3 and 4, respectively.

 Insert Figures 3 and 4 about here

3.2.1 Pre-exposure phase. Analyses for the pre-exposure phase were conducted for the shock expectancy and SCRs with separate $2 \times 2 \times 2 \times 2 \times 2$ (Fear relevance x Design x Context type x CS x Trial) ANOVAs. The expectancy of the shock was greater during the fear-relevant stimuli than during the fear-irrelevant stimuli, main effect for Fear-relevance, $F(1, 62) = 22.80, p < .0005, \eta_p^2 = .27$. The nature of the context also influenced shock expectancy as reflected in a Fear relevance x Context type interaction, $F(1, 62) = 5.03, p = .029, \eta_p^2 = .08$. The effect of fear relevance was much greater when the CSs were presented in an indoor office context, $t = 4.79, p < .01$, than when presented in an outdoor bush context, $t = 1.72, p > .05$. The analyses for the SCRs resulted in a CS x Trial interaction, $F(1, 62) = 5.42, p = .023, \eta_p^2 = .08$, but no significant effects that involved the Fear relevance or Context type factors.

3.2.2 Acquisition phase. A $2 \times 2 \times 2 \times 8$ (Fear relevance x Design x Context type x Trial) ANOVA was conducted separately for the US expectancy and SCRs for acquisition. The acquisition of shock expectancy was confirmed by a CS x Trial interaction, $F(7, 434) = 54.14, \varepsilon = .74, p < .0005, \eta_p^2 = .47$. The nature of the context influenced expectancy judgments as reflected in a Fear-Relevance x Context type x Trial interaction, $F(7, 434) = 2.27, p = .049, \eta_p^2 = .035$. The three-way interaction was due to higher expectation of shock early during acquisition for CS presentations made in the indoor office context than for presentations made in the outdoor bush context for fear-relevant CSs, $t = 5.22, p < .01$, but not for fear-irrelevant CSs, $t = .01, p > .05$. There were no other significant effects on subsequent trials, all $ts < 1.61, p > .05$. A Fear-relevance x Trial interaction, $F(7, 434) = 2.74, p = .02, \eta_p^2 = .04$, reflected that there was greater expectation of shock during fear-relevant stimuli than during fear-irrelevant stimuli on the first acquisition trial, $t = 5.62, p < .01$, but not on subsequent trials, all $ts < 1.74, p > .05$.

The development of conditioned SCRs was confirmed by a CS x Trial interaction, $F(7, 434) = 8.26, p < .0005, \eta_p^2 = .12, \varepsilon = .84$. As can be seen in Figure 4, a difference in SCRs emerged across acquisition such that SCRs were larger during the CS+ than during the CS- on the final acquisition trials.

3.2.3 Extinction phase. A $2 \times 2 \times 2 \times 2 \times 12$ (Fear-relevance x Design x Context type x CS x Trial) ANOVA confirmed the extinction of shock expectancy, CS x Trial interaction, $F(11, 682) = 22.37, p < .0005, \eta_p^2 = .27, \varepsilon = .44$. Some groups appeared to differ in the rate of extinction, as reflected in a Design x Trial interaction, $F(1, 682) = 3.79, p = .003, \eta_p^2 = .06$. The latter interaction reflected that overall shock expectancy was lower in the ABA design groups on extinction trials 2 to 7, all $t_s > 3.35, p < .05$, whereas there was no significant differences on any other trials, all $t_s < 1.60, p > .05$. The extinction of SCRs during extinction was confirmed by a CS x Trial interaction, $F(11, 682) = 2.03, p = .03, \eta_p^2 = .03$.

