

Running head: REINSTATEMENT OF EXTINGUISHED BEHAVIOUR

The effects of context changes on the reinstatement of extinguished
conditioned behavior in a conditioned suppression task with humans

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Abstract

Reinstatement refers to the return of previously extinguished conditioned responses to test trials of a conditional stimulus (CS) when presentations of the unconditional stimulus (US) alone are given following extinction. Four experiments were conducted to determine whether reinstatement could be found in a conditioned suppression task with humans and whether contextual changes can abolish it. Experiment 1 demonstrated the reinstatement of conditioned suppression when acquisition, extinction, US alone, and test trials were all given in the same context. Experiments 2 and 3 suggested that the reinstatement effect was still present when the US alone presentations were given in a different context to the subsequent test trials. Experiment 4 replicated this effect using additional controls over the amount of exposure to the various contexts. The results suggest that reinstatement can be robust across changing contexts. Aspects of the conditioned suppression task that promote the transfer of learning across contexts or the establishment of configural context-CS stimuli may underlie the apparent lack of contextual control over reinstatement.

Keywords: Pavlovian conditioning, reinstatement, context, conditioned suppression

Introduction

Extinction represents a fundamental behavior change mechanism. It is typically observed in a Pavlovian conditioning procedure in which a conditional stimulus (CS) is paired with an unconditional stimulus (US) to result in the acquisition of a conditioned response to the CS. In extinction, the CS is next repeatedly presented on its own to result in a reduction of the conditioned response. Evidence from the animal learning literature shows that extinction does not reflect an “unlearning” of the original CS-US association (e.g., see review by Bouton, 2002, 2004; Bouton, Westbrook, Corcoran, & Maren, 2006). This conclusion has been built around four phenomena, all of which demonstrate that much of the original CS-US association remains intact after extinction. These phenomena are renewal, reinstatement, spontaneous recovery, and faster reacquisition. Each phenomenon has implications for the development of learning theories and their application in behaviorally based psychological interventions, such as exposure therapy. The phenomena have provided a means to examine the learning processes involved in extinction and have led to the suggestion that extinction is the learning of a new relationship between the CS and US which is mediated by contextual cues (Bouton, 2002, 2004; Bouton et al., 2006).

Reinstatement has, to date, received most attention in the animal learning literature. It refers to the return of previously extinguished conditioned behavior on test presentations of the CS after presentations of the US alone are made. For instance, Bouton and Bolles (1979) used a conditioned suppression procedure with electric shocks as the US and observed reinstatement of conditioned suppression to the CS after the shocks were presented on their own following extinction training. Reinstatement has shown generality across conditioning procedures, being observed in conditioned suppression (Bouton & Bolles, 1979; Bouton, 1984), taste aversion

(Schachtman, Brown, & Miller, 1985), and appetitive conditioning (Bouton & Peck, 1989) procedures. Reinstatement also appears to be influenced by contextual cues. It was initially observed that reinstatement occurs when the CS is tested in the same context in which the US alone presentations were made, but not when the US was presented in a different context (e.g., Bouton, 1984; Bouton & Bolles, 1979; Bouton & Peck, 1989; Frohardt, Guarraci, & Bouton, 2000). Such context specificity can be explained by contextual conditioning (i.e., the formation of a context-US association) that occurs during the US alone presentations. However, reinstatement can also be found if the US alone presentations are given in the extinction context even when the CS is tested in a different context (Westbrook, Iordanova, McNally, Richardson, & Harris, 2002). In this situation, reinstatement might occur because the test presentation of the CS activates a representation of the extinction context which in turn activates a representation of the US. This reinstates conditioned behavior because of the prior extinction context-US association that was formed during the US alone presentations.

To date, reinstatement in humans (see Hermans, Craske, Mineka, & Lovibond, 2006 for a review) has been examined with a contingency judgment task (García-Gutiérrez & Rosas, 2003; Vila & Rosas, 2001) and a fear conditioning task (Dirikx, Hermans, Vansteenwegen, Baeyens, & Eelen, 2004, in press; Hermans, Dirikx, Vansteenwegen, Baeyens, Van den Bergh, & Eelen, 2005; LaBar & Phelps, 2005; Van Damme, Crombez, Hermans, Koster, & Eccleston, 2006). The latter task presents the greatest parallels to the fear conditioning paradigm used in animal learning research. Research by Hermans, Dirikx and colleagues (Dirikx et al., 2004; Hermans et al., 2005; Van Damme et al., 2006) employed a differential conditioning paradigm in which one CS (CS+) was followed by an electric shock US during acquisition and a second CS (CS-) was presented alone. Both CSs were presented alone during extinction trials after which

presentations of the shock US were made as part of the reinstatement manipulation.

Reinstatement was found when conditioned responses were measured by a spatial cueing paradigm (Van Damme et al., 2006), self-reported fear ratings (Dirikx et al., 2004; Hermans et al., 2005), self-reported judgments of US expectancy (Hermans et al., 2005), and secondary task reaction time slowing (Dirikx et al., 2004). However, some inconsistencies also emerged in that reinstatement was not consistently found with US expectancy judgments (Dirikx et al., 2004) or secondary task reaction time (Hermans et al., 2005) in the series of studies. Nevertheless, the weight of evidence appears to confirm the existence of reinstatement in human participants.

LaBar and Phelps (2005) examined reinstatement of conditioned fear following changes of context. A single cue conditioning procedure and a loud noise as the US was used. Participants received four reinstating US presentations in either the same or a different context to the preceding acquisition and extinction phases. Test was conducted in the same context as acquisition and extinction. Participants that received the reinstating US presentations in the same context as the subsequent test phase showed larger skin conductance responses to the CS during test relative to the last extinction trial. In contrast, participants that received the reinstating US presentations in a different context did not show any reinstatement of skin conductance responses. These results were replicated in a subsequent study that used an electric shock as the US. The results of LaBar and Phelps (2005) suggest that reinstatement in humans, like that reported in studies with non-human animals, is mediated by context.

An alternative approach to study recovery from extinction in humans has been to use the conditioned suppression task developed by Arcediano, Ortega, and Matute (1996). The amount of suppression observed in this procedure provides a behavioural measure of the strength of the association between the CS and US and can facilitate cross-species comparisons of conditioning

effects (Arcediano et al., 1996). Havermans, Keuker, Lataster, and Jansen (2005) and Neumann (2006, 2007) have used the conditioned suppression task to investigate another return from extinction phenomenon termed renewal. For instance, using a single cue conditioning procedure, Havermans et al. (2005) showed that after presenting acquisition trials in one context and extinction trials in a second context, a renewal of extinguished conditioned suppression is found if subsequent test trials of the CS are made in the original acquisition context (i.e., ABA renewal design). However, renewal was not observed in a subsequent experiment when acquisition occurred in one context, extinction in a second context, and test trials in a third (novel) context (i.e., ABC renewal design). Neumann (2006) also reported a clear ABA renewal effect, but not a clear ABC renewal effect, when a differential conditioning procedure was used. Havermans et al. (2005) suggested that one interpretation of their results is that the extinction context does not modulate extinguished conditioned responding. A generalization decrement due to the association of a configural context-CS with the US during acquisition or explicit cognitive rule learning were suggested as alternative mechanisms that governed performance during the acquisition, extinction, and test phases in the ABA renewal design. The presence of reinstatement and the question of whether any reinstatement effects can be influenced by the context in which the US is present has not been examined in the conditioned suppression task. Such research seems warranted in order to examine the generality of the reinstatement effect across the different conditioning paradigms used in human preparations. The present research was thus conducted to first determine whether the reinstatement of extinguished conditioned suppression could be found in the conditioned suppression task. The effect of the context in which the reinstating US presentations were made was next investigated.

Experiment 1

Arcediano et al. (1996) developed the human conditioned suppression task with the aim of providing a human analogue to the measurement of conditioned suppression in animal conditioning experiments. The measurement of conditioned suppression in animals initially requires the animal to be trained through operant conditioning to repeatedly press a bar to obtain reinforcement such as food. An association between a CS and an aversive US is next trained either on- or off-line. If the CS is later presented during performance, suppression of operant behavior is observed due to the CS eliciting a fear response (freezing). In extinction, this conditioned suppression is abolished, but can return in a reinstatement procedure (e.g., Bouton, 1984; Bouton & Bolles, 1979). The conditioned suppression task developed by Arcediano et al. (1996) uses a US that is salient because operant behavior during its presentation will lead to undesirable consequences. This avoids the ethical problem of using an aversive US that is intense enough to produce unconditional response suppression due to fear. As such, the development of response suppression during a CS that signals the US within the context of the task reflects knowledge of the punishment associated with the US (Havermans et al., 2005). However, despite this procedural difference, the term conditioned suppression will be used in the present experiment, consistent with prior applications of this task (e.g., Arcediano et al., 1996; Havermans et al., 2005; Neumann, 2006, 2007). Experiment 1 aimed to test whether a recovery of extinguished conditioned suppression could be observed in a reinstatement procedure. A differential conditioning design was used in which one CS (CS+) was associated with the US during acquisition, whereas a second CS (CS-) was presented alone. Following extinction trials of CS+ and CS- alone presentations, reinstating presentations of the US were made. A control group was also employed that received the same trial structure, but did not receive any

reinstating US presentations in between the extinction and test phases. It was hypothesized that reinstatement of extinguished conditioned suppression would be observed in the group given the reinstating US presentations and that the reinstatement effect would be specific to the CS+.

Method

Participants.

The participants were 10 male and 22 female first year psychology students from Griffith University. The participants ages ranged from 18 to 41 years ($M = 21.4$ years) and all participated in exchange for partial course credit. Informed written consent to a protocol approved by the Griffith University Human Research Ethics Committee was obtained from all participants. The participants were randomly assigned to either the Reinstatement or Control group with the restriction that there were an equal number of males and females in each group.

Apparatus.

The participants completed the experiment individually, in a 3 m square room, and were monitored via a closed circuit video system from an adjoining room. A Dell Latitude IBM compatible laptop computer controlled the task and recorded the participant's responses. The task was presented via an In Focus Lite Pro Model 730 LCD projector on to a 2.4 m wide by 1.2 m high white screen located in front of the participant. Participants responded by pressing the space bar on a separate computer keyboard that was attached to the computer controlling the task.

Procedure.

The participants were asked to press the space bar of the computer keyboard, which in the context of the task would fire a laser gun to destroy invading "Martians". The Martians were represented as a cartoon-style face with elongated eyes and large teeth. During the experiment,

the Martians appeared sequentially on the display starting at the top left corner and forming rows of 10 across. When eight rows filled the display, the rows were moved up and were replaced by the next row at the bottom. The participants learnt to press the space bar at a steady rate to destroy each Martian. In the context of the task, the US was a “laser shield”, which consisted of a white screen that flashed alternately between black and white for 3 s. Presses of the space bar during the US had the consequence of allowing 100 Martians to invade (forming 5 rows of 20 Martians across). The presentations of “signals” allowed participants to learn when to predict the occurrence of the US laser shield. The CS+ served as a signal that predicted a US presentation and the CS- served as the control signal because it did not predict a US presentation. Conditional behavior is evidenced by response suppression during the CS+, thus allowing participants to avoid pressing the space bar during the US presentation. As it took some time for the participants to react following the onset of the CS+, the participants invariably responded early during the CS+ presentation. However, so long as participants withheld responding during the latter portion of the CS+, they were able to avoid responding during the US presentation and, by consequence, an invasion of Martians.

The procedure entailed two pre-conditioning phases and the conditioning proper. For the first-preconditioning phase, the participants were informed that the purpose of the task was to press the spacebar in order to destroy invading Martians (see Neumann, 2006, for example of full instructions used). Martians were presented on the display every 300 ms. If the participant pressed the space bar immediately before the Martian appeared, the Martian face was presented with a red cross drawn over it. During this phase, 100 Martians were presented after which the percent of Martians destroyed was displayed. The second pre-conditioning phase then began in which the US was introduced. Participants were informed that the Martians possessed a “laser

shield” and that firing the laser gun during shield activation would allow a flood of Martians to invade. The Martians were presented at a rate of one every 300 ms for 160 Martians in total. In addition, there were three presentations of the US (flashing screen) at random intervals during this phase. As the US presentations were unpredictable, the participants pressed the space bar during its presentation and were exposed to the consequence of a swarm of invading Martians.

The conditioning proper began next. Participants were told that they might be able to predict when the laser shield was about to occur by the presentation of “signals”. They were also warned that there might be some “false signals”. The participants were encouraged to work out which signals were predictive of the laser shield, in order to destroy as many Martians as possible, but prevent an invasion of Martians flooding the screen. The signals were the two CSs which consisted of images of a circle with a cross in the middle, \oplus , or a circle with a diagonal line drawn through, \oslash , and were presented for 3 s behind the display of Martians. The nature of which image served as the CS+ and CS- was counterbalanced between participants. The conditioning proper consisted of three phases in which the Martians were displayed at a rate of one every 200 ms. Each phase ran continuously without any further instructions or interruption. Both the Reinstatement and Control groups were treated in an identical manner during the acquisition and extinction phases. In acquisition, there were nine presentations each of the CS+ and CS-. All presentations of the CS+ in acquisition were followed immediately by the presentation of the US. In the extinction phase, there were 13 presentations each of the CS+ and CS-. No presentations of the US were made during extinction. Following the extinction phase, but before the beginning of the test trials, participants in the Reinstatement group received six unwarned presentations of the US. In contrast, participants in the Control group did not receive any US presentations, although they received the same time delay between the end of extinction

and the start of test as did the Reinstatement group (52.5 s). The test phase was next presented and was identical in both groups. Test consisted of three presentations each of the CS+ and CS-. As was the case for extinction, no presentations of the US were made. In all phases of the experiment, the inter-trial intervals between the CS presentations were varied at random between 5 and 10 s, with a mean of 7.5 s. The order of the CS+ and CS- was randomized with the restriction that there were no more than three consecutive presentations of the same CS, and that the first CS presented in each phase was counterbalanced across participants. The CS duration was either 1 s or 3 s in order to reduce the predictability of the CS duration in the experiment. The duration varied according to a predefined sequence. The first trial for each CS type in the acquisition and extinction phases were 3 s in duration. The next three presentations of each CS type were 1 s in duration, after which another 3 s presentation was made. This sequence continued such that trials 1, 4, and 9 in acquisition and trials 1, 4, 9, and 13 in extinction were 3 s in duration, whereas the remaining trials were 1 s in duration. All three test trials of each CS type were 3 s in duration.