3.2.4 Transfer from extinction phase to test phase. Separate $2 \times 2 \times 2 \times 2 \times 2$ (Fear-relevance x Design x Context type x CS x Trial) ANOVAs were used to compare the last extinction trial and the first test trial for the shock expectancy and SCRs. The analyses for shock expectancy indicated that a renewal effect was present, Design x CS x Trial interaction, $F(1, 62) = 68.65, p < .0005, \eta_p^2 = .52$. Post hoc analyses confirmed that shock expectancy during the CS+ increased from the last extinction trial to the first test trial in the ABA design groups, $t = 17.21, p < .01$, whereas the change across trials for the CS- was not statistically significant, $t = 2.13, p > .05$. There were no differences across trials for either CS in the AAA design groups, both $t_s < 0.84, p > .05$. A Fear-relevance x Design x CS x Trial interaction, $F(1, 62) = 5.86, p = .018, \eta_p^2 = .09$, was also found. The interaction indicated that the increase in shock expectancy from extinction to test for the CS+ was significant for the ABA design when the fear-relevant and fear-irrelevant CSs were used, both $t_s > 10.59, p < .05$. However,

only the ABA design group that also received the fear-relevant CSs showed an increase in shock expectancy across trials for the CS-, $t = 3.48, p < .05$, suggesting that renewal of the learned discrimination was smaller with fear-relevant stimuli.

The renewal of conditioned responding was also evident in the SCRs. The analyses confirmed this with a Design x CS x Trial interaction, $F(1, 62) = 10.59, p = .002, \eta_p^2 = .15$. Examination of the three-way interaction showed that SCRs increased from acquisition to test for the CS+, $t = 7.67, p < .01$, but not for the CS-, $t = 1.94, p > .05$ in the ABA design groups. There were no differences between trials for either the CS+ and CS- in the AAA design groups, both $ts < 0.31, p > .05$. An interaction between all factors also emerged as shown by a Fear-relevance x Design x Context type x CS x Trial interaction, $F(1, 62) = 6.84, p = .01, \eta_p^2 = .10$. This interaction was examined by making comparisons across each trial for the CS+ and CS- in each individual group. The comparisons revealed that all groups that received the AAA design did not show any significant change from extinction to test for either CS, all $ts < 0.62, p > .05$. However, there was a significant change across trials in some groups that received the ABA design. The increase in SCRs for the CS+ across trials was large and significant for fear-relevant stimuli presented in the indoor office context during acquisition and test, $t = 5.52, p < .01, \eta_p^2 = .57$, and for fear-irrelevant stimuli presented in the outdoor bush context during acquisition and test, $t = 5.23, p < .01, \eta_p^2 = .56$. The change across trials for the CS+ was smaller and not statistically significant for the fear-relevant stimuli presented in the outdoor bush context for acquisition and test, $t = 2.38, p > .05, \eta_p^2 = .36$, and for the fear-irrelevant stimuli presented in the indoor office context during acquisition and test, $t = 1.93, p > .05, \eta_p^2 = .19$. The change across trials for the CS- for all fear-relevance and context type combinations was not significant, all $ts > 1.94, p > .05$.

3.2.5 Test phase. A 2 x 2 x 2 x 2 x 3 (Fear-relevance x Design x Context type x CS x Trial) ANOVA conducted for the shock expectancy and SCRs confirmed that a renewal of

shock expectancy was found, Design x CS x Trial interaction, $F(2, 124) = 8.66, p = .001, \eta_p^2 = .12, \epsilon = .86$. The fear-relevance of the CSs also influenced shock expectancy during the test phase as shown by a Fear-relevance x Design x CS x Trial interaction, $F(2, 124) = 4.18, p = .023, \eta_p^2 = .06, \epsilon = .86$, and a Fear-relevance x Context type x CS interaction, $F(1, 62) = 4.08, p = .048, \eta_p^2 = .062$. The interaction between fear-relevance, context type, and CS was due to no differences between the CS+ and CS- for any of the AAA design groups, all $t_s < 2.21, p > .05$. However, for the ABA design groups, the difference between the CS+ and CS- for the fear-relevant stimuli yielded a larger effect size when acquisition and test used an indoor office context, $t = 7.72, p < .01, \eta_p^2 = .69$, than an outdoor bush context, $t = 4.09, p < .05, \eta_p^2 = .24$. In contrast, the difference between the CS+ and CS- for the fear-irrelevant stimuli yielded a larger effect size when acquisition and test were presented in the outdoor bush context, $t = 12.06, p < .01, \eta_p^2 = .99$, than the indoor office context, $t = 9.61, p < .01, \eta_p^2 = .69$. Thus, while the renewal of US expectancy was present in all groups with an ABA context change design, the size of the effect varied as a function of the interaction between fear-relevance and context type.

The analyses on the three test trials for the SCRs also confirmed that the renewal effect was present with a Design x CS x Trial interaction, $F(2, 124) = 3.46, p = .037, \eta_p^2 = .05, \epsilon = .94$. A Fear-relevance x Design x Context type x CS x Trial interaction, $F(2, 124) = 4.12, p = .02, \eta_p^2 = .06, \epsilon = .94$, reflected that there were no significant differences between the CSs on any trials in the groups that received the AAA design, all $t_s < 1.96, p > .05$. In the ABA design groups that received the fear-relevant stimuli, the difference between CS+ and CS- on the first test trial had a larger effect size and was statistically significant for the indoor office context, $t = 5.70, p < .01, \eta_p^2 = .47$, but not significant for the outdoor bush context, $t = 2.39, p > .05, \eta_p^2 = .06$, used in acquisition and test. For the ABA design groups that received the fear-irrelevant stimuli, the larger SCRs for the CS+ than the CS- on the first test trial was

significant for acquisition and test presentations in the outdoor bush context, $t = 3.84, p < .05$, $\eta_p^2 = .39$, but not significant for presentations in the indoor office context, $t = 3.11, p > .05$, $\eta_p^2 = .37$.

3.3 Discussion

The present experiment, which included 12 extinction trials, compared to the 8 extinction trials used in Experiment 1, resulted in a much more pronounced reduction in conditioned fear responses during the extinction phase for both the fear-relevant and fear-irrelevant stimuli. Similar to Experiment 1, the context change influenced overall expectancy during extinction in that the groups that received a context change during extinction (ABA design groups) showed an overall lower expectation of the US than the groups that did not receive a context change (AAA design groups) for the CS+. The effect of the change in context from extinction to test resulted in a number of significant effects. Replicating the results of Experiment 1, a renewal effect was observed in that higher shock expectancy and larger SCRs to the CS+ emerged on first test trial relative to the CS+ on the last extinction trial and relative to the CS- on the first test trial. The present results confirm that a renewal of extinguished conditioned fear can be found for fear-relevant stimuli when extinction is conducted in a different context to subsequent test trials.

An intriguing new finding emerged in the present experiment. The results yielded several interactions that tentatively suggest that the magnitude of the renewal effect was influenced by the combination of the CS fear-relevance and context type presented during acquisition, extinction, and test. This effect was seen most clearly in the SCRs, but was also present with the US expectancy measure. The renewal effect for fear-relevant stimuli was statistically reliable and largest in magnitude when acquisition and test trials were conducted in an indoor office context and extinction was conducted in an outdoor bush context. In contrast, the renewal effect for fear-irrelevant stimuli was largest and most reliable when

acquisition and test trials were conducted in an outdoor bush context and extinction was conducted in an indoor office context. This latter result of finding a larger renewal effect with fear-irrelevant stimuli presented in an outdoor bush context during acquisition and test replicates the pattern of results that emerged in Experiment 1 (see Figures 1 and 2). The fact that the relevant interactions in Experiment 1 were only marginally significant may reflect that extinction was less complete than in Experiment 2. Taking the results of present research together, it would seem that the magnitude of the renewal effect can be influenced by the fear-relevant nature of the CS when certain types of contexts are used in the acquisition, extinction, and test phases.