Only those presentations of the CSs that were 3 s in duration were used for the measurement of conditioned suppression (Arcediano et al., 1996). These are designated as trials A1, A4, and A9 in acquisition, trials E1, E4, E9, and E13 in extinction, and trials T1, T2, and T3 in test. The dependent variable was suppression ratio as calculated by application of the formula $X/(X+Y)$, where X represents the number of spacebar presses during the 3 s duration of the CS presentation and Y is the number of spacebar presses in the 3 s immediately prior to the CS onset. A ratio of 0 is indicative of absolute response suppression during the CS, while a ratio of .5 indicates no suppression. In addition, the mean number of responses during the 3 s baseline period for each CS in each phase in the experiment was calculated. A 2 x 3 (CS x Phase)

ANOVA did not yield any significant effects, all F s < 2.06 , $p > .05$, indicating that responding remained stable across the experiment. The mean number of responses for each phase were 16.56 ($SD = 1.97$, range = 13 to 22) for the acquisition phase, 16.38 ($SD = 1.79$, range = 12 to 20) for the extinction phase, and 16.06 ($SD = 2.0$, range 13 to 20) for the test phase.

Results and Discussion

To ensure that an appropriate test for reinstatement could be conducted, participants who failed to show adequate acquisition or extinction of conditioned suppression were removed from the analyses. Acquisition of conditioned suppression was defined as a suppression ratio lower than 0.3 (Havermans et al., 2005) on the last acquisition trial (Trial A9) and extinction was defined as a suppression ratio greater than 0.3 on the last extinction trial (Trial E13). These criteria resulted in four participants being excluded due to failing to show adequate extinction. The mean suppression ratio for each 3 s trial during the three phases of the experiment is shown in Figure 1. The statistical analyses were conducted by focusing on the learning effects that were predicted to occur in each phase. In the analyses for this and all subsequent experiments, ANOVAs were used that employed Greenhouse Geisser adjusted degrees of freedom for main effects and interactions employing more than two within-subjects levels. The unadjusted degrees of freedom and epsilon (ϵ) used in the correction is reported. Planned comparisons were used to test for reinstatement effects. A conservative approach was adopted for the planned comparisons and any post hoc tests by using t tests that were adjusted for the accumulation of Type I error by using Šidák's multiplicative inequality (Games, 1977).

In the acquisition phase, a 2 x 2 x 3 (Group x CS x Trial) ANOVA was conducted. The establishment of conditioned suppression during the CS+ and the loss of conditioned suppression during the CS- was confirmed in these analyses by a main effect for CS, $F(1, 26) = 81.46$, $p <$

.0005, and a CS x Trial interaction, $F(2, 52) = 33.79$, $\epsilon = .15$, $p < .0005$. As can be seen in Figure 1, there was a clear difference in suppression between the CS+ and CS- by the last acquisition trial. In the extinction phase, the conditioned suppression that had developed during the CS+ was reduced to result in no difference in suppression between the CS+ and CS- on the last extinction trial. A 2 x 2 x 4 (Group x CS x Trial) ANOVA confirmed these impressions by yielding a main effect for CS, $F(1, 26) = 54.99$, $p < .0005$, a main effect for Trial, $F(3, 78) = 54.41$, $\epsilon = .56$, $p < .0005$, and a CS x Trial interaction, $F(3, 78) = 53.89$, $\epsilon = .66$, $p < .0005$. Post hoc tests confirmed that suppression was greater during the CS+ than during the CS- on the first extinction trial, $t = 9.74$, $p < .01$, whereas this difference was not present on the last extinction trial, $t = .55$, $p > .05$.

 Insert Figure 1 about here

Two strategies were used to test for the reinstatement of conditioned suppression during the test phase. The first was through similar analyses as applied in the earlier phases of the experiment by examining the difference between the CS+ and CS- on the test trials. Reinstatement would be reflected in greater conditioned suppression during the CS+ than during the CS-. The 2 x 2 x 3 (Group x CS x Trial) ANOVA resulted in a main effect for CS, $F(1, 26) = 6.82$, $p < .05$, a Group x Trial interaction, $F(2, 52) = 7.57$, $\epsilon = .68$, $p < .01$, and a near significant Group x CS x Trial interaction, $F(2, 52) = 3.08$, $\epsilon = .77$, $p = .069$. Planned comparisons were used to compare between the CS+ and CS- for each test trial separately for each group. In the Reinstatement group, there was more suppression for the CS+ than for the CS- on the first test trial, $t = 3.78$, $p < .01$, but not on subsequent trials, both $ts < 1.48$, $p > .05$.

The reduction of the difference in conditioned suppression across the test trials reflects that the test presentations of the CSs were not followed by the US. As such, the test phase consisted of a second extinction phase. In the Control group, the differences between the CS+ and CS- were not significant on any test trial, all $t_s < 1.97$, $p > .05$. The statistical analyses that compared conditioned suppression during the test phase thus yielded evidence for the reinstatement of conditioned suppression on the first test trial.

The second strategy to test for reinstatement was to compare the amount of conditioned suppression observed during test with that observed at the end of extinction. Reinstatement would be shown by a relative increase in conditioned suppression on the test trials. A 2 x 2 x 2 (Group x CS x Trial) ANOVA was conducted by using the last extinction trial (Trial E13) and first test trial (Trial T1). The analyses yielded a main effect for CS, $F(1, 26) = 8.98$, $p < .01$, a main effect for Trial, $F(1, 26) = 5.45$, $p < .05$, a Group x Trial interaction, $F(1, 26) = 7.93$, $p < .01$, and a near significant Group x CS x Trial interaction, $F(1, 26) = 3.89$, $p = .059$. Planned comparisons were conducted by comparing between the last extinction trial and first test trial separately for each group and CS. The comparisons showed that suppression was greater on the test trial than on the last extinction trial for the CS+, $t = 5.62$, $p < .01$, but not for the CS-, $t = 2.12$, $p > .05$, in the Reinstatement group. The comparisons between the extinction and test trial were not significant for the Control group, both $t_s < 0.65$, $p > .05$. These analyses thus support the analyses conducted on only the test trials by showing that there was reinstatement of conditioned suppression.

The present experiment demonstrated the reinstatement of conditioned suppression in the conditioned suppression task developed by Arcediano et al. (1996). The outcomes suggest that the task is sensitive to experimental manipulations that can influence the return of extinguished

conditioned behavior and as such supports the renewal of extinguished suppression found with this task in previous studies (Havermans et al., 2005; Neumann, 2006, 2007). The results are also consistent with prior reports of reinstatement in human participants in a contingency judgment task (García-Gutiérrez & Rosas, 2003; Vila & Rosas, 2001) and a fear conditioning task (Dirikx et al., 2004, in press; Hermans et al., 2005; LaBar & Phelps, 2005; Van Damme et al., 2006). The magnitude of the reinstatement effect was relatively modest in that conditioned suppression on the first test trial did not reach the same level of suppression as that observed on the last acquisition trial. However, the full return of extinguished conditioned behavior is rarely found in animal research (Frohardt, Guarraci, & Bouton, 2000) and the limited human research also appears to support this conclusion, at least with some measures (e.g., Hermans et al., 2005). The reinstatement effect was strongest on the first test trial and was statistically reliable, suggesting that the present task is suitable to study the various experimental and psychological factors that might underlie reinstatement in humans.