4. General Discussion

The present research sought to examine the effects of context changes on the extinction and subsequent renewal of conditioned behavior with fear-relevant and fear-irrelevant CSs. It has extended previous human renewal studies by being the first to combine the renewal effect with fear-relevant CSs. Presenting acquisition trials in one context and extinction trials in a second context resulted in a renewal of extinguished SCRs and expectancy of the US upon a return to the original learning context for fear-relevant and fear-irrelevant CSs. The present research thus provides the first demonstration of the return of extinguished conditioned behavior with fear-relevant stimuli in an ABA renewal design. The present task design complements research that has used human participants selected on the basis of pre-existing fears, and for which there is no experimental acquisition phase (e.g., Mystowski et al., 2002; Mineka et al., 1999; Rodriguez et al., 1999). In these studies, participants with self-reported fear of spiders showed a return of fear responses following exposure therapy when exposed to the feared object in a different context to which the treatment took place. The present research has replicated the return of fear effect with fear-relevant stimuli within an experimental procedure that provided greater control over the

contexts encountered during the acquisition of the conditioned response. It would be instructive to examine whether a return of fear would be supported with fear-relevant stimuli when used within an ABC or AAB renewal design. The present research in combination with the clinically based studies would suggest that a return of fear would be observed.

The present research also extends prior investigations of renewal by the way in which the context was operationalized. First, the contexts were more representative of real environments than those used in most previous experiments. For instance, presenting an outdoor environment of grass and leaves presents greater ecological validity than combinations of colored background lights and musical sounds (e.g., Neumann et al., 2007). The approach used in the present research was to present the context only when the CS was also presented. An alternative approach, and one that may be even more naturalistic, could be to present images of the context continuously with the discrete presentations of the CS superimposed on top of these images. Second, it was shown that using photographs of a CS within different contexts is an effective means by which context can be manipulated. In the present experiments, two contexts were used: an indoor office environment and an outdoor bush environment. However, multiple photographs of these contexts were taken. While the pictures for each context type were similar in their general features (e.g., presence of grass, rocks, leaves), the use of multiple photographs would have helped ensure that no specific feature of the contextual background (e.g., a uniquely shaped rock) would be associated with the US. Instead, common features of the background (e.g., grass, dirt, rocks) would be combined within a schema (Rumelhart, 1984) for that context (e.g., outdoor bush environment). Third, the present research examined unique combinations of CSs and contexts by using an outdoor bush and indoor office context. This general approach could be extended in future investigations. For instance, the use of manufactured objects that can be associated

with aversive events, such as an electrical outlet, may offer a means to use a CS that is more likely to be encountered in an indoor office context.

Several differences emerged between fear-relevant and fear-irrelevant stimuli during the pre-exposure, acquisition, extinction, and test phases. During the pre-exposure phase, expectancy of the US was higher for fear-relevant stimuli than for fear-irrelevant stimuli in Experiment 1 and 2. These findings suggest that the participants were more likely to associate fear-relevant stimuli with an aversive outcome prior to any pairings of the CS and US. During acquisition, there was also higher expectation of the shock during fear-relevant stimuli than during fear-irrelevant stimuli in Experiment 1. This finding supports the notion that humans easily learn to associate fear-relevant stimuli with aversive events (Seligman, 1971; see also Mineka & Öhman, 2002). Moreover, the difference in shock expectancy between fear-relevant and fear-irrelevant stimuli during acquisition in Experiment 2 was greater when the CSs were presented in an indoor office environment than in an outdoor bush environment. This difference may reflect that the unusual combination of an organism (CS) in an office (context) increased attention to the unique feature of the display, including the CS, resulting in an enhanced effect of prepared learning. During extinction, there was some evidence that fear-relevant stimuli are more resistant to extinction than fear-irrelevant stimuli (see Mineka & Öhman, 2002). In Experiment 1, participants were more likely to expect the shock US during fear-relevant stimuli than for fear-irrelevant stimuli in extinction, although this effect was limited to those participants that received a context change during extinction (i.e., ABA design) and was not replicated in Experiment 2. The fact that the resistance to extinction effect was limited to participants that received a context change during extinction is intriguing and may suggest that the contextual change increased attention to the fear-relevant nature of the stimulus, thus enhancing the resistance to extinction effect.