Experiment 2

The present experiment aimed to test whether reinstatement would be influenced by the context in which the reinstating US and test CS presentations are made. Context was manipulated by presenting different background lights and sounds in the room in which the conditioned suppression task was presented. This method has previously been shown to produce reliable renewal effects (Neumann, 2006, 2007; Neumann, Lipp, & Cory, 2007) suggesting that it represents a strong contextual manipulation. Three groups of participants were tested. The first two were the same as those used in Experiment 1 in order to replicate the basic reinstatement effect that was found. Both these groups received all phases of the experiment in the same context. A third group received the reinstating US presentations following extinction,

but did so following a context change. Test trials of the CS were conducted after a return to the original acquisition and extinction context. If the reinstatement effect in the present preparation is context dependent, similar to that found by LaBar and Phelps (2006) in their fear conditioning procedure, no reinstatement of extinguished conditioned suppression should be found in the latter group.

Method

Participants.

The sample consisted of 11 male and 38 female first year psychology students from Griffith University with a mean age of 27.7 years (range 18 to 46 years). No participants had previously completed Experiment 1. After providing informed consent, the participants were randomly assigned either to the Control group ($n = 16$), Reinstatement-Same group ($n = 17$), or Reinstatement-Different group ($n = 16$).

Apparatus and Procedure.

The methods used were based on those employed in Experiment 1 with the exception of an additional group of participants, the implementation of the context, changes in the number of trials, and the duration of the CSs. All participants remained in the testing room for the entire experiment. Three groups of participants were used: a Control group, a Reinstatement-Same group, and a Reinstatement-Different group. The context was manipulated by changing background lighting and sounds. The light component used a panel of Crompton 60 Watt reflector spot globes mounted 2 m above and behind the participant. Two globes each for the two colors (yellow and purple) were used. When a specific colored globe was switched on, the walls of the room were diffusely illuminated by the color. The sound component was musical instrument digital interface (MIDI) sounds pulsed at a tempo of 85 beats per minute. The sounds

used MIDI code 68 (low agogo sound) and MIDI code 61 (low bongo sound). The sounds were presented by a Dell Optiplex GX1 computer installed with a Crystal PnP Audio sound controller via four Altec Lansing speakers mounted in each corner of the room. The two contexts combined the yellow light and the low agogo sound and the purple light and the low bongo sound. The two contexts are designated as Context X and Context Y, although the nature of which light and sound combinations that served as Context X and Y were counterbalanced across participants.

Insert Table 1 about here

The experimental design for the three groups is shown in Table 1. In short, all groups received trials of the CS+ paired with the US and the CS- presented alone in acquisition, followed by extinction treatment of CS+ alone and CS- alone presentations in context X. The Reinstatement-Different group then received a change of context (Y). Both the Reinstatement-Same group and the Reinstatement-Different group next received presentations of the US. The context was returned to context X in the Reinstatement-Different group prior to the test phase. All groups in the test phase were given CS+ alone and CS- alone presentations. The number of trials in each experimental phase is shown in Table 1. Unlike Experiment 1, the CSs were presented for 3 s for all trials in the experiment. The mean number of responses during the 3 s baseline period before each CS presentation were 15.32 ($SD = 1.47$) for the acquisition phase, 15.46 ($SD = 1.32$) for the extinction phase, and 14.86 ($SD = 2.05$) for the test phase.

Results and Discussion

The mean suppression ratio in the three experimental phases for each group is shown in Figure 2. As a result of the screening, the data from four participants was excluded on the basis of failing to show adequate extinction (suppression ratio of less than 0.3 on the last extinction trial). All these four participants were from the Reinstatement-Different group. All groups showed a similar pattern across the acquisition phase with an increase in suppression for the CS+ and a loss of suppression for the CS-. These effects were examined with a 3 x 2 x 9 (Group x CS x Trial) ANOVA that confirmed the development of conditioned suppression with a main effect for CS, $F(1, 42) = 127.96, p < .0005$, a main effect for Trial, $F(8, 336) = 3.98, \epsilon = .64, p < .01$, and a CS x Trial interaction, $F(8, 320) = 4.36, \epsilon = .63, p < .001$.

 Insert Figure 2 about here

The response suppression during the CS+ that developed in the acquisition phase was lost in the extinction phase. The change in response suppression for the CS+ was confirmed by a main effect for CS, $F(1, 42) = 51.43, p < .0005$, main effect Trial, $F(8, 336) = 30.66, \epsilon = .38, p < .0005$, and a CS x Trial interaction, $F(8, 336) = 28.57, \epsilon = .43, p < .0005$. The Group x Trial, $F(16, 336) = 2.74, \epsilon = .43, p < .05$, and the Group x CS x Trial interaction, $F(16, 336) = 3.06, \epsilon = .43, p < .01$, were also significant. The latter interaction reflected that there were differences between groups early in the extinction phase. Suppression was more pronounced in the Reinstatement-Same group than in the Control and Reinstatement-Different group on trial E1 and E3 of extinction, all $t_s > 3.62, p < .05$, whereas there were no differences between groups on any other trials, all $t_s < 2.61, p > .05$. Extinction was complete in all groups as shown by no significant difference between the CS+ and CS- on the last extinction trial in any group, $t = 1.63$,

$p > .05$. It may thus be concluded that although groups showed some differences in rate of extinction, they all showed complete extinction by the last trial.

Similar to Experiment 1, two strategies were employed to test for reinstatement of conditioned suppression. The first that used a 3 x 2 x 3 (Group x CS x Trial) ANOVA yielded a significant main effect for Group, $F(1, 38) = 6.21, p < .01$, a significant main effect for CS, $F(1, 42) = 19.56, p < .0005$, a significant main effect for Trial, $F(2, 84) = 22.52, \epsilon = .56, p < .0005$, a significant Group x Trial interaction, $F(4, 84) = 9.44, \epsilon = .56, p < .01$, and a significant Group x CS x Trial interaction, $F(4, 84) = 11.43, \epsilon = .59, p < .0005$. Planned comparisons showed that there were no differences between the CS+ and CS- on any test trial in the Control group, all $t_s < 1.31, p > .05$, confirming the continued extinction of conditioned suppression. In the Reinstatement-Same group, conditioned suppression was greater during the CS+ than during the CS- on the first test trial, $t = 7.68, p < .01$, although there were no differences on subsequent test trials, all $t_s < 0.88, p > .05$. This pattern of results confirms that reinstatement of conditioned suppression occurred. In the Reinstatement-Different group, by contrast, no differences between the CS+ and CS- were statistically significant, all $t_s < 0.44, p > .05$.

The second strategy used to test for reinstatement employed a 3 x 2 x 2 (Group x CS x Trial) ANOVA. The analyses produced a main effect for Group, $F(1, 42) = 5.01, p < .05$, a main effect for CS, $F(1, 42) = 17.76, p < .0005$, a main effect for Trial, $F(1, 42) = 19.96, p < .0005$, a Group x CS interaction, $F(2, 42) = 4.61, p < .05$, a Group x Trial interaction, $F(2, 42) = 8.92, p < .001$, and a Group x CS x Trial interaction, $F(2, 42) = 10.60, p < .0005$. Subsequent pairwise planned comparisons that examined the change across trials separately for each CS and group showed that there were no differences between the extinction and test trials for the Control group for either CS, both $t_s < 0.31, p > .05$. Conditioned suppression in the Reinstatement-Same

group increased significantly from extinction to test for the CS+, $t = 8.63, p < .01$, but not for the CS-, $t = 1.25, p > .05$. The increase in suppression from extinction to test in the Reinstatement-Different group approached significance for the CS+ and CS-, both $ts < 2.69, p > .065$.

The results of the present experiment replicated the reinstatement effect that was observed in Experiment 1. In the Reinstatement-Same group, there was an increase in conditioned suppression to the CS+ relative to the CS- on the test trial and relative to the last CS+ presentation in extinction. In contrast, there was no significant increase in conditioned suppression to the CS+ in the Control-Same group. However, the results for the Reinstatement-Different group were more ambiguous. Although there appeared to be some increase in conditioned suppression on the first test trial relative to the last extinction trial, this effect only approached statistical reliability for the CS+ and was also present to a similar degree for the CS-. A direct comparison between the CS+ and CS- on the first test trial also indicated that suppression was not statistically different between the two CSs. Four participants in the Reinstatement-Different group were rejected from the analyses for failing to show adequate extinction. As a result, this reduced the final sample size in this group ($n = 12$) and this may have contributed to the ambiguity surrounding the outcomes. For this reason, a third experiment was conducted by replicating the Reinstatement-Different group with a larger sample size than was employed in the present experiment.

Experiment 3

Method

Participants.

A total of 40 (16 male and 24 female) first year psychology students from Griffith University with a mean age of 19.5 years (range 17 to 25 years) participated in exchange for

course credit. No participants had completed any of the previous experiments and all provided informed consent prior to participation.

Apparatus and Procedure.

The methods replicated that used in Experiment 2 with the exception that only the Reinstatement-Different group was tested. All participants reported that they had noted the context changes that occurred throughout the experiment. The mean number of baseline responses prior to the CS presentation were 14.33 ($SD = 1.95$) for the acquisition phase, 14.10 ($SD = 2.64$) for the extinction phase, and 13.31 ($SD = 2.88$) for the test phase.

Results and Discussion

The criterion for exclusion resulted in nine participants being rejected prior to statistical analysis for failing to show adequate extinction. The mean suppression ratio for the remaining participants in each experimental phase is shown in Figure 3. The acquisition phase was analyzed with a 2 x 9 (CS x Trial) ANOVA. Acquisition of conditioned suppression was supported by a main effect for CS, $F(1, 30) = 57.69, p < .0005$, a main effect for Trial, $F(8, 240) = 4.99, \epsilon = .48, p < .01$, and a CS x Trial interaction, $F(8, 240) = 8.99, \epsilon = .50, p < .0005$. The extinction phase was analyzed with a 2 x 9 (CS x Trial) ANOVA and resulted in a main effect for CS, $F(1, 30) = 24.07, p < .0005$, a main effect for Trial, $F(8, 240) = 9.86, \epsilon = .30, p < .0005$, and a CS x Trial interaction, $F(8, 240) = 8.64, \epsilon = .38, p < .0005$. Post hoc tests confirmed that suppression was greater during the CS+ than during the CS- on the first extinction trial, $t = 5.55, p < .01$, whereas this difference was not present on the last extinction trial, $t = .51, p > .05$.

Insert Figure 3 about here

In the test phase, reinstatement of conditioned suppression appeared to be present as reflected in greater conditioned suppression during the CS+ than during the CS- on the first test trial. The test for reinstatement that used a 2 x 3 (CS x Trial) ANOVA conducted for the three test trials yielded a main effect for CS, $F(1, 30) = 12.12, p < .01$, a main effect for Trial, $F(2, 60) = 4.81, \epsilon = .99, p < .05$, and a CS x Trial interaction, $F(2, 60) = 4.24, \epsilon = .87, p < .05$. Planned comparisons confirmed that conditioned suppression was greater during the CS+ than during the CS- on the first test trial, $t = 4.75, p < .01$, and the second test trial, $t = 2.99, p < .05$, but not on the third test trial, $t = 0.44, p > .05$. The second test for reinstatement employed a 2 x 2 (CS x Trial) ANOVA to compare conditioned suppression on the last extinction trial with the first test trial. The analyses resulted in a main effect for CS, $F(1, 30) = 9.83, p < .01$, a main effect for Trial, $F(1, 30) = 14.99, p < .001$, and a CS x Trial interaction, $F(1, 30) = 6.95, p < .05$. Subsequent post hoc comparisons revealed that the increase in conditioned suppression on the first test trial was found for the CS+, $t = 4.75, p < .01$, and not for the CS-, $t = 0.96, p > .05$.

The present experiment, in which a larger sample size for the Reinstatement-Different group was used, showed that presenting the reinstating US presentations in a different context to subsequent test trials did not abolish the reinstatement effect. Conditioned suppression was significantly more pronounced during the CS+ than during the CS- on the first two test trials. Suppression was also significantly greater on the first test trial than on the last extinction trial for the CS+. The reason why there appeared to be an increased suppression on the first test trial for

the CS- in the Reinstatement-Different group in Experiment 2 is not clear. In the application of the present conditioned suppression task to investigate the renewal effect, Neumann (2006) noted that conditioned suppression observed during the CS- on the test phase was influenced by whether the first test trial was a CS+ or CS- presentation. Conditioned suppression to the CS- tended to be greater when the first trial was a CS+ trial than when it was a CS- trial. Learning about the CS+ on the first test trial appeared to influence subsequent responses to the CS-. The exclusion of participants who failed to show adequate extinction resulted in four participants from the Reinstatement-Different group in Experiment 2 to be excluded. Of these participants, three received the CS- first in test and one received the CS+ first in test. The exclusion of participants may have created a minor bias in that the final sample included more participants that received the CS+ first in test than those that received the CS- first. This may have contributed to the apparent increase in conditioned suppression to the CS- observed on the first test trial¹. The present results indicate that the reinstatement of conditioned suppression is a reliable effect when examined with the behavioral preparation that has been used and that it may not necessarily be easy to abolish through manipulating the context in which the reinstating US presentations are given.