During the test phase, the results of Experiment 2 suggested that the magnitude of the renewal effect for fear-relevant stimuli depended on the interaction between the CS and the context. Bouton's (2004, Bouton et al., 2006) explanation of renewal suggests that contextual cues assume importance during the extinction phase. In contrast, acquisition learning is thought to be less context dependent, such that if the CS is presented in the same context as acquisition or a novel context, larger conditioned responses are elicited. A similar emphasis on the contextual cues presented during extinction was made by Darby and Pearce (1995). In their explanation of renewal, the contextual stimuli are not processed until there is surprise produced by the absence of the US during extinction. The surprise of the US omission increases attention to the contextual cues and results in one unitary CS-context representation developing an inhibitory association with the US. These two models of renewal thus suggest that the contextual cues present during acquisition had relatively little influence on conditioned responses, although it may not necessarily rule out the possibility that contextual cues were processed to some extent (e.g., see Effting & Kindt, 2007, for evidence that contextual cues influences acquisition in a fear conditioning procedure with humans).

The renewal effect was largest for fear-relevant stimuli when the nature of the CS and extinction context was *congruent* (i.e., an organism presented in the natural environment as in "snakes in the grass"). In this situation, the association with the outcome during extinction (i.e., CS+noUS association) may have been unexpected based on a schema an individual might have of a situation in which one will typically experience snakes and spiders. This elicitation of surprise may have increased attention to the contextual cues that accompanied the CS during extinction to result in a larger renewal effect upon a removal from the extinction context for fear-relevant stimuli in comparison to fear-irrelevant stimuli. In contrast, the renewal effect for fear-relevant stimuli was smaller than for fear-irrelevant stimuli when the extinction context was an indoor office environment. In this situation, the

fact that the fear-relevant CSs were not followed by an aversive event in an indoor office environment would have elicited some surprise because the contingency had changed.

However, the surprise may have relatively limited because such a change may make sense to the participant's current schema (e.g., people rarely encounter or are bitten by snakes in offices, but they can be in a bush environment). The reduced attention to the contextual cues resulted in a reduction in the magnitude of the renewal effect during the test phase for the fear-relevant stimuli relative to fear-irrelevant stimuli.

The present interpretation, that the effect of CS fear-relevance is influenced by the congruency between the CS and context, while speculative is more consistent with a cognitive or ontogenetic position for conditioning with fear-relevant stimuli. That is, the effect of fear-relevance on renewal reflects not so much an innate predisposition to associate certain fear-relevant stimuli with an aversive stimulus, but with the amount of surprise elicited within a particular context. Such expectations are more likely to have developed from prior ontogenetically based associations to the stimuli and context used (e.g., indoor office environments were not part of our evolutionary history). The distinction between these two positions, while not necessarily exclusive, is important in terms of the clinical implications of renewal as a mechanism for relapse. The cognitive interpretation may be more amenable to providing cognitive strategies to accompany extinction treatment that aim to reduce the potential for relapse when the feared stimulus is encountered in various contexts. Based on the present results, this would be particularly important when the feared stimulus is encountered in an unexpected or artificial context because such a situation may increase attention to contextual cues and bring about a return of fear. One way in which the relative contributions of prepared learning versus a cognitive evaluation account on renewal could be evaluated is by presenting fear-relevant and fear-irrelevant stimuli using a masking procedure (see Mineka & Öhman, 2002). A cognitive interpretation would suggest that the interaction

between fear-relevance and context would be eliminated because the masking procedure would prevent the conscious evaluation of the fear-relevant nature of the stimulus and the context it is presented in.