Experiment 4

A difficulty in the interpretation of the results from the Reinstatement-Different group tested in Experiment 3 arises because this group received context changes in between the extinction and test phases, whereas the Reinstatement-Same and Control groups tested in Experiment 2 did not. The reinstatement effect that was observed in the Reinstatement-Different group may reflect the fact that the participants merely received a change of context following extinction and not necessarily because presentations of the US were made. The present

experiment was thus conducted to provide additional controls for this possibility by including context changes in between the extinction and test phases for all groups. A Reinstatement-Same and Reinstatement-Different group received the same duration of exposure to two contexts following extinction, but differed in what context the reinstating US presentations were made. Two additional groups, a Control-Same and Control-Different group, were also tested. These groups received the same context exposures as the corresponding reinstatement groups, but did not receive any presentations of the US. A second change implemented for the present experiment was that there was a repeated alternation of the contexts that the participants were exposed to following the extinction phase. That is, groups received either exposure to contexts X, Y, X, Y before test or exposure to contexts Y, X, Y, X before test. The alternation was done on the supposition that by alternating between the contexts, the context specificity of the reinstating US presentations might prove to be stronger and result in the elimination of the reinstatement effect in the Reinstatement-Different group.

Method

Participants.

The participants were 11 male and 52 female first year psychology students from Griffith University who did not participate in any previous experiments. The mean age of the participants was 21.7 years (range 17 to 55 years) and all provided informed consent prior to participation. The participants were randomly assigned to either the Reinstatement-Same ($n = 16$), Reinstatement-Different ($n = 16$), Control-Same ($n = 16$) or Control-Different ($n = 15$) group with the restriction that there were a similar number of males and females in each group.

Apparatus and Procedure.

The apparatus and procedure replicated that used in Experiment 2 with the exception of the number of groups tested, the nature of the contextual changes that occurred during the experiment, the number and duration of the CS presentations, and the duration of the reinstatement phase. There were four groups of participants formed by crossing the occurrence or nonoccurrence of the reinstating US presentations and the nature of the context changes that occurred between the extinction and test phases: a Reinstatement-Same group, a Reinstatement-Different group, a Control-Same group, and Control-Different group. The trial structures and context changes that occurred in the four groups are shown in Table 2. In between the extinction and test phases, there were four periods of context exposure. For the reinstatement groups, two of these periods included US alone presentations and the remaining two periods did not have any CS or US stimuli. For the control groups, none of the four periods included CS or US presentations. All groups received the acquisition, extinction, and test trials in the same context (Context X). Following the extinction trials, the same context groups received exposure to context Y, a change to context X, a change to context Y, and a final change to context X before the test trials were conducted in context X. Following the extinction trials, the different context groups received additional exposure to context X, a change to context Y, a change to context X, a change to context Y, before a change back to context X for the test trials. The reinstatement groups received presentations of the US in the second and fourth context exposure periods. The US presentations occurred in context X for the Reinstatement-Same group, whereas the US presentations occurred in context Y for the Reinstatement-Different group. No US presentations were made in between the extinction and test phases for the control groups (Control-Same and Control-Different groups). The delay between the last extinction trial and the first test trial was

105 s. All participants reported that they had noticed the context and changes in the context during the experiment. The CS+ and CS- were each presented 17 times during acquisition, 21 times during extinction, and 3 times during test (see Table 2). Trials 1, 5, 9, 13, 17, and 21 (if applicable) in the acquisition and extinction phases were presented for 3 s whereas all other trials were presented for 1 s in order to reduce the predictability of the CS duration. All test trials were 3 s in duration. The mean number of responses during the 3 s baseline prior to each CS was 14.11 ($SD = 1.36$) for the acquisition phase, 14.26 ($SD = 1.23$) for the extinction phase, and 14.29 ($SD = 1.47$) for the test phase.

 Insert Table 2 about here

Results and Discussion

The criterion for exclusion resulted in five participants being rejected prior to statistical analysis due to showing insufficient extinction. The statistical analyses took into account the two factors that were systematically varied across the four groups: the presence of the US following extinction (US presence) and the nature of the context changes following extinction (Context). The mean suppression ratio for the four groups that resulted from the orthogonal manipulation of these two factors is shown in Figure 4. The statistical analyses for acquisition used a 2 x 2 x 2 x 5 (US presence x Context x CS x Trial) ANOVA. A main effect for CS, $F(1, 53) = 399.02, p < .0005$, a main effect for Trial, $F(4, 212) = 38.47, \epsilon = .80, p < .0005$, a CS x Trial interaction, $F(4, 212) = 96.95, \epsilon = .73, p < .0005$, confirmed the establishment of conditioning. An unexpected US presence x Context interaction was also found, $F(1, 53) = 6.96, p < .05$. The interaction reflected that conditioned suppression was overall lower in the

Control-Same group than in the Control-Different group, $t = 2.39$, $p < .05$, whereas there was no difference between the Reinstatement-Same and Reinstatement-Different groups, $t = 1.22$, $p > .05$.

The statistical analyses for extinction used a $2 \times 2 \times 2 \times 6$ (US presence \times Context \times CS \times Trial) ANOVA. A main effect for CS, $F(1, 53) = 91.92$, $p < .0005$, a main effect for Trial, $F(5, 265) = 87.11$, $\epsilon = .52$, $p < .0005$, and a CS \times Trial interaction, $F(5, 265) = 69.91$, $\epsilon = .56$, $p < .0005$, were found and indicated that there was extinction of conditioned suppression. Post hoc tests indicated that suppression was greater during the CS+ than during the CS- on the first extinction trial, $t = 16.83$, $p < .01$, whereas this difference was not present on the last extinction trial, $t = .07$, $p > .05$. The analyses also gave a US presence \times Context \times CS interaction, $F(1, 53) = 5.01$, $p < .05$, and a US presence \times Context \times Trial interaction, $F(5, 265) = 2.81$, $\epsilon = .52$, $p < .05$. Post hoc comparisons showed that the interaction reflected that suppression was marginally greater on the first extinction trial for the Control-Same group than in the Control-Different group, $t = 2.25$, $p < .1$, whereas all other comparisons for the other extinction trials in the control groups and for all trials the reinstatement groups were not significant, all $ts < 1.18$, $p > .05$. The between group difference appears to reflect carry over from the acquisition phase in which there was a slightly different greater conditioned suppression during the CS+ in the Control-Same group. However, groups were similar on the last extinction trial with no difference between CS+ and CS- evident.

The analyses during the test phase that used a $2 \times 2 \times 2 \times 3$ (US presence \times Context \times CS \times Trial) ANOVA gave a main effect for CS, $F(1, 54) = 15.43$, $p < .0005$, a main effect for Trial, $F(2, 108) = 16.37$, $\epsilon = .71$, $p < .0005$, and a CS \times Trial interaction, $F(2, 108) = 6.07$, $\epsilon = .73$, $p < .01$. Planned comparisons showed that conditioned suppression was more pronounced during the

CS+ than during the CS- on the first test trial for the Reinstatement-Same group, $t = 3.00, p < .05$, and the Reinstatement-Different group, $t = 3.79, p < .01$. These comparisons confirm that there was a reinstatement of conditioned suppression following the presentation of the US after extinction. There also appeared to be a marginal increase in conditioned suppression to the CS+ in the test phase for the control groups, possibly reflecting a spontaneous recovery effect (Pavlov, 1927) due to the time delay between the extinction and test phases. However, the difference between the CS+ and CS- were not statistically significant for either of the Control-Same or Control-Different groups on any test trial, all $ts < 2.17, p > .05$.

The second test for reinstatement that used a $2 \times 2 \times 2 \times 2$ (US presence x Context x CS x Trial) ANOVA for the last extinction and first test trials yielded a main effect for CS, $F(1, 54) = 9.40, p < .01$, a main effect for Trial, $F(1, 54) = 14.35, p < .0005$, and a CS x Trial interaction, $F(1, 54) = 12.03, p < .001$. Planned comparisons showed that conditioned suppression was greater on the first test trial than on the last extinction trial for the CS+ in the Reinstatement-Same group, $t = 3.91, p < .01$, and for the Reinstatement-Different group, $t = 3.69, p < .01$, whereas the difference for the control groups did not reach the required level of statistical significance, both $ts < 2.46, p > .05$. The difference between the trials for the CS- was not significant for any group, all $ts < 0.62, p > .05$. These analyses support those obtained during the test phase to suggest that a reinstatement of suppression was found regardless of the context in which the US presentations were made. These results support the outcomes from Experiment 3 in suggesting that presenting the reinstating USs in a context different from that which prior extinction trials and a subsequent test phase is conducted does not necessarily abolish the reinstatement effect.

General Discussion

The present research investigated the reinstatement of extinguished conditioned behavior with the conditioned suppression task developed by Arcediano et al. (1996) and which has been used previously to demonstrate renewal in humans (Havermans et al., 2005; Neumann, 2006, 2007). A consistent pattern emerged in which extinguished conditioned suppression was reinstated when there were six presentations of the US in between the extinction and test phases. The present results demonstrate the reinstatement of extinguished conditioned responses with a behavioural measure of conditioning in human participants. These findings complement prior research in which reinstatement was observed in a contingency judgment task (García-Gutiérrez & Rosas, 2003; Vila & Rosas, 2001) and a fear conditioning task (Dirikx et al., 2004, in press; Hermans et al., 2005; LaBar & Phelps, 2005; Van Damme et al., 2006) and increases the generality of the reinstatement effect to a different experimental task. The measurement of conditioned suppression also provides an additional procedural parallel between the human and animal research.

The effects of presenting the reinstating US in a different context to the preceding extinction and subsequent test trials was also investigated. Although the results of Experiment 2 were ambiguous, possibly owing to the reduced sample size, the results of Experiments 3 and 4 were consistent in that the reinstatement effect persisted even when the US presentations were made in an irrelevant context to the other phases of the experiment. The results suggest that mere re-exposure to the US can be sufficient to generate reinstatement and that it is not always necessary to conduct the test trials in the same context in which the US has been presented in order to observe reinstatement. The present results seem contrary to the one study conducted with human participants reported by LaBar and Phelps (2005) in which a fear conditioning

procedure was used. Indeed, the context dependency of reinstatement may not apply to all conditioning tasks. One such example in the animal learning literature is taste aversion learning (Schachtman et al., 1985). The apparent contradiction in the outcomes between the present experiment and those reported by LaBar and Phelps (2005) may have one of several explanations, each of which has differing implications for our understanding of reinstatement in humans.

One possible explanation is that the different outcomes reflect procedural differences between the conditioned suppression task used here and the fear conditioning task used by LaBar and Phelps (2005). It is noteworthy that different outcomes have also been reported with these two types of tasks when the renewal effect has been examined. For instance, Neumann (2006) found that presenting extinction trials in multiple contexts prior to test presentations of the CS abolished the ABA renewal effect in the conditioned suppression task. In contrast, the same approach did not completely abolish the ABA renewal of self-reported shock expectancy in a fear conditioning procedure (Neumann et al., 2007). Different outcomes such as these could reflect three or more potentially important procedural differences between the two tasks. First, the CS presentations in conditioned suppression task are considerably shorter (typically varied between 1 to 3 s) than that typically used in fear conditioning procedures (typically a constant 8 s). The shorter CS durations in the conditioned suppression task may encourage a fast, possibly non-cognitive decision making process (Neumann, 2007) that may be less influenced by contextual modulation. Second, the conditioned suppression task is a continuous task in that the participant is constantly making a response throughout each phase of the experiment. In contrast, the fear conditioning procedure is a punctuate task that involves discrete CS presentations separated by lengthy inter-trial intervals in which no stimuli are presented. The

latter procedure may allow for the contextual manipulations to have a greater impact on subsequent responding to extinguished CSs. For instance, the constant need to respond to the Martians might take attention away from the contextual changes that occur throughout the experiment. While the participants in the present research indicated that they had noticed the context changes, the full meaning of the context and how it might modulate the occurrence of the US may not have received sufficient attention. Third, the conditioned suppression task employs a constant presentation of the “Martians” across all phases of the experiment. The continuous presentations of the Martians may function as a cue that increases the transfer of learning between the different phases of the experiment. It has been shown that the presentation of the same distinctive cue in an extinction and test phase reduced the renewal of saliva weight and self-reported urge to drink following an extinction procedure in a sample of social alcohol drinkers (Collins & Brandon, 2002). In a similar manner, the constant presentation of the Martians may have reduced the context specificity of the US presentations in the present experiment if the Martians themselves formed part of the context in which the experiment is conducted. The test presentations of the CS may have lead to a return of conditioned behavior through this contextual conditioning effect. While these potential differences do not necessarily suggest that contextual control of conditioned behavior cannot be observed with the conditioned suppression task, they do suggest that contextual cues might be less powerful than when used in a fear conditioning procedure. Moreover, they also lead to ways in which contextual control of behavior might be enhanced. For instance, the three explanations would suggest an increased effect of contextual manipulations if the CS durations are made longer, the presentation rate of the Martians is slowed down (i.e., reduce the attentional demands of the task), and the nature of the Martians are changed between contexts (e.g., by using different images).

Another unique feature of the present methodology was that the acquisition, extinction, reinstatement, and test phases ran continuously without any interruptions from the experimenter. In contrast, the study of context specificity of reinstatement in animals typically involves a long interval of 24 hours after the reinstating US presentations before the test trials (e.g., Bouton & Bolles, 1979). The human fear conditioning study by LaBar and Phelps (2005) also included interruptions and longer delays between the reinstatement and test phases than that employed here. Participants in their experiment were required to sit in a waiting room for 5 min in between the extinction and reinstatement and the reinstatement and test phases. In this procedure, the interruptions and longer periods between the phases may have increased the perception of there being a demarcation between the different phases of the experiment, thus increasing the saliency of the contexts that the participants were exposed to. However, such a procedure might also increase the possibility that the return from extinction effects found reflect other recovery from extinction mechanisms such as spontaneous recovery (Pavlov, 1927) or a non-associative process such as dishabituation (Edwards & Siddle, 1976) as underlying the increase in responding to the CS on test trials. The use of a suitable control group that receives context changes, but not the reinstating US presentations, can rule out such possibilities. It would be instructive to incorporate a waiting period in a separate waiting room into the present design to investigate such issues further.