The treatment of anxiety and fears presents an ongoing challenge as researchers endeavor to elucidate the factors contributing to the relapse of extinguished fear responses (Waters & Craske, 2005). The renewal effect has been highlighted as a potential mechanism by which a return of fear (relapse) can emerge following exposure therapy for behavior problems (Bouton, 2002). Prior research in which renewal was demonstrated in participants who underwent exposure treatment for a self-reported fear of spiders (e.g., Mystowski et al., 2002; Mineka et al., 1999; Rodriguez et al., 1999) has provided evidence consistent with this claim. The present research also supports this conclusion by showing that the fear-relevant stimuli of snakes and spiders can be associated with a renewal of extinguished fear-responses within an experimental setting. Moreover, the present research has shown that the magnitude of the renewal effect may be influenced by the exact nature of the combination between the feared object and the context. Relapse following exposure therapy for feared objects like snakes and spiders may be particularly likely to occur if the feared object is encountered in an unusual context, even if extinction treatment is given in a context in which the animals are normally encountered. However, it should be noted that this conclusion is based on the present task that used an ABA renewal design and a selected group of participants that report low to moderate fear of snakes and spiders. As such, further research is warranted to explore the effects of different contexts on fear renewal within other renewal designs, particularly the ABC renewal design that would be more likely to be encountered in a real world example of relapse via a renewal effect, and within a clinical setting with participants that report a high level of fear to the stimuli prior to extinction.

References

- Alvarez, R. P., Johnson, L., & Grillon, C. (2007). Contextual-specificity of short-delay extinction in humans: Renewal of fear-potentiated startle in a virtual environment. *Learning and Memory, 14*, 247-253.
- Boschen, M. J., Parker, I. & Neumann, D. L. (2007). Changes in implicit associations do not occur simultaneously to Pavlovian conditioning of physiological anxiety responses. *Journal of Anxiety Disorders, 21*, 788-803.
- Bouton, M. E. (2002). Context, ambiguity, and unlearning: Sources of relapse after behavioral extinction. *Biological Psychiatry, 52*, 976 - 986.
- Bouton, M. E. (2004). Context and behavioral processes in extinction. *Learning and Memory, 11*, 485-494.
- Bouton, M. E., & Bolles, R. C. (1979). Role of conditioned stimuli in reinstatement of extinguished fear. *Journal of Experimental Psychology: Animal Behavior Processes, 5*, 368-379.
- Bouton, M. E., & King, D. A. (1983). Contextual control of the extinction of conditioned fear: Tests for the associative value of the context. *Journal of Experimental Psychology: Animal Behavior Processes, 9*, 248-265.
- Bouton, M. E., & Peck, C. A. (1989). Context effects on conditioning, extinction, and reinstatement in an appetitive conditioning preparation. *Animal Learning & Behavior, 17*, 188-198.
- Bouton, M. E., & Ricker, S. T. (1994). Renewal of extinguished responding in a second context. *Animal Learning & Behavior, 22*, 317-324.
- Bouton, M. E., Westbrook, R. F., Corcoran, K. A., & Maren, S. (2006). Contextual and temporal modulation of extinction: Behavioral and biological mechanisms. *Biological Psychiatry, 60*, 352-360.