An alternative explanation for the present results in which reinstatement was found regardless of the context in which the reinstating US presentations were made could be that the context does not modulate extinguished conditioned behavior in the present task. Havermans et al. (2005) suggested a similar conclusion following their demonstration of ABA renewal, but not ABC renewal. Instead, it was suggested that during conditioning a configural context-CS

stimulus is formed and associated with the US. The loss of conditioned suppression during extinction, in which there was a change in context, was suggested to reflect a generalization decrement. Conditioned suppression was renewed during test because there was a return to the original learning context. Other research also points to potentially important differences in the control of extinguished conditioned behavior during the conditioned suppression task. Neumann (2007) found that instructing the participants that the context was irrelevant to the predictive relationship between the CS and US did not attenuate the renewal effect. Such an attenuation would be expected if the context serves to modulate whether the CS-US or CS-noUS association is expressed in behavior following extinction. However, the instructions might be ineffective if conditioning results in a configural context A-CS association being formed during acquisition. A similar explanation might account for the present results. A configural context-CS stimulus may have been associated with the US presence during acquisition and associated with US absence during extinction. The subsequent reinstating US presentations may have changed the strength of the US representation (Rescorla & Heth, 1975) leading to an increased activation of the association between the configural context-CS stimulus and the US and in turn, the reinstatement of conditioned suppression during test. Whether a configural context-CS association is formed by humans in the present task will remain to be determined. Even if it is shown that no configural context-CS stimulus is formed, the suggestion that the reinstating US presentations change the strength of the US representation or its threshold of activation from that which existed after extinction (Rescorla & Heth, 1975) may explain the current data. This notion does not make any reference to contextual cues as moderating reinstatement and can thus account for the present results in which reinstatement was observed regardless of the change in context.

The reinstatement effect is of practical interest because of the practical application of extinction, typically termed exposure therapy, in the treatment of behavior problems. The reinstatement effect provides a potential explanation for why individuals might relapse following exposure therapy (Bouton, 2000, 2002). For instance, in the case of exposure therapy for a simple phobia, relapse might occur if the individual is exposed to a traumatic event (US) even in the absence of the feared object (CS). The present demonstration of reinstatement in humans supports this model as a potential explanation for relapse. It is noteworthy that the magnitude of the reinstatement effect observed on the first test trial was somewhat less than at the end of acquisition. This effect is consistent with animal research (e.g., Frohardt et al., 2000) and suggests that reinstated anxiety symptoms may not be as intense as that experienced prior to exposure therapy. However, reinstatement can still prove to be a relevant factor since a full relapse may be the result of successive lapses that progressively increase in intensity (Allsop, Saunders, Phillips, & Carr, 1997). The finding that the reinstatement effect was relatively independent on the context in which the reinstating US presentations were made, suggests that relapse through a reinstatement mechanism might be a more pervasive problem than originally thought. Further research might help to elucidate the reasons why the context was ineffective in modulating reinstatement with the present methods and apply this knowledge to relapse prevention methods following exposure therapy.

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Footnotes

¹ Additional statistical analyses were conducted to check this possibility. Inspection of the means appeared to indicate that a larger reinstatement effect was present if the CS+ was presented first (CS+ $M = 0.43$, $SD = 0.05$; CS- $M = 0.46$, $SD = 0.03$) than if the CS- was presented first (CS+ $M = 0.45$, $SD = 0.05$; CS- $M = 0.45$, $SD = 0.04$). However, a 2 x 2 factorial ANOVA conducted for the first test trial that included the factors of first CS presented in test (CS+ or CS-) and the CS type (CS+ or CS-) did not result in any significant main effects or interactions, all $F_s < 1$, possibly due to the small sample size.

Figures

Figure 1. Mean suppression ratio for the Control group (top panel) and Reinstatement group (bottom panel) for the CS+ and CS- during the acquisition, extinction, and test phases in Experiment 1. Trials A1, A5, and A9 represent the acquisition trials in which the conditional stimulus (CS) was presented for 3 s. Likewise, trials E1, E5, E9, and E13 and trials T1, T2, and T3 represent, respectively, the extinction and test trials in which the CS was presented for 3 s. Error bars depict the standard error of the mean.

Figure 2. Mean suppression ratio for the Control group (top panel) and Reinstatement-Same group (middle panel), and Reinstatement-Different group (bottom panel) for the CS+ and CS- during the acquisition, extinction, and test phases in Experiment 2. Trials A1 to A9 indicate the trials in the acquisition phase, trials E1 to E9 indicate the trials in the extinction phase, and trials T1 to T3 indicate the trials in the test phase. Error bars depict the standard error of the mean.

Figure 3. Mean suppression ratio for the Reinstatement-Different group for the CS+ and CS- during acquisition, extinction, and test phases in Experiment 3. Trials A1 to A9 indicate the trials in the acquisition phase, trials E1 to E9 indicate the trials in the extinction phase, and trials T1 to T3 indicate the trials in the test phase. Error bars depict the standard error of the mean.

Figure 4. Mean suppression ratio for the Control-Same (top left), Control-Different (bottom left), Reinstatement-Same (top right) and Reinstatement-Different (bottom right) groups for the CS+ and CS- during acquisition, extinction, and test phases in Experiment 4. Trials A1, A5, A13, and A17 represent the acquisition trials in which the conditional stimulus (CS) was presented for 3 s. Likewise, trials E1, E5, E9, E13, E17, and E21 and trials T1, T2, and T3 represent, respectively, the extinction and test trials in which the CS was presented for 3 s. Error bars depict the standard error of the mean.

Table 1.

Experimental design for the Control, Reinstatement-Same, and Reinstatement-Different groups for all phases of Experiment 2.

Group	Experimental Phase			
	Acquisition	Extinction	US exposure	Test
Control	X: 9 CS+ US, 9 CS-	X: 9 CS+, 9 CS-	X: -	X: 3 CS+, 3 CS-
Reinstatement-Same	X: 9 CS+ US, 9 CS-	X: 9 CS+, 9 CS-	X: 6 US	X: 3 CS+, 3 CS-
Reinstatement-Different	X: 9 CS+ US, 9 CS-	X: 9 CS+, 9 CS-	Y: 6 US	X: 3 CS+, 3 CS-

Note: X and Y refer to the two contexts used, CS+ and CS- were the two conditional stimuli, US was the unconditional stimulus, and the numbers indicate how many trials of each type were presented. There was no US exposure for the Control group.

Table 2.

Experimental design for the Control-Same, Control-Different, Reinstatement-Same, and Reinstatement-Different groups for all phases of Experiment 4.

Group	Experimental Phase						
	Acquisition	Extinction	CE ₁	USE ₁	CE ₂	USE ₂	Test
Control -Same	X: 17 CS+ US, 17 CS-	X: 21 CS+, 21 CS-	Y: -	X: -	Y: -	X: -	X: 3 CS+, 3 CS-
Control-Different	X: 17 CS+ US, 17 CS-	X: 21 CS+, 21 CS-	X: -	Y: -	X: -	Y: -	X: 3 CS+, 3 CS-
Reinstatement-Same	X: 17 CS+ US, 17 CS-	X: 21 CS+, 21 CS-	Y: -	X: 3 US	Y: -	X: 3 US	X: 3 CS+, 3 CS-
Reinstatement-Different	X: 17 CS+ US, 17 CS-	X: 21 CS+, 21 CS-	X: -	Y: 3 US	X: -	Y: 3 US	X: 3 CS+, 3 CS-

Note: X and Y refer to the two contexts used, CS+ and CS- were the two conditional stimuli, US was the unconditional stimulus, and the numbers indicate how many trials of each type were presented. There was no US exposure for the Control-Same or Control-Different groups. CE = context exposure and USE = US exposure.