- Cook, E. W., Hodes, R. L., & Lang, P. J. (1986). Preparedness and phobia: Effects of stimulus content on human visceral conditioning. *Journal of Abnormal Psychology, 95*, 195-207.
- Darby, R. J., & Pearce, J. M. (1995). Effects of context on responding during a compound stimulus. *Journal of Experimental Psychology: Animal Behavior Processes, 21*, 143-154.
- Effting, M., & Kindt, M. (in press). Contextual control of human fear associations in a renewal paradigm. *Behaviour Research and Therapy*.
- Field, A. P. (2006). Is conditioning a useful framework for understanding the development and treatment of phobias? *Clinical Psychology Review, 26*, 857-875.
- Fredrikson, M., Hugdahl, K., & Öhman, A. (1976). Electrodermal conditioning to potentially phobic stimuli in male and female subjects. *Biological Psychology, 4*, 305-314.
- Games, P. A. (1977). An improved *t* table for simultaneous control on *g* contrasts. *Journal of the American Statistical Association, 72*, 531-534.
- Havermans, R. C., Keuker, J., Lataster, T., & Jansen, A. (2005). Contextual control of extinguished conditioned performance in humans. *Learning and Motivation, 36*, 1-9.
- Hugdahl, K., Fredrikson, M., & Öhman, A. (1977). "Preparedness" and "arousability" as determinants of electrodermal conditioning. *Behavior Research and Therapy, 15*, 345-353.
- Hugdahl, K., & Johnsen, B. H. (1989). Preparedness and electrodermal fear-conditioning: Ontogenetic vs phylogenetic explanations. *Behavior Research and Therapy, 27*, 269-278.
- Klorman, R., Hastings, J. E., Weerts, T. C., Melamed, B. G., & Lang, P. J. (1974). Psychometric description of some specific-fear questionnaires. *Behavior Therapy, 5*, 401-409.

- Mineka, S., Mystkowski, J. L., Hladek, D., & Rodriguez, B. I. (1999). The effects of changing contexts on return of fear following exposure therapy for spider fear. *Journal of Consulting and Clinical Psychology, 67*, 599-504.
- Mineka, S., & Öhman, A. (2002). Phobias and preparedness: the selective, automatic, and encapsulated nature of fear. *Biological Psychiatry, 52*, 927-937.
- Mystkowski, J. L., Craske, M. G., & Echiverri, A. M. (2002). Treatment context and return of fear in spider phobia. *Behavior Therapy, 33*, 300-416.
- Neumann, D. L. (2006). The effects of physical context changes and multiple extinction contexts on two forms of renewal in a conditioned suppression task with humans. *Learning and Motivation, 37*, 149-175.
- Neumann, D. L. (2007). The resistance of renewal to instructions that devalue the role of contextual cues in a conditioned suppression task with humans. *Learning and Motivation, 38*, 105-127.
- Neumann, D. L., Lipp, O. V., & Cory, S. E. (2007). Conducting extinction in multiple contexts does not necessarily attenuate the renewal of shock expectancy in a fear conditioning procedure with humans. *Behaviour Research and Therapy, 45*, 385-394.
- Neumann, D. L., & Waters, A. M. (2006). The use of an unpleasant sound as an unconditional stimulus in a human aversive Pavlovian conditioning procedure. *Biological Psychology, 73*, 175-185.
- Öhman, A., Fredrikson, M., Hugdahl, K., & Rimmö, P. A. (1976). The premise of equipotentiality in human classical conditioning: Conditioned electrodermal responses to potentially phobic stimuli. *Journal of Experimental Psychology: General, 105*, 313-337.
- Öhman, A., & Mineka, S. (2001). Fears, phobias, and preparedness: toward an evolved module of fear and fear learning. *Psychological Review, 108*, 483-522.

- Rodriguez, B. I., Craske, M. G., Mineka, S., & Hladek, D. (1999). Context-specificity of relapse: Effects of therapist and environmental context on return of fear. *Behavior Research and Therapy*, 37, 845-862.
- Rumelhart, D. (1984). Schemata and the cognitive system. In R. S. Wyer, & T. K. Srull (Eds.), *Handbook of social cognition: Vol. 1*. Hillsdale, NJ: Erlbaum.
- Seligman, M. E. P. (1971). Phobias and preparedness. *Behavior Therapy*, 2, 307-320.
- Thomas, B. L., & Ayres, J. J. B. (2004). Use of the ABA fear renewal paradigm to assess the effects of extinction with co-present fear inhibitors or excitors: Implications for theories of extinction and for treating human fears and phobias. *Learning and Motivation*, 35, 22-52.
- Vansteenwegen, D., Hermans, D., Vervliet, B., Francken, G., Beckers, T., Baeyens, F., & Eelen, P. (2005). Return of fear in a human differential conditioning paradigm caused by a return to the original acquisition context. *Behaviour Research and Therapy*, 43, 323-336.
- Venables, P. H., & Christie, M. J. (1980). Electrodermal activity. In I. Martin & P. H. Venables (Eds.), *Techniques in Psychophysiology* (pp. 3-67). New York: John Wiley & Sons.
- Vervliet, B., Vansteenwegen, D., Baeyens, F., Hermans, D., & Eelen, P. (2005). Return of fear in a human differential conditioning paradigm caused by a stimulus change after extinction. *Behaviour Research and Therapy*, 43, 357-371.
- Waters, A. M. & Craske, M. G. (2005). Generalised anxiety disorder. In M. M. Antony, D. R. Ledley, & R. G. Heimberg, (Eds). *Improving outcomes and preventing relapse in cognitive behavioral therapy*. (pp. 77-127). New York : Guilford .
- Watson, J. B., & Rayner, R. (1920). Conditioned emotional reactions. *Journal of Experimental Psychology*, 3, 1-14.

Notes

¹The statistical analyses for the main hypotheses of interest will be reported. A full set of analyses are available upon request from the first author.

Acknowledgements

Correspondence concerning this article should be addressed to David Neumann, School of Psychology, Gold Coast Campus GRIFFITH UNIVERSITY QLD, 4222, Queensland, Australia,, or E-mail: D.Neumann@griffith.edu.au. The authors are grateful for the assistance of a Griffith University New Researcher Grant and to Rae Westbury and Stephen Brandis for assistance with manuscript preparation.

Figures

Figure 1. Mean shock expectancy for the groups that received the fear-relevant (top panel) and fear-irrelevant (bottom panel) conditional stimuli and each conditioning design (ABA and AAA) in Experiment 1. P1 and P2 are the pre-exposure trials, A1 to A8 are the acquisition trials, E1 to E8 are the extinction trials, and T1 to T3 are the test trials.

Figure 2. Mean skin conductance responses for the groups that received the fear-relevant (top panel) and fear-irrelevant (bottom panel) conditional stimuli and each conditioning design (ABA and AAA) in Experiment 1. P1 and P2 are the pre-exposure trials, A1 to A8 are the acquisition trials, E1 to E8 are the extinction trials, and T1 to T3 are the test trials.

Figure 3. Mean shock expectancy for the groups that received the outdoor bush context (left panels) and indoor office context (right panels) during acquisition and test phases for fear-relevant (top panels) and fear-irrelevant (bottom panels) conditional stimuli in Experiment 2. The AAA designs received the same extinction context as used in acquisition and test, whereas the ABA designs received the alternative extinction context (e.g., indoor office extinction context when acquisition and test was in the outdoor bush context). P1 and P2 are the pre-exposure trials, A1 to A8 are the acquisition trials, E1 to E12 are the extinction trials, and T1 to T3 are the test trials.

Figure 4. Mean skin conductance responses for the groups that received the outdoor bush context (left panels) and indoor office context (right panels) during acquisition and test phases for fear-relevant (top panels) and fear-irrelevant (bottom panels) conditional stimuli in Experiment 2. The AAA designs received the same extinction context as used in acquisition and test, whereas the ABA designs received the alternative extinction context (e.g., indoor office extinction context when acquisition and test was in the outdoor bush context). P1 and P2 are the pre-exposure trials, A1 to A8 are the acquisition trials, E1 to E12 are the extinction trials, and T1 to T3 are the test trials.